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CHAPTER 16.
WILDLIFE AND HABITAT
Bristol Bay Drainages

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ACRONYMS AND ABBREVIATIONS

AIC	Akaike's Information Criterion
ADF&G	Alaska Department of Fish and Game
AKNHP	Alaska Natural Heritage Program
ASG	Alaska Shorebird group
asl	above sea level
AWC	Anadromous Waters Catalog
BBS	(North American) Breeding Bird Survey
BLM	Bureau of Land Management
BPIF	Boreal Partners in Flight
FRI	Fisheries Research Institute (University of Washington
GIS	geographic information system
GMU	Game Management Unit
GPS	global positioning system
GSPE	Geospatial Population Estimator
HGM	hydrogeomorphic
km	kilometers
km^2	square kilometer(s)
KNP	Katmai National Park
LCNP	Lake Clark National Park
MCH	Mulchatna Caribou Herd
MCHTWG	Mulchatna Caribou Herd Technical Working Group
MODIS	Moderate Resolution Imaging Spectroradiometer
NDM	Northern Dynasty Mines Inc.
NMML	National marine Mammal Laboratory
NPS	National Park Service
NWR	National Wildlife Refuge
p	detectability probability
psi	occupancy probability
SCF	sightability correction factor
USDA-NRCS	United States Department of Agriculture, Natural Resources Conservation Services
USFWS	United States Fish and Wildlife Service
USFS	United States Forest Service
USGS	United States Geological Survey
VHF	very high frequency

16. WILDLIFE AND HABITAT

16.1 Habitat Mapping and Habitat-Value Assessments—Mine Study Area

16.1.1 Introduction

This chapter section summarizes the wildlife habitat mapping and habitat-value assessment studies conducted for the mine study area. This work was conducted to provide a baseline inventory of the availability of wildlife habitats in the study area and an assessment of the value of those habitats to a selected set of bird and mammal species of concern.

16.1.2 Study Objectives

The primary objectives of the wildlife habitat mapping and habitat-value assessment studies are to provide baseline mapping of wildlife habitats in the mine study area, quantify the areal coverage of the habitat types present, and identify the importance of those habitats to wildlife species.

16.1.3 Study Area

In 2004, the wildlife habitat mapping field surveys were conducted within a study area of 246 square kilometers surrounding the Pebble Deposit, and in 2005, the study area was expanded to 293 square kilometers. Currently, the study area designated for wildlife habitat mapping comprises 476 square kilometers. This mapping area encompasses a broad region surrounding the Pebble Deposit (Figures 16.1-1 and 16.1.2) and is referred to in this chapter section as the mine study area.

The mine study area is in an open, glaciated landscape at the headwaters of the north and south forks of the Koktuli River and Upper Talarik Creek and is largely dominated by upland and alpine vegetation. Terrain in the area varies from flat and gently rolling to mountainous, with relatively few lakes and small ponds. White spruce (*Picea glauca*) is present in only a few locations, typically occurring as scattered trees in an open forest or woodland form. Several isolated stands of poplar (*Populus balsamifera* and *Populus trichocarpa*) also occur in protected locations. These forest patches are anomalous occurrences, however, in a landscape strongly dominated by shrub and herbaceous habitats. The most common wildlife habitats in the area are Upland Moist Dwarf Scrub and Alpine Moist Dwarf Scrub. Dwarf scrub dominates on upland glacial moraine deposits and on higher elevation, alpine slopes where drainage is good. Alpine Dry Barrens occurs at higher elevations on ridge crests, slopes, and cliffs. At lower elevations and alternating with Upland Moist Dwarf Scrub in more protected locations are broad patches of upland low- and tall-scrub habitats, dominated by willows (*Salix* spp.) and Sitka alder (*Alnus sinuata*). These same upland low- and tall-scrub habitats also occur on more well-drained slopes. Lowland Low and Tall Willow Scrub occurs in wetter drainage swales, often adjacent to inactive riverine features. Riverine low- and tall-scrub habitats, again dominated by willow and alder, occur in the headwaters and floodplains of the larger streams and rivers in the area. The wetter habitats in the area are typically dominated by graminoid vegetation (e.g., wet graminoid meadows), but wet shrub-dominated bogs also occur; these habitats occur primarily in lowland and riverine areas with gentle slopes and impeded drainage. Marsh habitats, with permanent standing water, are relatively uncommon in the area and occur most extensively directly north of Frying Pan Lake and in other low-lying areas along drainages and around lakes and ponds.

16.1.4 Previous Studies

Only coarse-scale land-cover mapping has been conducted in the region of the Pebble Deposit. Early mapping of the area was conducted for the Bristol Bay Land Cover Mapping Project (Wibbenmeyer et al., 1982a, 1982b). These data were derived from a classification of Landsat Mulitspectral Scanner satellite imagery. Subsequently, additional coarse-scale land-cover mapping for the State of Alaska was conducted using Advanced Very High Resolution Radiometer satellite data; the land cover classes in this case were developed using a vegetation phenology index from data collected during the 1991 growing season (USGS, 1998). Given the relatively low accuracy of spectral-image classifications at fine-scales, and with cell sizes of 50 meters in Wibbenmeyer et al. (1982a) and one square kilometer in USGS (1998), neither of these mapping products will provide the necessary accuracy or resolution to adequately characterize wildlife habitats at a local scale within the mine study area. Both of these datasets, however, may be useful in characterizing wildlife habitats on a coarser regional scale.

More recently, a spectral image classification for Lake Clark National Park was conducted using Spot multispectral imagery acquired in 1995; this mapping was augmented with field data, aerial photo interpretation, and other geographic information system (GIS) datasets and is reported to be 83 percent accurate (NPS, 2001). Unfortunately, the mapping resolution is still fairly coarse (cell size of 30 meters) and only the northeast quarter of the mine study area is covered. Additionally, in an initial evaluation of this mapping, inaccuracies were found at fine scales in the mine study area, so it is likely these data will only be useful in characterizing wildlife habitats at a coarser regional scale.

16.1.5 Scope of Work

The wildlife habitat mapping study was conducted by Charles T. Schick, Wendy A. Davis, Matthew J. Macander, and Joanna E. Roth, of ABR, Inc. (hereafter ABR). Field surveys to ground-truth the aerial photography for the habitat mapping study were conducted during August and September 2004 and 2005. The field studies were conducted by Sally E. Anderson, Gerald V. Frost, Chandra B. Heaton, Patricia F. Miller, Erik R. Pullman, Joanna E. Roth, and Charles T. Schick according to the approach described in the *Draft Environmental Baseline Studies*, *Proposed 2004 Study Plan* (NDM, 2004) and the *Draft Environmental Baseline Studies*, *2005 Study Plans* (NDM, 2005). Digital habitat mapping was conducted by Wendy A. Davis, Patricia F. Miller, Katherine L. Beattie, Matthew J. Macander, and Charles T. Schick. The wildlife habitat-value assessments were conducted by Alexander K. Prichard and Brian E. Lawhead (mammals), Robert J. Ritchie (raptors), Ann M. Wildman (waterbirds), and Charles T. Schick (shorebirds and landbirds).

The habitat mapping and habitat-value assessment studies included the following tasks:

- Conduct field surveys to ground-truth the aerial photography and determine the photo signatures for vegetation, physiography, and surface forms in the mine study area.

- In a GIS, add physiographic categories (and landform and surface-form categories, as needed) to the vegetation map polygons prepared by Three Parameters Plus, Inc. (3PP) and HDR Alaska, Inc. (HDR).
- Combine vegetation and physiographic information (and landform and surface-form information, as needed) to develop preliminary multivariate wildlife habitat types.
- Aggregate the preliminary habitat types to develop a final set of habitat types suitable for evaluations of wildlife use in the study area.
- Conduct habitat-value assessments for the mapped habitat types using wildlife survey data specific to the mine study area and habitat-use information from the scientific literature.

16.1.6 Methods

16.1.6.1 Habitat-mapping Field Surveys and Data Management

Field surveys to ground-truth the aerial photography for the mine study area were conducted from August 17 through 20, 2004 and from August 14 through September 3, 2005. Field plot locations were selected prior to the field work using either color-infrared or true-color aerial photography depending on the survey year. In 2004, researchers used high-altitude, color-infrared aerial photography from the National Aeronautics and Space Administration to determine ground-truth plot locations; this photography dates from the late 1970s and early 1980s and was reproduced in digital orthophoto format with 0.76-meter pixels by Aero-Metric, Inc. In 2005, sample plots were selected using true-color aerial photography of the mine study area acquired in July 2004; digital orthophotos of this photography with 0.46-meter pixels were produced by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

Field sample plots were located along transects that crossed a number of distinct vegetation types or photo signatures identifiable on the aerial photography. Transects were located in areas that maximized the range of possible vegetation types to be encountered over distances that could be easily walked in a day. Field plots were accessed by helicopter, with a drop-off in the morning and a pick-up in the evening, and then on foot using handheld Global Positioning System (GPS) receivers and field maps of the digital aerial photography for the study area. Once at a particular field plot location, the final point to sample was chosen to reside in the habitat area representative of the larger type that would eventually be delineated as a map polygon from the aerial photography (i.e., small inclusions of other habitat types were avoided). Eighty field plots were sampled within the mine study area boundaries in 2004 and 139 plots in 2005. Considering both years combined, 219 field plots were sampled in the mine study area.

At each ground-truth plot, vegetation data were collected by assessing plant species composition and vegetation structure visually using percent-cover estimates within a 10-meter radius of the plot center. Cover estimates of individual plant species were made to the nearest 5 percent for cover values greater than or equal to 10 percent and to the nearest 1 percent for cover values less than 10 percent. Vegetation structure was documented by estimating the percent cover of all species combined in vegetation structure/strata classes (needleleaf trees, deciduous trees, tall shrubs, low shrubs, dwarf shrubs, forbs, graminoids, mosses, lichens) and in ground cover classes (water, litter, bare soil, rock). These data were used primarily to determine the most appropriate vegetation type for each field plot. The Level IV vegetation categories from *The Alaska Vegetation Classification* (Viereck et al., 1992) were used to classify the vegetation types in the mine study area.

In addition to vegetation data, physiographic and surface-form classes were recorded for each field plot from a list of pre-defined classes used by ABR for habitat mapping projects throughout Alaska. The physiographic types recorded at field plots in the mine study area were: alpine, subalpine, upland, lowland, lacustrine, and riverine. Upland and subalpine areas were very similar and were combined into an upland physiographic class for the final habitat map (see Section 16.1.6.2 below).The surface-form categories included both microtopographic types (from Washburn, 1973) and macrotopographic types (from Schoeneberger et. al., 2002) in a system described in Jorgenson et al. (2002). To collect basic, descriptive information on soils (which often is helpful in separating physiographic types such as lowlands and riverine-influenced areas), a small 40-centimeter soil pit was dug to determine water depth, drainage, soil moisture, organic depth, and dominant mineral type (e.g., organic, sandy, loamy). Each soil pit was photographed and documentary habitat photos and GPS coordinates were recorded at each field plot.

In the field, plant identifications for most vascular plants were made using *Flora of Alaska and Neighboring Territories* (Hultén, 1968). Trees and shrubs, with the exception of willows (*Salix* spp.), were keyed using *Alaska Trees and Shrubs* (Viereck and Little, 1972). Willows were keyed using *A Guide to the Identification of Willows in Alaska, the Yukon Territory and Adjacent Regions* (Argus, 2001). The final taxonomic nomenclature for the field data follows Argus (2001) for willows and Viereck and Little (2007) for other trees and shrubs. Nomenclature for all other taxa follows *Flora of North America North of Mexico* (FNAEC, 1993–2009) except for those taxa in plant families not yet revised by the FNAEC, for which nomenclature from *The Plants Database* (USDA-NRCS, 2009) was used.

In 2004, all data were recorded on paper and entered into *Microsoft Excel* after the field surveys. In 2005, all data were recorded directly into *Microsoft Excel* in the field on pocket PCs. The data from both years were uploaded to a *Microsoft Access* database designed specifically for the Pebble Project habitat mapping study. The field data then were checked for missing entries or errors in coding by using queries to compare the raw data with reference tables that list the plots surveyed and the correct codes for the data categories used. Quantitative vegetation data were checked for accuracy by comparing plot photos and field notes to the plant cover and vegetation-structure cover data for each plot. All data errors were corrected before proceeding with further study.

16.1.6.2 Mapping and Classification of Habitat Types

Vegetation Mapping

The first step in mapping wildlife habitats in the mine study area was the mapping of vegetation for the area (prepared by 3PP and HDR). The vegetation mapping in the study area was completed by these consultants in a set of 36 map sections of roughly 17.3 square kilometers each. In 22 of those 36 map sections, the complete map section was mapped for wildlife habitats. For the remaining 14 map sections, the area within each section was partially mapped for wildlife habitats, as needed, based on the extent of vegetation mapping completed in the section and/or the extent of ABR's habitat mapping study area within the section. For two map sections in the southeastern corner of the study area, only the vegetation in riverine drainages was mapped (Figures 16.1-1 and 16.1-2). The 35 map tiles displayed on Figure 16.1-2 were created to display the completed wildlife habitat mapping at a scale at which map polygons are discernable and do not represent the 36 map sections used during the mapping process.

Habitat Map Development

To derive wildlife habitats, ABR first added physiographic attributes (alpine, upland, lowland, lacustrine, and riverine) to the vegetation map polygons produced by 3PP and HDR. In general, except for water habitats (see below), this process relied on aerial photo-interpretation of landforms (geomorphology) and surface-from types, and ultimately physiographic types. The ground-truth data collected during the field surveys described above were used to help facilitate the photo-interpretation of physiographic types. All aerial photo-interpretation and digitizing of physiographic features were performed onscreen using *ArcGIS® 9.3* software. The true-color aerial photography for the mine study area collected in July 2004 (described above) was used as the base map for this work. The older, color-infrared aerial photography (also described above) was referred to occasionally, especially to help discern scrub and graminoid habitats.

In assigning physiographic attributes, the initial vegetation polygons received from 3PP and HDR first were split into water habitats and non-water habitats. Polygons with vegetation codes of Open Water (OW) or Aquatic Herbaceous (AH) were treated as water habitats while all other vegetation codes were assigned to the non-water habitat category. The water and non-water habitats were processed independently and then combined to produce a complete set of map polygons for the study area (see below).

Water Habitats

For water habitats, physiography was assigned based on the value of the hydrogeomorphic (HGM) field prepared by 3PP and HDR. If the HGM field was Riverine or Riverine Corridor, the physiography was assigned to Riverine and the Rivers and Streams habitat type was used; otherwise, physiography was assigned to Lacustrine and the Lakes and Ponds habitat type was used.

To delineate those streams supporting anadromous fish, GIS shapefiles from the version of the *Anadromous Waters Catalog* (AWC) that was current at the time of the final mapping effort in 2010 (ADF&G, 2010) were obtained for southwestern and southcentral Alaska. These files were overlaid on the Rivers and Streams habitat type to visually identify which streams were anadromous. The scale of the AWC data was coarser than the detailed stream mapping in the study area, but in general it was clear which channels the AWC data corresponded to. The main channels of the rivers and streams that corresponded to the AWC data were manually assigned to the Rivers and Streams (Anadromous) habitat type.

Non-Water Habitats

For non-water habitats, physiography was assigned based on aerial photo-interpretation. A generalized and coarse-scale physiography map for the mine study area was prepared by ABR biologists based on photo-interpretation of landforms and surface forms, and elevation data. The generalized physiography map was overlaid on the non-water vegetation polygons and each non-water map polygon was assigned a preliminary physiographic type based on the generalized physiographic type with the largest overlapping area.

Once physiographic types were assigned to each map polygon in each of the 36 map sections, a preliminary set of wildlife habitat types for the mine study area was created by assembling all unique combinations of physiographic and vegetation type. This process resulted in a large number of habitat types with all possible combinations of physiographic and vegetation type included. A preliminary habitat type name was assigned to each physiography/vegetation combination when the interpretation was obvious. Other combinations in which the interpretation of a habitat type was unclear were noted as possible errors or as requiring further investigation to verify the classification of physiography.

The preliminary habitat map then was systematically reviewed at a scale of 1:2,000 except in cases where the existing mapping required closer analysis. Based on this review, the preliminary physiography type, which was mapped at a coarse scale, frequently was revised to conform to the finer-scale vegetation mapping. Two types of polygon editing also were performed. For cases in which a vegetation map polygon occurred in one or more physiographic types, the vegetation polygon was split to represent the different physiographic areas; the vegetation attributes in the resulting polygons remained the same. This alteration of polygon boundaries occurred most commonly during the process of delineating riverine areas for the vegetation types mapped by 3PP and HDR. Second, river or stream channels occasionally were split from surrounding polygons and were recoded to the Open Water vegetation code. Other than this, no vegetation codes were changed.

The vegetation mapping included many very small polygons that in the ABR habitat-mapping approach would typically be treated as patches or inclusions of other types within a broader scale habitat type (these small polygons, when they are not waterbodies, are typically below the size to attract use by most vertebrate species). To facilitate development of broader scale wildlife habitats and to reduce the number of very small polygons requiring physiography assignment and habitat review, a minimum polygon mapping size of 0.25 acre was enforced for non-water polygons (see below). Water bodies less than 0.25 acre were retained because these often represent an important habitat feature.

Non-water polygons less than 0.25 acre were merged into adjacent types through an automated procedure. First, the 36 map sections were merged into a single, seamless polygon file. The merged vegetation polygons at the original map section boundaries then were dissolved based on the preliminary habitat type, so that adjacent polygons with the same code were treated as a single habitat polygon. Dissolved non-water polygons less than 0.25 acre then were merged into the adjacent non-water polygon with the greatest shared border using the *ArcGIS® 9.3 Eliminate* tool. This automated approach removed nearly all the very small non-water habitat patches. Islands in waterbodies that were less than 0.25 acre were retained because non-water polygons were not merged into adjacent water.

Habitat Aggregation

Following the review and refinement of physiography and preliminary habitat-type coding, and the elimination of very small non-water habitats, the preliminary habitat types were aggregated to produce a smaller set of final habitat types that better represent use by wildlife. This aggregation process was conducted to emphasize features in the final habitat types that are known to be important for use by wildlife in Alaska. As in other habitat mapping studies by ABR, the habitat aggregation process focused primarily on two variables (vegetation structure and physiography) and, to a lesser extent, on additional variables (landforms, surface-form features, proximity to open water, and elevation) as needed.

16.1.6.3 Habitat-value Assessments

A subset of 38 species was assessed for wildlife habitat values from the full set of bird and mammal species known or expected to occur in the mine study area (Table 16.1-1). For birds, which are more easily detected than mammals, researchers have a verified list of the species that occur in the mine study area. For mammals, and especially for the smaller species (furbearers and small mammals), the occurrence information for the mine study area is less complete, hence researchers constructed a list of those mammal species observed and those with a reasonable likelihood of occurring in the study area. The species to be assessed for habitat values then were selected for their conservation, cultural, and/or ecological importance using the criteria listed below. To be included in the subset of species for habitat-value assessments, each species had to fall into at least one of the five categories below.

- Legally protected species under the Endangered Species Act or the Bald and Golden Eagle Protection Act.
- Species of conservation concern for southwestern Alaska (based on the most current listings of species of conservation concern for the mine study area; see Chapter 17).
- Species sensitive to human disturbance and development in freshwater habitats and serves as an indicator of environmental health.
- Species of concern for management, primarily because of subsistence and/or sport hunting/trapping use.
- Species provides important ecological function(s) because of its role as predator or prey (not otherwise represented by another species under one of the other criteria above), or because its presence can result in broader ecosystem effects (e.g., beaver).

Wildlife habitat-value assessments then were conducted using the habitat map described above and the wildlife survey data collected by ABR for the Pebble Project. The wildlife survey data were augmented, for those species with few observations, with assessments of habitat use from the scientific literature and/or from professional judgment based on extensive field experience with bird and mammal species in Alaska. This process generally involved four steps: (1) overlaying the wildlife observations on the habitat-map polygons in a GIS to determine the specific habitats being used at the time of observation; (2) assessing the frequency of use of each habitat type from the survey data; (3) evaluating coverage of the survey data to determine which habitats and wildlife species may be adequately sampled, under sampled, or unsampled; and (4) augmenting the project-specific observations (for under sampled and unsampled species and habitats) with information on habitat use derived from the scientific literature and/or from professional judgment. More specific methods for the habitat-value assessments are listed below in separate subsections for each wildlife species-group.

For each of the 38 bird and mammal species assessed, habitat values for each mapped habitat type were categorized into one of four value classes: high, moderate, low, or negligible value (Table 16.1-2). For birds, the assessment of habitat value in the mine study area was based primarily on the observed or potential use of the available habitats for breeding (nesting and brood-rearing), and for foraging during the breeding, migration, and wintering seasons (if applicable). For mammals, the assessment of habitat value in the mine study area was based on several criteria: (1) the availability of specific plant foods (for herbivores and omnivores) or the expected availability of specific prey (for carnivores); (2) the presence of habitat suitable for denning/overwintering; and (3) the presence of suitable vegetation cover for concealment.

Mammals

For mammals, habitats rankings were based primarily on findings from a review of pertinent literature on habitat preferences and requirements for each species. The literature review was augmented by personal observations of the various species during field work conducted in the region of the Pebble Project since 2004. Because the literature for mammals seldom had information related to the specific habitat types delineated in the mine study area, researchers often assessed habitat value based on more general characteristics such as vegetation structure (e.g., forest, meadow, scrub), physiography (e.g., riverine, lowland, upland, or alpine), or the presence of specific plant species known to be important for forage. Habitats were given low rankings if the species was thought to be absent or rare in a particular study area. For instance, few black bears are present in the mine study area (see Section 16.2).

To assist with habitat rankings, researchers compiled a list of all mammals observed in mapped habitats during wildlife surveys for the Pebble Project. The sources of data included ABR aerial-transect surveys for terrestrial wildlife; a random transect survey of bears in the Bristol Bay drainages area conducted by ADF&G in spring 2009; a moose survey of the Bristol Bay drainages area conducted by ABR in April 2010; locations of terrestrial mammals recorded opportunistically during surveys for other species; and telemetry locations of Mulchatna Herd caribou collected through cooperative survey efforts involving ADF&G, Togiak National Wildlife Refuge (NWR), Yukon Delta NWR, NPS, and BLM (Hinkes et al., 2005).

For three reasons, however, mammal observational location data were not subject to statistical analysis of habitat use. First, many of the locations are too imprecise to map to habitats accurately. Telemetry data in particular can be offset from the true location by over 1 km. Second, most observation methods, and opportunistic sightings in particular, are biased by the differing detectability of animals in different habitats. Animals are more likely to be observed in open habitats than closed habitats because they are easier to spot. Third, the search areas differed for each type of location data, meaning that the proportional coverage of each mapped habitat differed, and this difference would have to be accounted for in any comparison of habitat use and availability. Data screening, to isolate only those data with high spatial resolution, high detectability, and a known search area, resulted in sample sizes too small for statistical analysis.

Raptors

The assessment of habitat value for nesting and foraging raptors was based on project-specific habitat-use information for raptor nests and raptor observations recorded in the mine study area (see Section 16.3), personal field observations in the region of the Pebble Project, habitat descriptions in the scientific literature for raptor populations in Alaska and elsewhere in their ranges, and personal field experience of the raptor biologists involved in this project. Habitat values for seven species of concern (Bald and Golden eagles, Northern Goshawks, Peregrine Falcons, Gyrfalcons, Merlins, and Great Horned Owls) were assessed by combining nesting, foraging, and migration habitat values to derive an overall habitat value for each wildlife habitat type mapped in the study area. These seven raptor species were selected because of their protected status, their status as species of conservation concern (see Chapter 17), and/or their ecological importance as predators of other wildlife species.

Waterbirds

Eight waterbird species of concern (Tundra Swan, Red-throated Loon, Common Loon, Harlequin Duck, Surf and Black Scoters, Long-tailed Duck, and Arctic Tern) recorded using the mine study area during the breeding or migration seasons were assessed for habitat value. Tundra Swans and Common Loons are sensitive species and indicators of the environmental health of lakes and wetlands and Harlequin Ducks are indicators of productive riverine systems; each of these species is sensitive to contaminants, changes in water quality, human disturbance, and they return to the same nesting territory year after year, often reusing nest sites (Bengtson, 1966; Limpert and Earnst, 1994; Robertson and Goudie, 1999; Barr et al., 2000; Evers et al., 2010). The other five species (Red-throated Loon, Surf Scoter, Black Scoter, Long-tailed Duck, and Arctic Tern) are considered species of conservation concern for southwestern Alaska (see Chapter 17).

Habitat rankings for breeding Tundra Swans in the mine study area were determined by overlaying nest and brood locations from 2004 and 2005 on the habitat-map polygons to determine the specific habitats being used. In addition, habitat values were based on the frequency of use of each habitat type for nesting and brood-rearing and the location of habitats used for nesting relative to a lacustrine waterbody. For Common Loons, survey data also were used to evaluate the habitat rankings for nesting and brood-rearing. Nests were not found for the remaining five species, but broods of Harlequin Ducks, Black Scoters, and Long-tailed Ducks were found in the study area in 2004 and 2005. For these three species, habitat rankings for nesting were derived by consulting the scientific literature on habitat use and applying it to an evaluation of the habitat types occurring around Lakes and Ponds, where all broods were found. The habitat rankings of the breeding habitat for Surf Scoter, Red-throated Loon, and Arctic Tern were based, in part, on their occurrence in the mine study area during the breeding season, on information on habitat use derived from the scientific literature, and for Red-throated Loon and Arctic Tern, on knowledge of nesting habits in other areas of Alaska. The importance of the habitats of the mine study area to these eight waterbird species during spring and fall migration was evaluated using survey data from 2004 and 2005.

Shorebirds and Landbirds

Habitat values were assessed for a set of 10 shorebird and landbird species of concern (six shorebirds and four landbirds; Table 16.1-1) that were found to occur in the mine study area during field surveys in 2004 and 2005. These species were selected based on their status as species of conservation concern (see Chapter 17) or because of management concern for sport and subsistence hunting (ptarmigan only).

The assessments of habitat value for shorebird and landbird species were conducted primarily using the dataset of breeding shorebird and landbird observations recorded during point-count surveys in the mine study area in 2004 and 2005 (see Section 16.5). Additional observations of shorebirds and landbirds made during other wildlife surveys in the study area also were used, largely to corroborate the habitat-value rankings derived from the point-count dataset. When these project-specific data were insufficient (e.g., for habitats that were under sampled or unsampled during point-count surveys and for uncommon species), additional habitat-use information was sought in the published literature on shorebirds and landbirds and supplemented by professional judgment based on observations of habitat use by these species elsewhere in southwestern and southcentral Alaska.

To derive habitat-use information for shorebirds and landbirds, each point-count location in the mine study area from 2004 and 2005 was assigned a mapped habitat in a GIS (defined by the wildlife habitat map polygon that each point-count location occurred in). Average-occurrence figures then were calculated for the shorebird and landbird observations that occurred in each mapped habitat (Appendix 16.1A). Using average occurrence (defined as the number of birds observed divided by the number of point-count surveys) corrects for the different numbers of point-counts that were conducted in each habitat. This standardizes the abundance data across habitats and allows direct comparisons of relative bird abundance among habitats. In calculating average-occurrence figures, only those observations recorded in the focal habitat at each point count were used. Observations made in non-focal habitats (habitats adjacent to the focal habitat at an individual point-count location) were not used because those observations may be biased towards more vocal and/or more active species. This is because observations in non-focal habitats are typically made at some distance from the point-count location, so less vocal and less active species may be missed, and inclusion of data from non-focal habitats may downwardly bias the average-occurrence figures for such species.

To determine the habitat-value class for each combination of habitat and shorebird/landbird species, the average-occurrence data for each shorebird and landbird species were inspected for natural groupings of average-occurrence figures and for breakpoints between those groupings. In many cases, it was clear from the data which habitats were used to a substantially greater degree, which were used very little, and which were used moderately. In cases like these, with three clear classes of average-occurrence figures, the habitats in the three classes were defined as high, moderate, and low value. Negligible-value habitats were classified as those that were not observed to be used in the 2004 and 2005 breeding seasons. For less common species, for which there sometimes were only one or two classes of average-occurrence figures in the dataset, the habitat(s) with the highest (or only) average-occurrence figure(s) was typically treated as high value; those with lower average-occurrence figures were treated as moderate- or low-value habitats depending on the numerical distance between the higher and lower average-occurrence figures.

Several corrections to the habitat-value classifications then were needed for those habitats that were under sampled or not sampled during point-count surveys in 2004 and 2005 and for the less common species, for which insufficient data were available to adequately evaluate habitat use. First, for habitats that were under sampled (<10 point counts) and for which no observations were recorded for a particular species, and for habitats that were not sampled at all, habitat-value classes were determined by comparison with the data from adequately sampled habitats. Habitat-value classes for under sampled and unsampled habitats were determined to be similar to those assessed for adequately sampled habitats that shared similar vegetation structure and/or physiography. To account for the uncertainty involved, habitat-value classifications for under sampled and unsampled habitats were typically reduced one class from the comparable sampled habitat. For example, Alpine Moist Dwarf Scrub was adequately sampled and classified as high value for Rock Ptarmigan, whereas Upland Moist Dwarf Scrub was under sampled (and no observations of Rock Ptarmigan were recorded there). Using this method, Upland Moist Dwarf Scrub, being similar in vegetation structure to Alpine Moist Dwarf Scrub, was similarly classified (but reduced one class) to moderate value for Rock Ptarmigan.

Second, when possible, habitat-association data from non-focal observations, incidental observations, and in-transit observations made during the point-count surveys (see Section 16.5) and from additional observations made during other wildlife surveys in the mine study area also were evaluated to help classify habitat values for under sampled and unsampled habitats. In these cases, to account for the lower data quality in the incidental-observation dataset, the habitats used often were treated as moderate or low value depending on how often the species was recorded in each habitat. In some cases, however, these incidental observation data were used to classify habitats as high value (e.g., when the habitats were known to be important for breeding for a particular species but were simply under sampled or unsampled).

Third, in cases in which data from the mine study area were insufficient to assess habitat use for a particular species, the published and unpublished literature on habitat use for that species and professional judgment based on field experience and knowledge of habitat use for the species elsewhere in southwestern and southcentral Alaska were used to classify habitat values for under sampled and unsampled habitats.

Finally, corrections were needed to minimize the bias that can occur for uncommon species, which may be observed only in a few habitats but that actually use a greater number of habitats. For each species that was expected to occur more commonly in the mine study area, additional habitat-association observations were sought in the dataset of non-focal observations, incidental observations, and in-transit observations from all wildlife surveys conducted in the mine study area. Any additional habitats used were given a habitat-value class, but to account for the lower data quality of the incidental observations, the habitat classes often were treated as moderate or low value depending on how often the species was recorded in each habitat. Similar to the treatment of under sampled and unsampled habitats (above), exceptions were made for those incidental observations made in habitats known to be important for breeding for a particular species; in those cases the incidental observation data were used to classify the habitats as high value.

16.1.7 Results and Discussion

16.1.7.1 Wildlife Habitat Availability

The wildlife habitat mapping area in the region of the Pebble Deposit (the mine study area) encompasses 475.7 square kilometers. The mine study area is primarily comprised of alpine and un-forested, upland habitats on glacial moraine deposits, but three prominent riverine corridors (the north and south forks of the Koktuli River and Upper Talarik Creek) also occur in the area. Lacustrine waterbodies and poorly drained, un-forested habitats occur in lowland areas and a small number of upland forest patches also occur. Twenty-five wildlife habitat types were mapped in the mine study area (Figures 16.1-1 and 16-1.2). The mapped habitat types are described in Appendix 16-1B, and summaries of the areal coverage of each type are presented in Table 16.1-3.

The two most common habitats in the mine study area are Upland Moist Dwarf Scrub (130.0 square kilometers) and Alpine Moist Dwarf Scrub (115.8 square kilometers); together these types account for over 51.7 percent of the mine study area. The two habitat types share roughly similar plant-species composition and both are dominated by dwarf ericaceous shrubs, but they occupy different physiographic areas (upland and alpine). In this mapping effort, alpine areas were classified based on physiography, but there are subtle floristic and plant community characteristics that also help define alpine habitats in the study area. In general, Alpine Moist Dwarf Scrub occurs at higher elevations than Upland Moist Dwarf Scrub on ridges, crests, and upper slopes. This habitat type is closely associated with Alpine Moist Graminoid–Forb Meadow (7.5 square kilometers; 1.6 percent of study area) and Alpine Dry Barrens (31.7

square kilometers; 6.7 percent of study area), and the three types often are interspersed in alpine areas. Alpine Wet Dwarf Shrub–Sedge Scrub is much less common than the other three alpine habitats (4.3 square kilometers; 0.9 percent of study area); it occurs in poorly drained alpine swales and high valleys at the headwaters of creeks.

Upland Moist Dwarf Scrub predominates in the mine study area on lower slopes and wide, valley-bottom moraine deposits, and on abandoned fluvial deposits where substrates are more or less well-drained. In areas with little soil development, Upland Moist Dwarf Scrub transitions to Upland Dry Dwarf Shrub–Lichen Scrub (31.0 square kilometers, 6.5 percent of study area); the latter type is better drained and is characterized by a conspicuous cover of foliose and fruticose lichens. In highly exposed areas, Upland Dry Barrens occur, but this type is relatively rare in the mine study area, accounting for only 3.2 square kilometers (0.7 percent of study area). Also associated with Upland Moist Dwarf Scrub in upland areas in the study area are low- and tall-scrub habitats, including Upland Moist Tall Alder Scrub, Upland Moist Tall Willow Scrub, and Upland Moist Low Willow Scrub, together accounting for 82.6 square kilometers or 17.4 percent of the study area. The low- and tall-scrub habitats occupy moist substrates in sheltered depressions, on low slopes, and in abandoned fluvial channels throughout undulating upland terrain in the study area.

More poorly drained lowland habitats occur in relatively discrete patches throughout the mine study area on toe slopes, flats associated with abandoned lacustrine or riverine systems, and in small, isolated, depressional features throughout the area. Several lowland habitats commonly occur in close association including Lowland Wet Graminoid–Shrub Meadow, Lowland Low and Tall Alder or Willow Scrub, Lowland Ericaceous Scrub Bog, and Lowland Sedge–Forb Marsh, the latter type often at the edges of waterbodies. Together these habitats account for 34.9 square kilometers (7.3 percent of study area). Large concentrations of these lowland habitats occur directly north of Frying Pan Lake and in the headwaters of Upper Talarik Creek and, to a lesser extent, in the complex of waterbodies in the north-central portion of the study area and adjacent to the riverine corridors of the north and south forks of the Koktuli River (Figures 16.1-1 and 16.1-2).

Well-developed riverine corridors in the mine study area support Riverine Tall Alder or Willow Scrub, Riverine Low Willow Scrub, and Riverine Wet Graminoid–Shrub Meadow. Together these types account for 22.8 square kilometers or 4.8 percent of the study area. Riverine habitat types in the study area were delineated based on their occurrence in active river floodplains. These types are well distributed throughout the riverine systems in the study area and occur in association with headwater streams as well as larger, valley-bottom rivers.

Aquatic habitats are an important feature in the mine study area with Lakes and Ponds accounting for 8.2 square kilometers (1.7 percent of the study area) and Rivers and Streams (both anadromous and non-anadromous) accounting for 2.5 square kilometers (0.5 percent of the study area). Lakes and Ponds are widely dispersed throughout the low valleys where the undulating terrain from moraine deposits produces kettle depressions in the landscape. The average size of these lacustrine waterbodies is small (3,200 square meters) and they are generally isolated from one another, surrounded by well-drained uplands. In many cases, the smaller ponds in the study area are ephemeral and will drain as the summer progresses, thus the total areal coverage of Lakes and Ponds is variable depending on the season. Lakes or ponds that have gone dry are delineated as Lacustrine Moist Barrens and this type is rare, comprising only 0.4 square kilometers (less than 0.1 percent of the study area). Rivers and Streams were categorized into two types (anadromous and non-anadromous) depending on whether they were known to support anadromous fishes; the areas for each type were similar at 1.4 and 1.1 square kilometers (0.3 and 0.2 percent of the study area), respectively.[1] Riverine Barrens (unvegetated, exposed banks and river bars) occur rarely in the study area (0.2 square kilometers; less than 0.1 percent of the study area).

Three forested habitats (Riverine Moist Mixed Forest, Upland and Lowland Moist Mixed Forest, and Upland and Lowland Spruce Forest) occur rarely within the mine study area and are found almost exclusively at the far eastern edge of the study area near the boundary with the transportation-corridor, Bristol Bay drainages study area. Together these forested habitats comprise 0.7 square kilometers or 0.1 percent of the study area).

16.1.7.2 Habitat-value Assessments

Habitat values for 38 bird and mammal species of concern were assessed for each of the 25 mapped habitats in the mine study area; 25 bird species and 13 mammal species were evaluated (Appendix 16.1C). Using this set of 38 species, researchers assessed the overall wildlife value of each of the mapped habitats in the mine study area by determining the number of species (species richness) of birds and mammals with moderate- or high-value rankings in each habitat (Figures 16.1-3 and 16.1-4). This analysis of species richness by habitat indicates that three open and poorly drained habitats (Lowland Ericaceous Scrub Bog, Lowland Wet Graminoid–Shrub Meadow, and Riverine Wet Graminoid–Shrub Meadow) have the highest numbers of bird and mammal species of concern with moderate- or high-value habitat rankings (19–20 species; Figure 16.1-3). Concentrations of these habitat types occur directly north of Frying Pan Lake, in the headwaters of Upper Talarik Creek, in the complex of waterbodies in the north-central portion of the study area, and along the north and south forks of the Koktuli River (Figure 16.1-4). A set of 10 other habitats has relatively high numbers of bird and mammal species with moderate or high habitat rankings (13–16 species); these habitats include Lakes and Ponds, Lowland Sedge–Forb Marsh, Rivers and Streams (Anadromous), and a variety of dwarf-, low-, and tall-scrub, and forested habitats in upland, lowland, and riverine settings. Another set of eight habitats has lower numbers of species with moderate or high habitat rankings (eight–11 species); these habitats include Rivers and Streams, and various dwarf- and tall-scrub, meadow, and forested habitats in upland and alpine settings. A small set of barren habitats in alpine, upland, riverine, and lacustrine areas have the fewest numbers of bird and mammal species with moderate or high habitat rankings (three–six species).

In the sections below, the habitat-value assessments for each of the 38 individual bird and mammal species of concern in the mine study area are described.

Mammals

Wolf. The wolf is a generalist species that may be found in most habitats from alpine areas to the coast. Wolves feed on a variety of prey including moose, caribou, beaver, hare, porcupine, salmon, and small mammals, and their use of habitats is largely dependent on the presence of prey in suitable numbers. Moose, caribou, and beaver are thought to be the main prey species for wolves in the northern Bristol Bay region (Woolington, 2006). In the Pebble Deposit area, caribou are uncommon during most of the year

[1] Fish studies for the Pebble Project indicate there are additional anadromous streams and stream reaches in the mine study area; these additional stream sections are not represented in the area figures noted here because the nomination process to the ADF&G Anadromous Waters Catalog was not complete at the time of this writing (see Chapter 15).

but can be abundant during summer, whereas moose are present year-round in lower densities (see Section 16.2).

A landscape-scale study of habitat use by wolves was conducted in the boreal forest region in Minnesota (Mladenoff et al., 1995) where wolf packs were found to use greater proportions of mixed forest and forested wetlands, and lower proportions of agricultural lands, deciduous forest, and large lakes. Wolves also avoided areas with high road densities and preferred areas with complex habitat-patch boundaries.

Wolf packs typically stay within their territories year-round, but some wolves may follow caribou herds (Frame et al., 2004). Wolf numbers in Game Management Unit (GMU) 9, which encompasses the Pebble Deposit area, appeared to have been rising during the early part of this decade (Butler, 2006) but, in view of the continuing decline in the size of the Mulchatna caribou herd (Woolington, 2007a), wolf numbers probably have declined since then.

One wolf was observed in the Pebble Deposit area during aerial transect surveys, in Riverine Tall Alder or Willow Scrub (see Section 16.2). Most of the habitats in the region of the Pebble Project provide moderate-value wolf habitat, supporting one or more prey species favored by wolves. Alpine and open upland areas support caribou, arctic ground squirrels, and ptarmigan; upland tall-scrub habitats support moose in fall and early winter; and riverine and lower elevation forested areas will be used as winter habitat by moose. Wolves also have been observed feeding on salmon in anadromous streams (Darimont et al., 2003). Wolves may use coastal areas as travel corridors, but generally are not abundant at the coast and do not make extensive use of marine habitat types.

Because the wolf is a generalist species and can use a wide variety of habitats, no individual habitat in the mine study area was considered to be of high value and neither was any habitat considered to be of negligible value. A set of 18 habitats was considered to be of moderate value and the remaining seven habitats were categorized as low value (Appendix 16.1C).

Red Fox. The red fox is the most widely distributed carnivore in the world and is able to live in a wide variety of habitats as long as suitable prey is available (Lariviére and Pasitschniak-Arts, 1996). Red foxes in the mine study area probably feed on small mammals, snowshoe hares, ptarmigan, grouse, squirrels, berries, eggs, and carrion (Dibello et al., 1990; Lariviére and Pasitschniak-Arts, 1996; Woolington, 2007b). In areas where their ranges overlap, red fox distribution may be affected by avoidance of coyotes (Voigt and Earle, 1983; Van Etten et al., 2007). Their distribution also is affected by snow conditions, which can influence fox mobility and access to prey.

Comprehensive studies of habitat use by red foxes have been conducted in Switzerland (Weber and Meia, 1996) and Yellowstone National Park (Van Etten et al., 2007), where foxes preferred forest habitats. On Prince Edward Island, Canada (Silva et al., 2009), however, foxes avoided forests. These different habitat-use patterns were related to differing prey availability, threat of human harvest, and snow cover. In Maine, red foxes hunted small mammals when snow was shallow, but switched to snowshoe hare when snow was deep or heavily crusted (Halpin and Bissonette,1988).

Based on trapper questionnaire data, the red fox is the most prevalent furbearer species in GMU 9, although their perceived abundance declined from 2003 to 2006 and is influenced by periodic rabies epizootics (Butler, 2007). Beavers, however, also are common in appropriate aquatic habitats in southwestern Alaska and are known to be locally abundant in parts of GMU 9 (e.g., in the mine study area; see Section 16.2).

Red foxes are expected to be present in most habitats within the Pebble Deposit area that provide adequate vegetation cover and potential prey. Given the presence of coyotes, however, which prey on foxes, foxes are less likely to frequent open areas. Small mammals and berries will be present in many different habitats, hares will be in riverine and forested areas, waterfowl will be present near lacustrine waterbodies, and moose carcasses may be most available in riverine areas during winter.

Because the red fox, like the wolf, is a generalist predator and can use a diversity of habitats, no individual habitat in the mine study area was considered to be of high value and neither was any habitat considered to be of negligible value. A set of 13 habitats was considered to be of moderate value and the remaining 12 habitats were categorized as low value (Appendix 16.1C).

River Otter. River otters are tied closely to productive aquatic habitats, feeding heavily on fishes (Reid et al., 1994a; Larivière and Walton, 1998). Winter habitat availability may be a key factor for determining carrying capacity and ice cover and low temperatures may limit forage opportunities (Reid et al., 1994). River otters require suitable shorelines for winter denning, preferring beaver-influenced lakes and ponds with banked shores and burrows (Reid et al., 1994b; Larivière and Walton, 1998; LeBlanc et al., 2007). River otters prefer dense vegetation and avoid open fields (Bowyer et al., 1995; Gallant et al., 2009). In the marine environment, river otters forage along the shoreline, feeding on slow-moving, moderately sized fishes (Larsen, 1984; Stenson et al., 1984; Cote et al., 2008).

River otters occur primarily in aquatic habitats and adjacent, associated habitat types. Lakes, ponds, and rivers are used for foraging, and nearby areas are used for travel, cover, and denning. River otters in marine areas use habitats along the coastal fringe and forage in intertidal and nearshore subtidal waters (Bowyer et al., 1995; Ben-David et al., 1996).

In the mine study area, three habitats (Rivers and Streams, Rivers and Streams [Anadromous], and Lakes and Ponds) were considered to be of high value for river otters (Appendix 16.1C). A set of six associated riverine and lacustrine habitats was considered to be of moderate value. The remaining habitats were categorized as either low or negligible value for river otters.

Wolverine. Wolverines have a circumpolar distribution but occur at low densities and are sensitive to human disturbance (Pasitschniak-Arts and Larivière, 1995; May et al., 2006). Wolverines have large home ranges and take a broad range of foods, consisting mostly of small mammals and birds, but also including carrion and occasionally preying on larger mammals (Pasitschniak-Arts and Larivière, 1995). In questionnaires, trappers in GMU 9 rated wolverine as having a low but stable population (Butler, 2007).

Wolverines use a variety of different habitats but, due to their low abundance, few habitat studies are available. Wolverines in the middle Susitna River basin of southcentral Alaska moved to higher elevations during summer than in winter and tended to use broad habitat categories (forest, shrub, rock/ice) in relation to availability, although they avoided forest in summer and high-elevation tundra habitats in winter (Whitman et al., 1986). This pattern may have resulted from the availability of arctic ground squirrels and other small mammals in alpine habitats in summer and moose and caribou carcasses at low elevations in winter (Whitman et al., 1986). Banci and Harestad (1990) found that wolverines used habitat classes in proportion to their availability in southwest Yukon, where few small mammals were available in alpine habitats. Copeland et al. (2007) reported that wolverines in Idaho favored higher elevation areas during the summer but showed little selection for specific habitat types. Rock and grass–shrub habitats were avoided, especially during the winter. Krebs et al. (2007) found that wolverine habitat selection in British Columbia varied by sex and season, but in general wolverines selected alpine areas and avalanche chutes, where marmots and ground squirrels were plentiful in summer, and moose winter range in winter. Both sexes avoided areas used for winter recreation.

Wolverines are expected to use virtually all of the habitats in the region of the Pebble Project. Alpine and upland areas with large numbers of arctic ground squirrels may be important in the summer, and lower elevation forested and riverine areas may be more important in the winter when moose carcasses are present. Wolverines likely are rare in coastal habitats.

Because the wolverine is a generalist predator known to use many different habitats, no individual habitat in the mine study area was considered to be of high value and neither was any habitat considered to be of negligible value. A set of 19 habitats was considered to be of moderate value and the remaining six habitats were considered to be of low value (Appendix 16.1C).

Brown Bear. The brown bear density around Iliamna Lake is moderately high (47.7 bears per 1,000 km^2; Becker, 2010). Bears in the region use a variety of seasonal resources. In spring, large concentrations of bears are present in sedge meadows along the coast foraging on vegetation. During summer and early fall, brown bears concentrate along salmon-spawning streams. Bears also feed on ground squirrels, moose and caribou calves, and berries when available. In late fall and early winter, bears excavate winter dens.

Habitat selection by brown bears varies by season, sex, and by the scale of detection (Ciarniello et al., 2007). In a detailed study of habitat use in mountainous areas of southeastern British Columbia (an area with many habitats similar to those found in the mine study area), bears were more often detected in high-elevation areas with relatively steep slopes, rugged terrain, and low human access; areas that were used had more avalanche chutes, alpine tundra, barren areas, and burned and older forests (Apps et al., 2004). In Wyoming, male brown bears used open areas preferentially and were largely nocturnal, whereas female bears were crepuscular (Holm et al., 1999). In Alaska, adult female brown bears in the Kuskokwim Mountains moved to lower elevation areas near anadromous streams in mid-July to mid-August, and then moved to higher elevations during September for foraging and later for denning; in the Kuskokwim Mountains study area, there was an inverse relationship between salmon availability and the distance of bears to salmon streams (Collins et al., 2005).

Early season herbaceous vegetation in coastal salt marshes, such as sedges (*Carex* spp.), grasses (*Elymus* spp.), and forbs (*Plantago* spp. and *Triglochin* spp.), provide a highly digestible, abundant source of protein (Bennett, 1996; Rode et al., 2001). Brown bears travel along coastal beaches and may augment forage plants with clams during favorable low tides (Carlton and Hodder, 2003; Smith and Partridge, 2004). Bears in alpine areas of Kodiak Island fed heavily on *Carex macrochaeta* in *Carex*–forb meadows (Atwell et al., 1980).

Use of salmon streams varies by sex and by the abundance of salmon. Bear-viewing sites with low salmon capture rates and no waterfalls had low use by adult males. Use of bear-viewing sites by female bears with dependent young was significantly related to the prevalence of adult males (Rode et al., 2006).

On Kodiak Island, brown bears denned most often in alder–willow thickets at elevations ranging from 30–1006 meters (100–3,300 feet) (Lentfer et al., 1972). Bears on Admiralty Island in southeast Alaska frequently denned in rock caves at high elevations and bears on Chichagof Island excavated dens under bases of large spruce or snags in old-growth forest (Schoen et al., 1987). Bears enter dens later in areas with late salmon runs (Schoen et al., 1987, Van Daele et al., 1990). Terror Lake bears on Kodiak Island selected steep alpine slopes for dens, whereas southwestern Kodiak bears selected moderate midslope habitats, usually within or at edges of alder thickets, where tundra systems stabilized the dens; use of lowlands was less than the availability in both areas (Van Daele et al., 1990).

The vegetation at bear denning locations in the Talkeetna Mountains was alpine tundra (52 percent), shrubs (alder, willow, or birch [*Betula* spp.]; 35 percent), and tussock grass and rocks (13 percent); females with cubs of the year remained at high elevations for 2–5 weeks after emergence, presumably to decrease risk to young cubs (Miller, 1990). Female bear dens on the Kenai Peninsula were located in high-elevation areas with steep slopes and away from human disturbance (Goldstein et al., 2010). Ciarniello et al. (2005) found that in the mountains of British Columbia, bears denned in excavations into sloping ground (74 percent) or natural caves (26 percent), whereas 90 percent of bears in a lower plateau excavated dens under the base of trees. Bears on the plateaus preferred to den in stands with tall trees and away from roads.

In studies of denning in other areas with alpine and upland habitats similar to those in the mine study area (e.g., the Greater Yellowstone Ecosystem), suitable denning habitat was found to be abundant and widely distributed (Podruzny et al., 2002). The Pebble Deposit area also appears to have abundant denning habitat due to the varied mountainous topography.

Brown bears in the region of the Pebble Project use different habitats at different times of year. They den most frequently at high elevations and often feed on arctic ground squirrels in spring. Riverine and forested areas also may be used for travel corridors and for hunting moose calves. Coastal sedge meadows and mudflats can support very high densities of bears in early summer. In mid- and late summer, brown bears congregate at salmon-spawning streams throughout the region. They occur commonly along coastal beaches, especially near the mouths of rivers with spawning runs of anadromous fishes.

In the mine study area, only one habitat (Rivers and Streams [Anadromous]) was considered to be of high value for brown bears because of the concentrated foraging that can occur along salmon streams in mid- and late-summer (Appendix 16.1C). Because brown bears are known to use a wide variety of habitats for foraging and denning, another 20 habitats in the study area were considered to be of moderate value. The remaining four habitats were considered to be of low value; no habitats were categorized as negligible value for brown bears. In the mine study area, moderate- and high-value habitats for brown bears are common and widespread (Figure 16.1-5).

Moose. Moose habitat requirements vary seasonally and geographically in relation to the availability of forage and specific nutrients, protection from predators, and refuge from deep winter snow. Productive seral shrub habitats provide high-quality forage, aquatic habitats provide important nutrients such as sodium and early emerging, high-quality spring vegetation (MacCracken et al., 1993; Kellie, 2005), and mature forests with closed canopies provide lower snow depths in winter. Some of the best moose habitat is found in forests disturbed by flooding, fire, insect outbreaks, or logging (Telfer, 1978; Loranger et al., 1991; Forbes and Theberge, 1993). Deltas and floodplains are especially productive moose habitat (LeResche et al., 1974; Telfer, 1984; MacCracken et al., 1997) due to the large proportion of early successional shrub habitats created by continuous shifts in vegetation. In mountainous areas, high-elevation shrub communities are a highly productive and stable habitat (Telfer, 1984) when not covered by deep snow. Home-range sizes tend to be larger in areas with more non-preferred habitat (Herfindal et al., 2009).

Because different habitats fulfill different requirements for moose survival (e.g., forage, cover) and the utility of each habitat type varies seasonally and according to different abiotic factors such as snow depth and fire frequency, moose require areas with a variety of different habitat types. Maier et al. (2005) found that moose densities in interior Alaska were highest in burned areas 11–30 years old, near towns, near rivers, in areas of moderate elevations, and in large compact areas of varied habitats. Moose densities were lower in areas of variable terrain and unvegetated areas. A portion of most moose populations migrate seasonally to reach optimal habitat types at different times of year. Males and females may prefer different habitats during some seasons due to their different body sizes, nutritional requirements, and susceptibility to predation (Miquelle et al., 1992).

In spring, moose seek out high-quality forage to compensate for the negative energy balance that occurs during severe winters. Moose in Alaska exhibit high fidelity in early spring to areas with abundant aquatic vegetation, which typically greens-up earlier than terrestrial vegetation (MacCracken et al., 1997; Kellie, 2005).

During calving, female moose look for areas that balance the need for abundant forage with protection from predators. Maternal moose often make rapid movements to a new area just before calving (Bowyer et al., 1999; Testa et al., 2000; Kellie, 2005) and then remain near the calving sites for an extended period of time (Bowyer et al., 1999; Testa et al., 2000). Many moose calve in isolated pockets of dense forage near water, but some move to high elevations during calving (Poole et al., 2007). Miquelle et al. (1992) found that moose typically calved in areas with spruce–aspen (*Populus tremuloides*) or birch–willow habitats, whereas males used areas of upland willow. Bowyer et al. (1999) reported that moose calving locations were distributed randomly with respect to vegetation type habitats, but that moose selected locations for microsite characteristics such as forage availability and aspect. Kellie (2005) found that moose used open areas prior to calving then moved to areas of denser cover during parturition but showed no fidelity to specific calving locations.

During summer, moose have many options for high-quality forage and therefore use a wide variety of habitat types. In most moose populations, summer browse is not a limiting factor. During fall, moose congregate in specific rutting areas. Males search out females and, in some areas, gather harems of females (Molvar and Bowyer, 1994). Cows with calves may be more solitary during rut. Higher elevations areas with large openings often are preferred rutting areas and may attract moose from surrounding areas. Peek et al. (1976, cited in Peek 1997) found that moose in northern Minnesota used moist lowlands and sparsely stocked forest stands during the rut. On the Copper River delta in southcentral Alaska, moose home ranges were located in areas with a high proportion of aquatic and willow-sweetgale (Myrica gale) habitats. Within home ranges, moose selected areas with tall alder–willow habitats (MacCracken et al., 1997).

In mountainous areas, moose use low-elevation areas almost exclusively during winter due to deep snow accumulation at higher elevations (Modaferri, 1999). Snow more than 70 centimeters (28 inches) deep limits moose mobility and covers many preferred forage plants (Coady, 1974; Collins and Helm, 1997).

In some locations, moose follow specific migratory routes when snow accumulation forces them to lower elevations (Hundertmark, 1997).

Poole and Stuart-Smith (2006) reported that elevation was the strongest determinant of moose winter density in southeastern British Columbia. Various studies have suggested that habitat with mature closed canopies is preferred by moose during winter because the interlocking canopy intercepts snow (Pierce and Peek, 1984; Forbes and Theberge, 1993), but access to adequate winter forage also is important. Collins and Helm (1997) found that areas of old poplar forest and birch–spruce forest were used in winter when snow depths were below approximately 110 centimeters (42 inches); when snow was deeper, areas with abundant feltleaf willow (*Salix alaxensis*) were used. Similarly, Collins (2002) noted that moose used riverine feltleaf willows in years of deep snow but used the more abundant diamondleaf willow (*S. pulchra*) on hillsides when snow depth was lower.

Miquelle et al. (1992) reported different habitat selection by male and female moose during winter in interior Alaska. Males used upland willow in years with deep snow and alluvial willow in years with low snow depth. Females predominately used spruce–aspen forest in all winters of the study. Collins and Helm (1997) found that moose used areas of mature white spruce in late spring, possibly to take advantage of the shade during warm days. Suring and Sterne (1998) found that, during winters with deep snow, moose on the Kenai Peninsula used deciduous forest and tall alder–willow communities and avoided mixed deciduous–coniferous forest, sweetgale, and herbaceous–grass communities. During a late-winter moose survey of the Pebble area in April 2010, when snow cover was relatively shallow, all moose observed were below 335 meters (1,100 feet) elevation and the highest densities were in low-elevation areas near the Pile River and Chekok Creek (see Section 16.7).

Moose populations are limited either by predators or forage availability. Limiting factors differ in different parts of the range and include winter habitat, summer habitat, calf predation, and adult predation. In areas with high predator populations, such as in the region of the Pebble Project, predation and not forage typically is the limiting factor (Testa, 2004). The Pebble region has a high brown bear population and a sizeable wolf population (~350 wolves in GMUs 9 and 10; Butler 2006). The number of moose calves observed in GMU 9B was low, at 19 calves:100 cows in fall 2005 and 2 calves:100 cows in fall 2007 (Butler, 2008). Observations suggest that calf predation and occasional winters with deep snow may be limiting the moose population in the area. A minimum calf-cow ratio of 31.8 calves:100 cows was observed during the moose survey conducted in spring 2010 in the Pebble area (see Sections 16.2 and 16.7), but the sample size was low (38 moose).

Moose distribution in the region of the Pebble Project is heavily influenced by snow cover and elevation. Moose calve in riverine and forested areas in spring and may use lakes and ponds for early emergent vegetation and nutrients. Higher elevation tall-scrub habitats are used in fall and during the rut, and then moose move to lower elevations when snow becomes too deep at higher elevations. Riverine willows are especially important for moose during winter. Much of the deposit area is high-elevation habitat that is not used during late winter, but some moose are found along the Koktuli River, Upper Talarik Creek, and other lower elevation areas.

In the mine study area, the four low and/or tall willow-scrub habitats in upland, lowland, and riverine settings, and two other habitats (Lakes and Ponds and Riverine Moist Mixed Forest) were considered to be of high value for moose (Appendix 16.1C), primarily for forage. Another eight scrub, meadow, scrub-bog, marsh, forest, and lacustrine habitats were considered to be of moderate value for moose, also for forage. All other habitats were considered to be of low or negligible value for moose. In the mine study area, the moderate- and high-value moose habitats tend to be concentrated in stream drainage systems (Figure 16.1-6).

Caribou. The Pebble Deposit area is located at the eastern edge of the range of the Mulchatna caribou herd. In recent years, most use of the region around the Pebble Deposit by the Mulchatna herd has occurred during summer, whereas in earlier years, the area also received high-density use during autumn and winter and some use during all seasons (see Section 16.2). Mulchatna caribou most often are found in the western portion of the deposit area and rarely are observed east of the Newhalen River. The Mulchatna herd has experienced precipitous population swings (Woolington, 2007a) and major changes in distribution (Hinkes et al., 2005) in the last few decades.

Caribou are highly mobile animals and have the lowest net cost of locomotion (movement over the ground surface) measured for any species of terrestrial mammal (Fancy and White, 1987). A fundamental characteristic of tundra-dwelling caribou is movement over large areas of range to minimize the risk of predation and exposure to insect harassment while maximizing their intake of high-quality forage and, consequently, their reproductive fitness.

Caribou distribution and habitat selection vary seasonally in response to forage availability, predation risk, and insect harassment. In general, caribou prefer tundra and other open areas where predators are visible, but they also may use spruce forest or other closed habitats in some seasons. In winter, caribou feed primarily in areas where lichens are abundant and snow depth and hardness are low, such as windswept ridge tops or coastal areas (Tucker et al., 1991, Saperstein, 1993). Caribou also tend to avoid areas of deep, soft snow where travel is difficult and they are more susceptible to predators. The net cost of locomotion in snow increases exponentially with sinking depth and is related to caribou brisket height (Fancy and White, 1987). Overgrazing of lichens on winter range is thought to be a factor limiting population growth in some areas (Adamczewski et al., 1988; Ferguson, 1999), although some biologists disagree with that hypothesis (Bergerud, 1996).

During calving, caribou in large herds typically select areas with fewer predators (Bergerud et al., 1984) and newly emergent, highly nutritious forage (Fancy and White, 1991). Calving areas often have patchy snow cover, providing a complex visual pattern that may make it harder for predators to find them (Eastland et al., 1989). As the snow melts, caribou feed on a variety of newly emerging sedges, grasses, forbs, and low-growing shrubs, especially willows (Boertje, 1984; Kuropat, 1984; Russell et al., 1993). Although the protein content and digestibility of forage vary among vegetation types, they generally peak in newly emergent vegetation and then decline throughout the growing season (Kuropat, 1984; Boertje, 1984, 1990; Klein, 1990; Russell et al., 1993; Cebrian et al., 2008). Selective foraging can have a multiplier effect, with relatively small increases in forage quality reaping large benefits for caribou body condition and reproductive success (White, 1983).

During mid-summer, caribou distribution is strongly related to the occurrence of insect harassment. When harassment by mosquitoes and flies (especially oestrid [warble and nose-bot] flies) is severe, caribou seek out insect-relief habitat in barren areas such as river bars or cool, windy areas such as ridges, coastlines, or elevated sites (Walsh et al., 1992). Caribou move more and expend more energy during the insect season in midsummer than at any other time of year (Boertje, 1985; Fancy et al., 1989; Person et al., 2007), which can reduce body condition and cause calves to become separated from their mothers. When oestrid flies are active, caribou seek out unvegetated habitats such as river bars, sand dunes, and ridge tops, thereby reducing access to forage.

Caribou use of the Pebble Deposit area typically peaks in mid-summer, when large groups of caribou may move through the area. Such groups generally occur in alpine or open upland habitats. Ridge tops, snow beds, and large river bars can serve as insect-relief habitat during midsummer. Caribou rarely use habitats east of the deposit area.

Because caribou primarily pass through the mine study area in mid-summer, no individual habitat in the mine study area was considered to be of high value. Caribou, however, can use a variety of open, scrub, and forest habitats when migrating; consequently, no habitat was considered to be of negligible value. Fourteen barren, dwarf- and low-scrub, meadow, scrub-bog, marsh, and forest habitats were considered to be of moderate value and the remaining 11 habitats were categorized as low value (Appendix 16.1C). Moderate-value habitats for caribou are common and widespread in the mine study area (Figure 16.1-7).

Arctic Ground Squirrel. Arctic ground squirrels inhabit arctic and alpine tundra, where they occur commonly in meadow, riverbank, and lakeshore habitats. They prefer permafrost-free areas with loose soils, good visibility, and an adequate supply of low, early successional vegetation (MacDonald and Cook, 2009). Ground squirrels survive the long winters by putting on large fat reserves during summer and dropping their body temperature below the freezing point of water during winter hibernation (Barnes, 1989; Buck and Barnes, 1999).

Arctic ground squirrels were widely distributed in Katmai National Park (Schiller and Rausch, 1956; Cook and MacDonald, 2004a). In Lake Clark National Park, they were captured along streams in herbaceous vegetation, on boulder slopes with dwarf willow–tussock and grass vegetation, on stream banks with dwarf willows, and near the community of Port Alsworth (Cook and MacDonald, 2004b). They eat a wide variety of plant species including forbs, grasses and grass seed, and legumes, but tend to avoid evergreen shrubs (Batzi and Sobaski, 1980; McLean, 1985). In the Yukon, arctic ground squirrels occur both in boreal forests and alpine areas (Hik et al., 2001); the population in boreal forests fluctuated with snowshoe hare cycles because predators switched to alternative prey when hare numbers declined. In contrast, ground squirrels in alpine areas have greater visibility to limit predation and have more stable populations (Karels and Boonstra, 1999).

Arctic ground squirrels in the region of the Pebble Project occur most frequently in open alpine and upland habitats with well-drained soil and good visibility. There also make use of riverbanks and lakeshores. They are uncommon in coastal areas in the Pebble Project region.

In the mine study area, a single habitat (Upland Dry Dwarf Shrub–Lichen Scrub) was considered to be of high value for arctic ground squirrels (Appendix 16.1C). A set of five other open upland and alpine habitats was considered to be of moderate value. All other habitats were categorized as low or negligible value.

Red Squirrel. Red squirrels are abundant across much of boreal Canada and the northern and western United States. They are restricted largely to coniferous forest but also may use mixed forests (Steele, 1998). They prefer coniferous habitats for the abundant conifer seed, fungi, and interlocking canopies that allow for effective escape from predators and efficient foraging (Steele, 1998). Red squirrels prefer white spruce cones to black spruce cones, presumably for their larger size and higher caloric content (Brink and

Dean, 1966; Smith, 1968). Red squirrels are highly territorial and collect conifer cones in late summer and autumn and store them in middens. Red squirrel population size was significantly related to the crop of white spruce cones in Alberta (Kemp and Keith, 1970). Red squirrel populations in poplar stands in Alberta were comprised mostly of juveniles that were unlikely to survive the winter (Rusch and Reed, 1978). Natural cavities in trees are preferred for nest sites, but leaf nests or underground nest cavities also are used.

Primary food items are seeds of trees and fungi, although tree leaf buds and flowers, fleshy fruits, tree sap, bark, insects, bird eggs, juvenile animals, carrion, and birds also are eaten (Steele, 1998). Red squirrels are prey for hawks, owls, and mammalian predators such as lynx and red fox (Steele, 1998).

Within the region of the Pebble Project, red squirrels occur in forested areas, predominantly using dense spruce forests, with lower densities occurring in mixed forests and open spruce forests. These forested habitats are rare within the deposit area.

In the mine study area, two forest habitats (Upland and Lowland Spruce Forest, and Upland and Lowland Moist Mixed Forest) were considered to be of high value for red squirrels (Appendix 16.1C). A third forest habitat (Riverine Moist Mixed Forest) was considered to be of moderate value. All other habitats were considered to be of low or negligible value.

Beaver. The beaver is one of the most common furbearers in the region of the Pebble Project, occurring in freshwater aquatic habitats bordered by woody shrub and forest vegetation. The only aquatic habitats unsuitable for beavers are fast-moving streams and rivers and those with widely varying levels of water flow. Beavers are abundant in the mine study area and lodges were found on most of the suitable ponds, lakes, and streams (see Section 16.2). The beaver is an ecologically important species whose presence and activities affect the distribution of aquatic and riparian habitats and the abundance of fish and other wildlife species (Johnston and Naiman, 1987; Mitchell and Cunjak, 2007). Beaver ponds can provide important overwintering habitat for juvenile salmon (Rosell et al., 2005). Beavers prefer to forage on aspen, balsam poplar (cottonwood), and willow, but also eat birch and alder (Jenkins and Busher, 1979).

In the region of the Pebble Project, beavers occur in rivers, lakes, and ponds, and in adjacent forest and tall-scrub habitats. Beavers build dams, lodges, and food caches in waterbodies, and travel short distances to gather aspen, poplar, willow, and occasionally alder. Other areas may be used for travel to preferred areas or for dispersal of young beavers to new areas.

In the mine study area, two habitats (Rivers and Streams, and Rivers and Streams [Anadromous]), along with four other vegetated riverine habitats were considered to be of high value for beavers (Appendix 16.1C). Two other habitats (Lakes and Ponds, and Upland and Lowland Moist Mixed Forest) were considered to be of moderate value. All other habitats were considered to be of low or negligible value.

Northern Red-Backed Vole. The northern red-backed vole is one of Alaska's most ubiquitous and common mammal species, inhabiting forests, shrublands, alpine tundra, and riparian areas (MacDonald and Cook, 2009). They feed on fungi, berries, succulent green plants, and lichens (Bangs, 1984).

In Lake Clark National Park and Preserve, red-backed voles were recorded in a broad range of vegetation types, but were most abundant in forest and scrub habitats (Cook and MacDonald, 2004b). Their distribution appears to be related closely to the presence of overhead plant cover. In Katmai National Park and Preserve, red-backed voles were found in a variety of plant communities including alder–horsetail (*Equisetum* spp.), spruce–alder–willow, and bluejoint (*Calamagrostis canadensis*) communities (Schiller and Rausch, 1956; Cook and MacDonald, 2004a).

In the southeastern Yukon, overwinter survival was an important determinant of vole population size and was thought to be a function of average snow depth and the presence of dwarf-shrub berries, especially crowberry (*Empetrum nigrum*) (Boonstra and Krebs, 2006; Krebs et al., 2010).

In the region of the Pebble Project, northern red-backed voles are likely to be widely distributed in a variety of forest and scrub habitats. Densities are probably highest in mixed forest and spruce forest habitats. These forested habitats are rare within the deposit area.

In the mine study area, three forest habitats (Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, and Riverine Moist Mixed Forest) were considered to be of high value for northern red-backed voles (Appendix 16.1C). Six other scrub and scrub-bog habitats were considered to be of moderate value and the remaining 16 habitats were categorized as low or negligible value.

Tundra Vole. Tundra voles (also known as root voles) inhabit a wide variety of open herbaceous habitats at various elevations. Although they can be found in shrublands, tundra, grasslands, and riparian areas, they are most abundant in wet sedge and grass–forb meadows and bogs (MacDonald and Cook, 2009). In northern Alaska, tundra voles reach their highest densities in swales and watercourses with dense, wet sedge meadows dominated by rhizomatous monocotyledons, especially sedges (*Carex* and *Eriophorum* spp.), which are their primary food (Bee and Hall, 1956; Batzli and Henttonen, 1990).

In Lake Clark National Park and Preserve, tundra voles were found in grassy areas across a broad range of habitats and elevations (Cook and MacDonald, 2004b). They were most abundant in scrub and herbaceous habitats and were least abundant in forest habitats. In Katmai National Park and Preserve, they were most common in herbaceous habitats; none were captured in forest habitats. Tundra voles were abundant along the coast of Cook Inlet in Katmai National Park (Schiller and Rausch, 1956).

Tundra voles in the region of the Pebble Project are expected to occur in wet open habitats dominated by graminoid vegetation; they may occur especially in Riverine Wet Graminoid–Shrub Meadow and Lowland Wet Graminoid–Shrub Meadow. Use of marine habitat types by this species is negligible.

In the mine study area, three habitats (Alpine Moist Graminoid–Forb Meadow, Riverine Wet Graminoid–Shrub Meadow, and Lowland Wet Graminoid–Shrub Meadow) were considered to be of high value for tundra voles (Appendix 16.1C). Nine other scrub, scrub-bog, and marsh habitats were considered to be of moderate value and the remaining 13 habitats were categorized as low or negligible value.

Snowshoe Hare. When abundant, snowshoe hares have large effects on the ecosystems in which they occur. For example, snowshoe hares can remove a large proportion of the standing shrub biomass (Hodges, 1999). Snowshoe hare populations undergo cyclical fluctuations and predators such as lynx, coyotes, red foxes, Northern Goshawks, and Great Horned Owls show a similar numerical response to changes in hare numbers, often with a lag period. Other small mammals also show cyclical population fluctuations possibly because of food competition or increased predation.

Snowshoe hares select habitats with dense understory cover in boreal coniferous forests, avoiding young re-growth, clearings, and other open areas (Hodges, 1999); dense understory is more important than canopy closure and interspersion of different stand types may be preferred. They are more likely to use deciduous forest types in summer than in winter because of the greater cover afforded by leaves and they may occur in areas of sparse cover mainly during darkness. Open areas may be used more when hare densities are high (Wolff, 1980). Dense understories provide escape cover and thermal protection and were correlated with spring densities and overwinter survival in Maine (Litvaitis et al., 1985).

In southcentral Alaska, snowshoe hares prefer white spruce forest, and alder- and willow-dominated scrub habitats during winter and early spring. Snowshoe hare pellets from southcentral Alaska contained predominately spruce, willow, Labrador tea (*Ledum groenlandicum*), and dwarf birch (*Betula nana*), with lesser amounts of blueberry (*Vaccinium* spp.), horsetail, and unidentified forbs and grasses (MacCracken et al., 1988); alder was not an important forage species even though it was abundantly available. Habitats used in winters when hare densities are low may be important in supporting remnant populations until hare numbers subsequently increase (Wolff, 1980). GMU 9 is on the edge of the range of snowshoe hares and trappers rated them as moderately abundant with recently stable numbers (Butler, 2007). Cook and MacDonald (2004) found that snowshoe hare abundance in Katmai National Park was low.

In the region of the Pebble Project, snowshoe hares are most likely to be found in dense cover in forest and in tall willow-scrub habitats. They are not likely to occur in open alpine habitats or in coastal areas.

In the mine study area, three habitats (Upland and Lowland Spruce Forest, Riverine Tall Alder or Willow Scrub, and Lowland Low and Tall Willow Scrub) were considered to be of high value for snowshoe hares (Appendix 16.1C). Six other scrub and forest habitats were considered to be of moderate value and the remaining 16 habitats were categorized as low or negligible value.

Tree-nesting Raptors

Habitat availability in the mine study area for the four tree-nesting raptor species of concern addressed in this study was assessed spatially in map form (Figure 16.1-8). This figure displays the suitability of habitats (moderate or high habitat-value rankings) for both nesting and foraging tree-nesting raptors considered as a group. One rare habitat (Riverine Moist Mixed Forest) was considered suitable for all four tree-nesting raptor species for nesting and/or foraging (Appendix 16.1C). Other forest, riverine, lacustrine, and barren habitats were considered suitable for fewer species and those habitats similarly occurred uncommonly across the mine study area. Overall, habitats suitable for tree-nesting raptors are not common or widespread in the mine study area.

Bald Eagle. Bald Eagles are common to the forests, anadromous streams, and lakes of southwestern Alaska (Buehler, 2000). Typically they nest in forested areas adjacent to large bodies of water but are widespread from coastal to alpine habitats when foraging and migrating. They nest in trees but also will nest on cliffs or the ground, especially in coastal areas when trees are absent (Buehler, 2000).

Suitable nesting habitat for Bald Eagles in the mine study area is limited and occurs primarily along streams within the Upper and Lower Talarik Creek basins; a single habitat (Riverine Moist Mixed Forest) was considered to be of high value for nesting (Appendix 16.1C). Similarly, one habitat (Rivers and Streams [Anadromous]) was considered to be of high value for foraging. Moderate-value foraging habitats include Rivers and Streams, Riverine Barrens, and Lakes and Ponds. Low-value habitats include all the upland areas, forests, and scrub habitats; however, because Bald Eagles range widely, they will use most of these open habitats at least infrequently. Use of tall-scrub habitats is probably negligible.

Northern Goshawk. Goshawks nest in most forest types within their range and use a diverse set of habitats for foraging, ranging from open steppes to dense forest, including riparian areas (Squires and Reynolds, 1997). The southwestern extent of the breeding range of Northern Goshawks in Alaska includes woodlands in the Iliamna Lake area (Squires and Reynolds, 1997). However, the Northern Goshawk appears to be rare in the mine study area based on the lack of observations during surveys for the Pebble Project (see Section 16.3) and from previous work in the area (Williamson and Peyton, 1962).

Northern Goshawks prefer to nest in large trees in forests with high canopy-closure and sparse ground cover, near the bottom of slopes (Squires and Reynolds, 1997). Only one habitat (Riverine Moist Mixed Forest) is likely to meet these qualifications in the mine study area and it was considered to be of high value for nesting and foraging (Appendix 16.1C). Upland and Lowland Moist Mixed Forest was considered to be of moderate value for nesting and foraging. However, goshawks forage in a larger suite of habitats within and adjacent to forested nesting habitats, so there would be at least low-value foraging habitats in lowland and open upland settings in the mine study area.

Merlin. Merlins breed throughout the arctic, alpine, and boreal areas of Alaska in open to semi-open habitats, and migrate to more temperate zones in winter (Warkentin et al., 2005). They do not build nests, but typically occupy old corvid, hawk, or magpie nests; infrequently they nest in tree cavities and on the ground. Merlins tend to use nests located near forest openings, in woodlots, and near rivers, lakes, or bogs as they prefer to forage in open areas.

Merlins probably nest on upland slopes in Upland Moist Tall Alder Scrub, and in Upland and Lowland Moist Mixed Forest, and Riverine Moist Mixed Forest habitats in the mine study area. These habitats were considered to be of either high or moderate value for nesting Merlins (Appendix 16.1C). They also probably range widely through the study area while foraging during breeding and migration. Moderate-value foraging habitats in the study area include Rivers and Streams, Rivers and Streams (Anadromous), Riverine Wet Graminoid–Shrub Meadow, Lakes and Ponds, and any of the few forested habitats in the study area.

Great Horned Owl. The greater Iliamna Lake area is within the southwestern extent of the range of Great Horned Owls in Alaska (Houston et al., 1998). Nest sites are extremely variable and Great Horned Owls commonly use stick nests made by other birds (e.g., hawks, ravens), but also will nest in tree cavities, cliffs, and occasionally on the ground (Houston et al., 1998). They are resident throughout their range, but may wander extensively outside the breeding season. They are opportunistic predators with one of the widest prey bases of all owls, preying on small- and medium-sized mammals, hares, and birds (including ducks, geese, grouse, and loons). In northern regions during the winter, snowshoe hares may be especially important foods for owls due to the scarcity of other prey (Houston et al., 1998).

High-value breeding habitat in the mine study area for Great Horned Owls probably is limited to Riverine Moist Mixed Forest. Upland and Lowland Moist Mixed Forest was considered to be moderate-value breeding habitat for this species (Appendix 16.1C). Because breeding habitat (forests and sometimes cliffs) is limited in the mine study area and because Great Horned Owls forage in habitats closely associated with forests, most other habitats in the study area probably are of low to negligible value.

Cliff-nesting Raptors

The suitability of habitats (moderate or high habitat-value rankings) for both nesting and foraging cliff-nesting raptors in the mine study area was assessed spatially in map form (Figure 16.1-9). This figure displays the overall habitat availability for the three cliff-nesting raptors species of concern addressed in this study. Two habitats (Rivers and Streams and Rivers and Streams [Anadromous]) were considered suitable for all three cliff-nesting raptor species for foraging and/or nesting (nesting only in situations where cliffs are present) (Appendix 16.1C). Alpine Dry Barrens also provides cliff areas for nesting raptors and was considered suitable for two cliff-nesting raptor species. Other forest, scrub, scrub-bog, meadow, marsh, and aquatic habitats (both riverine and lacustrine) were considered suitable for one to two species, largely for foraging. These habitats, considered together, are common and widespread in the mine study area. Overall, there is a preponderance of open habitats in the mine study area preferred by cliff-nesting raptors.

Golden Eagle. Golden Eagles inhabit open coniferous forest, tundra, and barren habitats in Alaska, and are known to occur in the Iliamna Lake area (Kochert et al., 2002). They are fairly common breeders in the mine study area and nest primarily on cliffs in upland and riparian areas. Golden Eagles also will nest in trees, riverbanks, on the ground, or on human-built structures (Kochert et al., 2002). Foraging habitats during the breeding and migration seasons include a variety of open lowland and upland habitats.

Golden Eagles probably range widely throughout the mine study area feeding primarily on ground squirrels, hares, marmots, and ptarmigan, but also feeding occasionally on caribou calves, waterfowl, and carrion. High-value habitats for nesting include all cliff areas, which are primarily located in Alpine Dry Barrens (Appendix 16.1C). Moderate-value nesting habitats include areas where cliffs occur along Rivers and Streams or Rivers and Streams (Anadromous). Moderate- to high-value habitats for foraging include all the barren, dwarf-, and low-scrub types in alpine and upland areas, riverine meadows, and low-scrub, scrub-bog, meadow, and marsh habitats in lowland areas.

Gyrfalcon. Gyrfalcons nest in tundra habitats throughout Alaska (Clum and Cade, 1994) and they are common summer breeding birds in the mine study area. Nests usually are located on cliffs, but nesting in trees also has been recorded (Clum and Cade, 1994). Gyrfalcons generally are non-migratory but will move, especially if winter prey are limited (Cade, 1960). Foraging habitats during all seasons include the majority of upland and alpine habitats found in the study area.

All Gyrfalcon nests in the study area have been located on cliffs in Alpine Dry Barrens and along Rivers and Streams or Rivers and Streams (Anadromous). These habitats were considered to be of either high or moderate value (Appendix 16.1C). Moderate- to high-value foraging habitats include all the dwarf- and low-scrub types in alpine and upland areas, and low-scrub, scrub-bog, meadow, and marsh habitats in riverine and lowland areas.

Peregrine Falcon. Peregrine Falcons nest on ledges and in stick nests built by other raptors and corvids along riverine and marine habitats in Alaska (Cade, 1960). They are much less common on lacustrine cliffs, off-river cliffs, and artificial platforms. No nests have been located in the mine study area, but suitable cliff habitat occurs and migrating birds probably use the area.

Cliff habitats, particularly along Rivers and Streams, and Rivers and Streams (Anadromous) (e.g., Upper Talarik Creek) are potentially moderate-value breeding habitat for Peregrine Falcons in the mine study area (Appendix 16.1C). Moderate-value habitats for foraging in the mine study area include Rivers and Streams, Rivers and Streams (Anadromous), and Lakes and Ponds. Numerous open low- and tall-scrub habitats have at least low value for foraging Peregrine Falcons in the study area.

Waterbirds

All eight waterbird species assessed for habitat value (Tundra Swan, Harlequin Duck, Surf Scoter, Black Scoter, Long-tailed Duck, Red-throated Loon, Common Loon, and Arctic Tern) are dependent on one or more types of waterbody/wetland habitat during the breeding and/or migration seasons (Appendix 16.1C). Lakes and Ponds was considered to be a moderate- or high-value habitat for seven of the eight species. Stable water levels, irregular shorelines, emergent vegetation, organic content, and water clarity, acidity, and depth are some of the important features that determine whether a lake or pond is used by waterbirds for foraging, nesting, and/or brood-rearing (Palmer 1976a, 1976b). Both types of Rivers and Streams were considered to be high-value habitats for Harlequin Ducks and Arctic Terns, moderate value for Tundra Swans, and low value for the remaining five species. The value and use of habitats for nesting by waterbirds depends on their proximity to a waterbody that serves as foraging and/or brood-rearing habitat. Distance of a nest from water depends on each species' habitat preferences and requirements sometimes can vary widely within a species. Meadow- and shrub-edge habitats adjacent to waterbodies are most frequently used for nesting and for protective cover during brood-rearing. Many waterbirds use the mine study area during the breeding and migration seasons because of the extensive amount of waterbody and wetland habitats.

In the mine study area, waterbirds were associated with 17 of the 25 mapped habitats during breeding and migration (Appendix 16.1C). Eleven habitats were considered to be of high value for one to seven species, which includes five shrub types (Upland Dry Dwarf Shrub–Lichen Scrub, Upland Moist Dwarf Scrub, Upland Moist Low Willow Scrub, Riverine Low Willow Scrub, and Lowland Ericaceous Scrub Bog), three meadow/marsh types (Riverine Wet Graminoid–Shrub Meadow, Lowland Sedge–Forb Marsh, and Lowland Wet Graminoid–Shrub Meadow), and three waterbody types (Lakes and Ponds and both types of Rivers and Streams). Three riverine habitats (Riverine Barrens, Riverine Tall Alder or Willow Scrub, and Riverine Moist Mixed Forest) were ranked no higher than moderate value and three scrub and forest habitats (Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, Lowland Low and Tall Willow Scrub) were ranked no higher than low value. The value of eight habitats (mostly alpine and tall-scrub types) was considered to be negligible for waterbirds.

The overall habitat availability in the mine study area for the eight waterbird species of concern addressed in this study was assessed spatially in map form (Figure 16.1-10). Suitable habitats (moderate or high habitat-value rankings) for an increasing number of waterbird species include lacustrine waterbodies and associated wetland habitats in lowland and riverine areas, and dwarf-scrub habitats in upland settings (Appendix 16.1C). Suitable habitats for fewer species include various open wetland, upland-scrub, and forest habitats, and stream drainages. Suitable habitats for waterbirds are found primarily in the lower elevation headwaters areas of the three major riverine corridors in the area.

Tundra Swan. Tundra Swans breed in North America in subarctic and arctic tundra wetlands. The Iliamna Lake area is near the southeastern limits of their breeding distribution in Alaska (Limpert and Earnst, 1994). Spring staging occurs on rivers and other ice-free water bodies near nesting grounds. In the mine study area, swans occupy lakes and ponds near their nesting grounds as soon as open water is created by stream runoff and they depend on these stream outlet areas for foraging. Tundra Swans return to former nest sites or build new nests by pulling up surrounding vegetation into mounds 10-20 cm high (Wilk, 1988; Limpert and Earnst, 1994). Nests are located near or in wetlands and waterbodies with emergent vegetation. High densities of Tundra Swans are associated with an abundance of shallow waterbodies (King and Hodges, 1981).

In the mine study area in 2004 and 2005, Tundra Swans were found nesting in six different habitats: Upland Dry Dwarf Shrub–Lichen Scrub, Upland Dwarf Moist Scrub, Riverine Wet Graminoid–Shrub Meadow, Lakes and Ponds, Lowland Wet Graminoid–Shrub Meadow, and Lowland Ericaceous Scrub Bog. All six habitats were considered to be of moderate to high value depending on the frequency with which nesting occurred in each habitat, the availability of the habitat in the study area, and the occurrence of the habitat adjacent to waterbodies (Appendix 16.1C). These six habitats not only have the requirements needed for a nest site but they also provide escape, resting, and/or foraging habitat. Both types of Rivers and Streams were considered to be moderate-value habitats because they provide open water for foraging and resting during spring staging and create open water for foraging on lakes and ponds near nesting grounds. Three low willow-scrub habitats that occur adjacent to nesting and foraging habitats were considered to be of low value and provide potential escape and resting habitat.

Harlequin Duck. Harlequin Ducks nest and rear their young along clear, fast-moving streams with abundant aquatic food (midge larvae, caddisflies, stoneflies, mayflies, and crustaceans) in riparian, subalpine, or coastal habitats (Bengtson, 1966; Palmer, 1976b; Robertson and Goudie, 1999). The surrounding vegetation can be closed forest, open forest, valleys with willow or alder, or tundra (Robertson and Goudie, 1999). Nests can be on the ground, on small cliff ledges, or in tree cavities or stumps low to the ground, but they are always near stream waters and commonly are built on islands (Bengtson, 1966; Robertson and Goudie, 1999). Harlequin Ducks return to the same breeding territory each year and sometimes reuse the same nest site (Robertson and Goudie, 1999). They are a common breeder along rivers in the Iliamna Lake area, including in the mine study area.

Pre-nesting and brood-rearing Harlequin Ducks were found during field surveys in 2004 and 2005 in the headwater drainages of the north and south forks of the Koktuli River and Upper Talarik Creek, all of which are classified as Rivers and Streams (Anadromous). Both types of Rivers and Streams were considered to be high-value habitats for Harlequin Ducks because they are used for pair bonding and mating during pre-nesting, and for foraging during nesting and brood-rearing (Appendix 16.1C). Riverine Wet Graminoid–Shrub Meadow and Riverine Low Willow Scrub, found on islands and along the shorelines of Rivers and Streams (both types), were considered to be high-value nesting habitats. These two habitats also provide escape and resting habitat for Harlequin Ducks. Riverine Tall Alder or Willow Scrub and Riverine Moist Mixed Forest were considered to be moderate-value habitats that provide escape, resting, and potential nesting habitat. Riverine Barrens was considered to be a moderate-value habitat that provides resting location for foraging ducks and broods. Lakes and Ponds and four other lowland habitat types were considered to be of low value and may be used if they occur adjacent to Rivers and Streams (Appendix 16.1C).

Surf Scoter. The breeding habitat of Surf Scoters in Alaska is mostly confined to closed and open boreal forest (Bellrose, 1980). For nesting, Surf Scoters prefer shallow lakes less than 10 hectares in size that are clear, saturated in oxygen, slightly acidic, low in conductivity, and have little emergent vegetation (Savard and Lamothe, 1991). Nest sites are variable distances from open water, often under low-spreading branches of conifers or fallen tree trunks (Savard et al., 1998). Rivers and large, deep lakes are avoided during the breeding season (Savard et al., 1998). During migration, Surf Scoters use coastal estuaries, inshore ocean areas, and freshwater lakes near the ocean (Savard et al., 1998).

Surf Scoters were observed in small staging flocks on large lakes in the mine study area during spring and fall migration surveys in 2004 and 2005. No evidence of breeding by Surf Scoters was found in the study area. Lakes and Ponds was considered to be of high value because it provides staging habitat during both spring and fall when Surf Scoters are migrating between their wintering area along the Aleutian Islands and their breeding grounds in forested habitats to the north and east of the study area (Appendix 16.1C). Two upland forest habitat types probably meet the nesting requirements of Surf Scoters, but they were considered to be of low value because these types are rare in the study area.

Black Scoter. In Alaska, the greater Bristol Bay area (which includes the western part of the Iliamna Lake area) is second only to the Yukon Delta in abundance of breeding Black Scoters (Conant and Groves, 2004). Black Scoters arrive paired on breeding grounds and nest in coastal or upland tundra habitats (Bordage and Savard, 1995). For nesting, Black Scoters prefer lakes less than 10 hectares in size that are relatively shallow and located on rock substrate (Bordage and Savard, 1995). Rivers and large, deep lakes are avoided during the breeding season (Bordage and Savard, 1995). Nests are well concealed in large clumps of grass on the tundra or in dense shrubby areas, usually within 30 m of a pond (Bellrose, 1980).

Black Scoters used large lakes and ponds in the mine study area during the breeding and migration seasons in 2004 and 2005. During the breeding season, adult Black Scoters were seen in the study area on 26 different ponds; four of which had broods. Lakes and Ponds and some of the habitats surrounding those ponds (Upland Moist Dwarf Scrub, Lowland Sedge–Forb Marsh, Lowland Ericaceous Scrub Bog, and Lowland Wet Graminoid–Shrub Meadow) were considered to be of high value for Black Scoters because they provide nesting, foraging, brood-rearing, and escape habitat (Appendix 16.1C). Five other shrub habitats that provide potential nesting and escape habitat were considered to be of low or moderate value (Appendix 16.1C).

Long-tailed Duck. Long-tailed Ducks nest in tundra habitats from southwestern to northern Alaska (Gabrielson and Lincoln 1959, Wilbor 1999). The Iliamna Lake area is part of the southern limits of the duck’s breeding range (Bellrose, 1980). Long-tailed Ducks prefer to nest near shallow ponds and wetlands with emergent vegetation and raise their brood in ponds and lakes in the nesting area (Robertson and Savard, 2002). Post- and non-breeders prefer deep ponds and deep open lakes (Derksen et al. 1981).

Long-tailed Ducks were observed in pairs on lakes in spring and with broods in July in the mine study area in 2004 and 2005. During the breeding season, adult Long-tailed Ducks were seen in the study area on 14 different ponds, five of which had broods. Lakes and Ponds and some of the habitats surrounding those ponds (Upland Moist Dwarf Scrub, Upland Moist Low Willow Scrub, Lowland Sedge–Forb Marsh, Lowland Ericaceous Scrub Bog, and Lowland Wet Graminoid–Shrub Meadow) were considered to be of high value for Long-tailed Ducks because they provide nesting, foraging, brood-rearing, and escape habitat (Appendix 16.1C). Four other shrub habitats that provide potential nesting and escape habitat were considered to be of low or moderate value (Appendix 16.1C).

Red-throated Loon. Red-throated Loons prefer to breed in low wetlands in coastal areas, but also will nest in lakes and ponds in bogs, forested habitats, and mountainous areas (Douglas and Reimchen, 1988; Barr, et al., 2000). Red-throated Loons use smaller nesting ponds where they co-occur with Pacific Loons and larger ponds where they are the only nesting loon species (Bergman and Derksen, 1977; Douglas and Reimchen, 1988; Dickson, 1994). A nest platform is built with plant material on the edge of the shoreline or in shallow water surrounded by emergent vegetation (Bergman and Derksen, 1977). Red-throated Loons return to the same breeding territory each year and sometimes reuse the same nest site (Dickson, 1993). Adults forage for fish up to 20 km from the nest pond in nearby lakes, rivers, and nearshore marine waters for themselves and their young (Eberl and Picman, 1993). Red-throated Loons stage on large lakes and coastal waters during spring and fall migration (Barr, et al., 2000).

Red-Throated Loons were not recorded breeding in the mine study area during waterbird surveys in 2004 and 2005, but they were observed staging in lakes and rivers to the north and south of the study area (Nikabuna Lakes area and Upper Talarik Creek near Iliamna Lake). Lakes and Ponds was considered to be a moderate-value habitat because it can be used during staging and nesting (Appendix 16.1C). Some ponds in the study area probably meet the nesting requirements of Red-throated Loons (i.e., shallow with shorelines of Lowland Sedge–Forb Marsh or Lowland Graminoid–Shrub Meadow), but the distance to a large waterbody with a reliable food source (e.g., Iliamna Lake), where there also is no competition from Common Loons, may exceed the limits of their ability to nest successfully. Rivers and Streams (Anadromous) in the study area was considered to be of low value because Red-throated Loons prefer larger and deeper rivers for foraging.

Common Loon. Common Loons nest and raise their young in fish-bearing lakes in boreal forest, mixed forest, subarctic, and arctic tundra habitats and are an indicator species for the health of lakes (Evers et al., 2010). The lakes of the Bristol Bay region support one of the highest densities of Common Loons in Alaska (Groves et al., 1996). The Iliamna Lake area is located on the eastern edge of the Bristol Bay nesting grounds and has many lakes within its mosaic of forest and tundra habitats that can support Common Loons (Williamson and Peyton, 1962). Breeding territories may include an entire lake, just a section of a large lake or several smaller lakes. Mid-size or large lakes greater than 24 hectares with an abundance of small fish, numerous small islands, and an irregular shoreline with plant cover are preferred by Common Loons (Evers et al., 2010). Common Loons nest on a simple scrape, or a low mound of emergent vegetation, located near the shoreline or on floating islets (Vermeer, 1973; Strong et al., 1987). Individuals usually return to the same territory year after year and commonly reuse nest sites from previous years (Evers et al., 2010). Spring and fall staging habitat include rivers, large lakes, and near-shore areas (Evers et al., 2010).

During waterbird surveys in 2004 and 2005, Common Loons were found on nine lakes in the mine study area, all of which were greater than 15 hectares in size. One nest found in the study area in 2005 was in Lowland Sedge–Forb Marsh along the shore of Big Wiggly Lake. Lowland Sedge–Forb Marsh and Lowland Wet Graminoid–Shrub Meadow that occur along the shores of large lakes in the study area were considered to be high-value habitats for nesting and resting (Appendix 16.1C). Lakes and Ponds greater than 15 hectares in size was considered to be a high-value habitat for foraging, nesting, and brood-rearing. Rivers and Streams (Anadromous) provide potential staging habitat, but because Common Loons were not recorded staging on rivers in the study area, it was considered to be of low value. Lowland Ericaceous–Scrub Bog sometimes occurs along the shores of large lakes and may provide potential nesting habitat, but was considered to be of low value.

Arctic Tern. Arctic Terns breed throughout Alaska in tundra and open boreal forest habitats (Hatch, 2002) and they were considered an abundant breeder near large waterbodies in the Iliamna Lake region during studies in the late 1950's (Williamson and Peyton, 1962). Arctic Terns nest in a wide variety of open, usually treeless terrain, often with no vegetation or with low or scattered plant cover (Hatch, 2002). Generally they nest close to water, frequently on small rocky, gravelly, grassy, or peaty islands (Hatch, 2002). Arctic Terns also nest on barrier beaches and sand or gravel spits, gravel bars in rivers, or glacial moraines, as well as marshes, bogs, and grassy meadows (Hatch, 2002).

Arctic Terns were observed using lakes and rivers for foraging during spring migration surveys in the mine study area in 2004 and 2005. Observations ranged from individuals to large flocks. Lakes and Ponds, and Rivers and Streams (Anadromous) were considered to be high-value foraging habitats. No nesting Arctic Terns were found during waterbird studies in the study area in 2004 and 2005, but potential nesting habitat occurs in Riverine Barrens, Riverine Wet Graminoid–Shrub Meadow, Lowland Ericaceous Scrub Bog, and Lowland Wet Graminoid–Shrub Meadow, all of which were considered to be low- or moderate-value habitats.

Shorebirds

The six breeding shorebird species of concern evaluated in this study regularly are associated with a wide variety of habitat types for nesting and brood-rearing. In the mine study area, breeding Surfbirds use higher elevation alpine habitats, both barren and dwarf-scrub dominated types, and American Golden-Plovers use alpine and upland dwarf-scrub habitats as well as lowland scrub-bog and meadow types. Four other species (Lesser Yellowlegs, Whimbrel, Hudsonian Godwit, and Short-billed Dowitcher) all regularly are associated with open, wet, lowland and riverine habitats (meadows, scrub-bogs, marshes) as well as the shorelines of lacustrine waterbodies. Lesser Yellowlegs also can use poorly drained spruce woodland and tall-scrub habitats.

The overall habitat availability in the mine study area for these six shorebird species was assessed spatially in map form (Figure 16.1-11). Suitable habitats (moderate or high habitat-value rankings) for the largest number of species include wet, lowland meadows, scrub-bogs, and marshes, especially when these types are associated with lacustrine waterbodies (Appendix 16.1C). Concentrations of these habitat types in the study area occur directly north of Frying Pan Lake, in the headwaters of Upper Talarik Creek, and in the complex of waterbodies in the north-central portion of the study area. Suitable habitats for a decreasing number of species include wetland habitats in lowland and riverine settings and along the shores of lacustrine waterbodies. Suitable habitats for the fewest number of species include well-drained upland and alpine habitats, which are widely distributed throughout the study area.

American Golden-Plover. Breeding American Golden-Plovers in Alaska occur in open arctic, subarctic, alpine, and upland tundra habitats (Johnson and Connors, 1996; ASG, 2008). In the state, they breed as far south as southwestern Alaska, including the northern portions of the Alaska Peninsula, where they use open upland and alpine habitats. Typically, a substantial cover of lichens on rocks or soil is present in nesting areas, which aids in making the eggs more cryptic in open-cup nests on the tundra. Brood-rearing occurs in open tundra and in adjacent open wetland habitats.

Montane tundra habitats suitable for breeding American Golden-Plovers are abundant in the mine study area, and the species was recorded commonly during the point-count surveys in 2004 and 2005. Habitats categorized as high value for American Golden-Plovers were Alpine Moist Dwarf Scrub, Upland Moist Dwarf Scrub, Upland Dry Dwarf Shrub–Lichen Scrub, Lowland Ericaceous Scrub Bog, and Lowland Wet Graminoid–Shrub Meadow, the latter two types probably only used by brood-rearing birds (Appendix

16.1C). Alpine Wet Dwarf Shrub–Sedge Scrub was considered to be of moderate value and all other mapped habitats were categorized as low or negligible value for American Golden-Plovers.

Lesser Yellowlegs. Lesser Yellowlegs are common breeders in boreal forest openings and in forest/tundra transition areas, but often they are less common in adjacent subarctic tundra habitats (Tibbitts and Moskoff, 1999; ASG, 2008). Complexes of open forest and scrub, wet sedge meadows, bogs, marshes, and ponds are typically used as nesting areas. Brood-rearing occurs along lake and pond margins, often with emergent vegetation and a border of concealing vegetation.

Suitable scrub and wetland habitats for breeding Lesser Yellowlegs are common in the mine study area, but forested habitats are uncommon. This species was recorded only rarely during the point-count surveys in 2004 and 2005. Habitats categorized as high value for Lesser Yellowlegs were Lowland Ericaceous Scrub Bog, Lowland Wet Graminoid–Shrub Meadow, Lowland Sedge–Forb Marsh, and Lakes and Ponds (Appendix 16.1C). Moderate-value habitats were the tall-scrub types in lowland and riverine areas, Upland and Lowland Spruce Forest, Riverine Wet Graminoid–Shrub Meadow, and both types of Rivers and Streams. All other mapped habitats were categorized as low or negligible value for Lesser Yellowlegs.

Whimbrel. Across their range, Whimbrels breed in subarctic and alpine tundra and taiga habitats (Skeel and Mallory, 1996; ASG, 2008). Breeding can occur in well-drained, dwarf-scrub habitats and in poorly drained, graminoid-dominated wetlands, often with hummocks of dwarf and/or low scrub.

Alpine tundra and wetland habitats suitable for breeding Whimbrels are common in the mine study area, and the species was recorded commonly during the point-count surveys in 2004 and 2005. In the mine study area, however, Whimbrels were only found breeding in wetland habitats. Only two habitats were categorized as high value for Whimbrels (Lowland Ericaceous Scrub Bog and Lowland Wet Graminoid–Shrub Meadow) (Appendix 16.1C). Habitats considered to be of moderate value were Riverine Wet Graminoid–Shrub Meadow and Upland Moist Dwarf Scrub. All other mapped habitats were categorized as low or negligible value for Whimbrels.

Hudsonian Godwit. In Alaska, Hudsonian Godwits have been found to breed in areas where open wet sedge meadow and bog habitats are intermixed with shallow ponds, drier upland areas, and forests, especially spruce forests (Elphick and Klima, 2002; ASG, 2008). In western Alaska, breeding also can occasionally occur far from forested areas in open wetland habitats, often with a scrub component.

Complexes of forest and wetland habitats suitable for breeding Hudsonian Godwits do not occur in the mine study area but open wetland habitats are present. Hudsonian Godwits were recorded infrequently during the point-count surveys in 2004 and 2005 and were found only in the area of wetlands and small ponds directly north of Frying Pan Lake. Habitats categorized as high value for Hudsonian Godwits were Lowland Ericaceous Scrub Bog, Lowland Wet Graminoid–Shrub Meadow, Lowland Sedge–Forb Marsh, and Lakes and Ponds (Appendix 16.1C). One habitat (Riverine Wet Graminoid–Shrub Meadow) was considered to be of moderate value and all other mapped habitats were categorized as low or negligible value for Hudsonian Godwits.

Surfbird. Surfbirds breed exclusively in dry alpine areas characterized by barren rocky ground (often scree and rock fields) and scattered vegetation, typically dominated by dwarf shrubs and lichens, and occasionally moss (Senner and McCaffery, 1997; ASG, 2008).

Rocky alpine habitats suitable for breeding Surfbirds are common in the mine study area but, as is typical for this uncommon species, Surfbirds were recorded only infrequently during the point-count surveys in 2004 and 2005. Only two habitats (Alpine Dry Barrens and Alpine Moist Dwarf Scrub) were categorized as high value for Surfbirds (Appendix 16.1C). All other mapped habitats were categorized as low or negligible value for Surfbirds.

Short-billed Dowitcher. In Alaska, Short-billed Dowitchers breed in bog and open wet meadow habitats, often near the coast or in the floodplains of large rivers and streams (Jehl et al., 2001; ASG, 2008). Wetland meadow areas intermixed with open scrub, woodlands or open dwarf forests (e.g., wet black spruce forests) often are used for nesting.

Woodland bog habitats suitable for breeding Short-billed Dowitchers are uncommon in the mine study area, but open wetland habitats are present. Short-billed Dowitchers were recorded infrequently during the point-count surveys in 2004 and 2005 and were found almost exclusively in the area of wetlands and small ponds directly north of Frying Pan Lake. Habitats categorized as high value for Short-billed Dowitchers were Lowland Ericaceous Scrub Bog, Lowland Wet Graminoid–Shrub Meadow, Lowland Sedge–Forb Marsh, and Lakes and Ponds (Appendix 16.1C). One habitat (Riverine Wet Graminoid–Shrub Meadow) was considered to be of moderate value and all other mapped habitats were categorized as low or negligible value for Short-billed Dowitchers.

Landbirds

The four landbird species of concern evaluated in this study regularly are associated with several different habitats including barren alpine and upland areas (Rock Ptarmigan), dwarf-scrub habitats in alpine and upland areas (Rock and Willow Ptarmigan), and low- and tall-scrub habitats in upland, lowland, and riverine settings (Willow Ptarmigan and Gray-cheeked Thrush); breeding Blackpoll Warblers are associated primarily with tall-scrub habitats in upland, lowland, and riverine areas, and with Upland and Lowland Moist Mixed Forest.

The overall habitat availability in the mine study area for these four landbird species was assessed spatially in map form (Figure 16.1-12). Tall-scrub habitats in upland, lowland, and riverine areas provide suitable breeding habitat (moderate or high habitat-value rankings) for the largest number of landbird species (Appendix 16.1C). In general, these habitats are widely distributed across the study area although concentrations tend to occur in stream drainage systems. Suitable habitats for a decreasing number of species include low- and dwarf-scrub habitats, barrens, scrub-bogs, and forests in a variety of physiographic settings. These habitats occur commonly throughout the study area.

Willow Ptarmigan. In Alaska, breeding Willow Ptarmigan commonly occur in low- and tall-scrub habitats, primarily in arctic, subarctic, and subalpine areas; they also use meadows and open tundra habitats, especially when there is a dwarf-shrub or low-shrub component (Kessel, 1989; Hannon et al., 1998). Willow Ptarmigan are resident in Alaska, and during the nonbreeding seasons, they tend to use areas with a greater vegetative cover of shrubs than during the summer months; they sometimes are found at lower elevations during the winter (Hannon et al., 1998).

Suitable alpine and upland habitats for Willow Ptarmigan are abundant in the mine study area, but the species was only infrequently recorded during the point-count surveys in 2004 and 2005. Habitats categorized as high value for Willow Ptarmigan were the alpine and upland forms of moist dwarf scrub and all the low- and tall-scrub habitats in upland and lowland areas (Appendix 16.1C). Habitats categorized as moderate value were the low- and tall-scrub types in riverine areas and Lowland Ericaceous Scrub Bog. All other mapped habitats were categorized as low or negligible value for Willow Ptarmigan.

Rock Ptarmigan. Throughout their range, Rock Ptarmigan breed in arctic and alpine tundra habitats; in alpine areas, they are typically found in areas with abundant, barren, rocky ground and sparse vegetation, often characterized by patches of dwarf shrubs (Montgomery and Holder, 2008). During the nonbreeding seasons, they often are found in these same habitats.

Dwarf scrub and alpine barrens habitats suitable for Rock Ptarmigan are abundant in the mine study area, but the species was recorded rarely during the point-count surveys in 2004 and 2005. Alpine Dry Barrens and Alpine Moist Dwarf Scrub were categorized as high value for Rock Ptarmigan, and Upland Dry Barrens, Upland Dry Dwarf Shrub–Lichen Scrub, and Upland Moist Dwarf Scrub were considered to be of moderate value (Appendix 16.1C). All other mapped habitats were categorized as low or negligible value for Rock Ptarmigan.

Gray-cheeked Thrush. Gray-cheeked Thrushes in Alaska breed in dense tall-scrub habitats, often willow or alder, with a thick understory of low or dwarf shrubs (Kessel, 1998; BPIFWG, 1999; Lowther et al., 2001). Low-scrub habitats without an overstory of tall shrubs are less used than tall scrub. Gray-cheeked Thrushes are variable in their habitat use, however, and can occur in spruce forests near treeline, riverine tall-scrub habitats, open deciduous riverine forests, deciduous woodlands, scrub-bogs, alder patches in tundra, scrub–tundra transition areas, tall alder on coastal slopes, and in tall scrub on glacial moraines.

Tall-scrub habitats are abundant in the mine study area, and Gray-cheeked Thrushes were recorded frequently during the point-count surveys in 2004 and 2005. The habitats used most commonly and categorized as high value for Gray-cheeked Thrushes were Upland Moist Tall Willow Scrub and Upland Moist Tall Alder Scrub (Appendix 16.1C). Habitats used less often and considered to be of moderate value were Riverine Tall Alder or Willow Scrub, Riverine Low Willow Scrub, Lowland Low and Tall Willow Scrub, and Upland Moist Low Willow Scrub. All other mapped habitats were categorized as low or negligible value for Gray-cheeked Thrushes.

Blackpoll Warbler. In tundra regions in Alaska, Blackpoll Warblers often breed in riverine alder–willow thickets, with or without an overstory of riverine forest, and in deciduous scrub habitats in transition areas between taiga and tundra (Kessel, 1998; BPIFWG, 1999; Hunt and Eliason, 1999). Typically, tall shrubs are heavily used and lower shrubs are used to a lesser degree. Coniferous and deciduous forests and woodlands also are used in boreal forest areas.

In the mine study area, riverine tall-scrub habitats and tundra–scrub transition areas are common, and Blackpoll Warblers were recorded frequently during the point-count surveys in 2004 and 2005. Riverine Tall Alder or Willow Scrub was used most commonly and was categorized as high value for Blackpoll Warblers (Appendix 16.1C). Habitats used less often and considered to be of moderate value were Lowland Low and Tall Willow Scrub, Upland Moist Tall Willow Scrub, and Upland and Lowland Moist Mixed Forest. All other mapped habitats were categorized as low or negligible value for Blackpoll Warblers.

16.1.8 Summary

In the region of the Pebble Deposit, the mine study area designated for wildlife habitat mapping is 476 square kilometers in size and includes a broad area surrounding the deposit. Twenty-five wildlife habitat types in the mine study area were mapped from aerial photography taken in July 2004. Habitat types were defined primarily by two variables (vegetation structure and physiographic setting). Habitats in the study area range from barren areas in the alpine zone to lowland scrub-bog and marsh habitats. The study area is dominated by open and well-drained upland habitats on glacial moraine deposits and alpine habitats on higher elevation slopes and ridges. Two habitat types (Upland Moist Dwarf Scrub and Alpine Moist Dwarf Scrub) account for 52 percent of the study area. Barren habitats in upland and alpine areas cover another seven percent of the area. Willow- and alder-scrub habitats in both low and tall forms are common and occur primarily in protected upland and riverine areas (21 percent of the study area). Wetter low and tall willow-scrub habitats are more rare (2 percent of the study area) and occur in poorly drained lowland areas often adjacent to inactive riverine features. As is typical of other mountainous areas in southwestern Alaska, only small patches of forest habitats occur. Lacustrine waterbodies, wet graminoid-dominated meadows, and shrub-dominated bog habitats occur primarily in lowland and riverine physiographic settings (8 percent of the study area). Marsh habitats are rare and occur along the margins of lakes and ponds. Three prominent riverine corridors (the north and south forks of the Koktuli River and Upper Talarik Creek) occur in the area and support numerous stream channels and associated riverine meadow and scrub vegetation. Many of the streams in the study area support anadromous fish populations and provide foraging opportunities for wildlife.

Habitat-value assessments were made for 38 bird and mammal species of concern (25 birds and 13 mammals) that have been recorded or are strongly expected to occur in the mine study area. These 38 species were selected because of their protected status, conservation concern, sensitive/indicator status, management concern, and/or ecological importance. Habitat values were ranked for the 38 birds and mammals for each of the 25 mapped wildlife habitat types. Habitat values were categorically ranked into four classes (high, moderate, low, and negligible value) based upon project-specific field data whenever possible. When project-specific data were lacking, habitat values were determined by referencing habitat-use information in the scientific literature and/or using professional judgment based on field experience with the species in question in Alaska.

The most species-rich habitats in the mine study area are the open and poorly drained types; three habitats (Lowland Ericaceous Scrub Bog, Lowland Wet Graminoid–Shrub Meadow, and Riverine Wet Graminoid–Shrub Meadow) have the highest numbers of bird and mammal species of concern with moderate- or high-value habitat rankings (19–20 of the 38 species assessed). A diverse set of other habitats including Lakes and Ponds, Lowland Sedge–Forb Marsh, Rivers and Streams (Anadromous), and a variety of dwarf-, low-, and tall-scrub, and forested habitats in upland, lowland, and riverine settings have relatively high numbers of species with moderate- or high-value rankings (13–16 species). Another set of habitats have lower numbers of species with moderate or high habitat rankings (eight–11 species); these habitats include Rivers and Streams, and various dwarf- and tall-scrub, meadow, and forested habitats in upland and alpine settings. A small set of barren habitats in alpine, upland, riverine, and lacustrine areas have the fewest numbers of bird and mammal species with moderate or high habitat rankings (three–six species).

The mine study area provides at least some suitable habitat (moderate and/or high habitat-value rankings) for a set of 13 mammal species (wolf, red fox, river otter, wolverine, brown bear, moose, caribou, arctic ground squirrel, red squirrel, beaver, northern red-backed vole, tundra vole, and snowshoe hare). Brown bears are known to use a wide variety of habitats depending on the season, and 20 habitats were considered to be of moderate value for brown bears; these types are common and widespread in the study area. One habitat (Rivers and Streams [Anadromous]) was considered to be of high value for brown bears because salmon streams are heavily used by foraging bears in late summer. For moose, willow-scrub habitats, riverine forests, and lacustrine waterbodies were considered to be of high value, although moose have been recorded only infrequently in the study area. Other meadow, scrub-bog, marsh, forest, and lacustrine habitats were considered to be of moderate value. Moderate- and high-value moose habitats in the study area are concentrated in stream drainage systems. Caribou pass through the mine study area in mid-summer after calving elsewhere and currently are not known to winter in the area. Because caribou are known only to move through the area, no habitats were considered to be of high value for caribou. However, a set of 14 (primarily open) habitats was considered to be of moderate value for caribou; these habitats are common and widespread in the study area.

For birds, the mine study area provides at least some suitable habitat (moderate and/or high habitat-value rankings) for a set of four tree-nesting raptor species (Bald Eagle, Northern Goshawk, Merlin, Great Horned Owl), three cliff-nesting raptor species (Golden Eagle, Gyrfalcon, Peregrine Falcon), eight waterbird species (Tundra Swan, Harlequin Duck, Surf Scoter, Black Scoter, Long-tailed Duck, Red-throated Loon, Common Loon, Arctic Tern), six shorebird species (American Golden-Plover, Lesser Yellowlegs, Whimbrel, Hudsonian Godwit, Surfbird, Short-billed Dowitcher), and four landbird species (Willow, Ptarmigan, Rock Ptarmigan, Gray-cheeked Thrush, Blackpoll Warbler). Habitats considered suitable for nesting and/or foraging tree-nesting raptors (forests, lacustrine and riverine waterbodies, and some barren habitats) are of limited occurrence in the study area. In contrast, the study area provides abundant (mostly open) habitat for cliff-nesting raptors. Thirteen barren, scrub, forest, meadow, scrub-bog, marsh, riverine, and lacustrine habitats suitable for nesting and/or foraging cliff-nesting raptors are common and widespread in the area.

For breeding and migrant waterbirds, suitable habitats in the study area include lacustrine waterbodies and stream drainages and associated wetland habitats, low and dwarf scrub, riverine forests, marshes, scrub-bogs, and meadows. These habitats are concentrated in the lower elevation headwaters areas of the three major riverine corridors in the study area. Suitable habitats for breeding shorebirds include wet, lowland meadows, scrub-bogs, and marshes, especially when associated with lacustrine or riverine waterbodies. Concentrations of these habitats occur directly north of Frying Pan Lake, in the headwaters of Upper Talarik Creek, and in the complex of waterbodies in the north-central portion of the study area. Well-drained upland and alpine habitats also are used by other shorebird species, and these habitats are widely distributed in the study area. Habitats suitable for breeding landbirds include tall willow and alder scrub in upland, lowland, and riverine areas. In general, these habitats are widely distributed across the study area, although concentrations tend to occur in stream drainage systems. Landbirds also use low- and dwarf-scrub habitats, barrens, scrub-bogs, and forests in a variety of physiographic settings. These habitats occur commonly across the study area.

16.1.9 References

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16.1.10 Glossary

Abiotic—non-biological

Crepuscular—refers to animals that are active during the twilight hours of dusk and dawn

Crustose (lichen)—lichens that grow horizontally, appressed to the growing surface, which is often bare rocks or soil

Epizootic—a disease outbreak affecting many animals at the same time, often with the implication that the disease could be transferred to human populations

Ericaceous—a vascular plant belonging to the family Ericaceae; in Alaska, these plants are typically dwarf or low-growing shrubs with characteristic urn-shaped flowers (e.g., blueberry)

Fluvial—geomorphological features created by rivers and streams; also the processes of landform development through the action of rivers and streams

Foliose (lichen)—lichens that grow in a wavy, leaf-like form elevated above the growing surface

Forb—any herbaceous that is not a graminoid (see definition below)

Fruticose (lichen)—lichens that grow erect in a shrub-like form with branching stalks

Graminoid—grass and grass-like plants (including sedges and rushes)

Lacustrine—associated with lakes and ponds and landscape features derived from the development of lakes and ponds

Locomotion— in the limited sense used here, a biological term for the movement of animals across the surface of the ground

Mesic—moderately moist conditions, not wet and not dry

Monocotelydon—one of the two major groups of flowering plants; monocotelydonous plants are characterized by one leaf in the embryonic stage; in Alaska, most “monocots” are grass or grass-like plants (e.g., sedges and rushes, but also lilies and irises)

Oestrid (fly)—a fly in the Oestridae (warble and bot fly) family; the larvae of these flies are obligate parasites that develop in mammalian tissue; in Alaska, oestrid flies are notorious for infecting caribou

Orthophoto—a digital image of an aerial photo in which corrections have been to account for the camera angle and curvature of the earth so as to accurately represent the area displayed on a flat plane (i.e., computer screen)

Parturition—in mammalian species, the process of giving birth to offspring

Phenology—the study of recurring biological phenomena in plant and animal species due to changing weather conditions (e.g., seasonal changes in plant growth)

Photo signature—in the limited sense used here, a combination of color and texture on an aerial photo indicative of a particular vegetation, physiographic, or surface-form type

Physiography—in the limited sense used here, a categorization of landforms/topographic regions into classes, which are based largely on the geomorphological forces shaping the landforms in those areas (e.g., alpine, upland, lowland, lacustrine [see above], and riverine [see below])

Rhizomatous—refers to a vascular plant that produces rhizomes (horizontal stems that often grow underground)

Riverine—associated with rivers and streams and landscape features developed from the actions of rivers and streams

TABLES

TABLE 16.1-1
Criteria for the Selection of Bird and Mammal Species for Habitat-value Assessments, Mine Study Area, 2010

Common Name	Scientific Name	Protected Species [a]	Conserv. Concern [b]	Sensitive Species [c]	Manage. Concern [d]	Ecol. Important [e]
Birds						
Tundra Swan	*Cygnus columbianus*			X		
Harlequin Duck	*Histrionicus histrionicus*			X		
Surf Scoter	*Melanitta perspicillata*		X		X	
Black Scoter	*Melanitta americana*		X		X	
Long-tailed Duck	*Clangula hyemalis*		X		X	
Willow Ptarmigan	*Lagopus lagopus*				X	
Rock Ptarmigan	*Lagopus muta*				X	
Red-throated Loon	*Gavia stellata*		X			
Common Loon	*Gavia immer*			X		
Bald Eagle	*Haliaeetus leucocephalus*	X				
Northern Goshawk	*Accipiter gentilis*					X
Golden Eagle	*Aquila chrysaetos*	X				
Merlin	*Falco columbarius*					X
Gyrfalcon	*Falco rusticolus*		X			
Peregrine Falcon	*Falco peregrinus*		X			
American Golden-Plover	*Pluvialis dominica*		X			
Lesser Yellowlegs	*Tringa flavipes*		X			
Whimbrel	*Numenius phaeopus*		X			
Hudsonian Godwit	*Limosa haemastica*		X			
Surfbird	*Aphriza virgata*		X			
Short-billed Dowitcher	*Limnodromus griseus*		X			
Arctic Tern	*Sterna paradisaea*		X			
Great Horned Owl	*Bubo virginianus*					X
Gray-cheeked Thrush	*Catharus minimus*		X			
Blackpoll Warbler	*Dendroica striata*		X			
Mammals						
Wolf	*Canis lupus*				X	X
Red fox	*Vulpes vulpes*					X
River otter	*Lontra canadensis*				X	
Wolverine	*Gulo gulo*				X	

Common Name	Scientific Name	Protected Species [a]	Conserv. Concern [b]	Sensitive Species [c]	Manage. Concern [d]	Ecol. Important [e]
Brown bear	*Ursus arctos*				X	X
Moose	*Alces alces*				X	X
Caribou	*Rangifer tarandus*				X	X
Arctic ground squirrel	*Spermophilus parryii*				X	X
Red squirrel	*Tamiasciurus hudsonicus*					X
Beaver	*Castor canadensis*				X	X
Northern red-backed vole	*Myodes rutilus*					X
Tundra vole	*Microtus oeconomus*					X
Snowshoe hare	*Lepus americanus*				X	X

Notes:

a. Legally protected under the Bald and Golden Eagle Protection Act.

b. Species is of conservation concern (see Chapter 17 for more information).

c. Species is sensitive to human disturbance and development in freshwater habitats and serves as an indicator of environmental health.

d. Species is of management concern for subsistence and/or sport hunting/trapping.

e. Ecologically important as predator or prey (not otherwise represented by another species under one of the other criteria above) or because of other prominent ecosystem effects.

TABLE 16.1-2
Wildlife Habitat-value Categories, Mine Study Area, 2010

Wildlife Group	Value Class	Ranking Score	Description
Birds	High value	3	Known to be frequently used for nesting and/or foraging during the breeding season; these habitats are also often used during migration
	Moderate value	2	Moderate-value habitats would be regularly used during the breeding and/or migration seasons but less so than high-value habitats
	Low value	1	Low-value habitats would see little use by the species under consideration
	Negligible value	0	The species is not expected to occur, or will occur very rarely, in negligible-value habitats
Mammals	High value	3	Known to be frequently used for breeding, calving, denning, etc., and/or foraging during critical seasons
	Moderate value	2	Moderate-value habitats would be regularly used (e.g., especially for foraging) but less so than high-value habitats
	Low value	1	Low-value habitats would see little use by the species under consideration
	Negligible value	0	The species is not expected to occur, or will occur very rarely, in negligible-value habitats

TABLE 16.1-3
Areas (Square Kilometers) and Relative Abundance (Percent of Study Area) for Mapped Wildlife Habitat Types, Mine Study Area, 2010

Habitat Type	Area (Square Kilometers)	Percent of Study Area
Alpine Dry Barrens	31.68	6.66
Alpine Moist Dwarf Scrub	115.75	24.33
Alpine Moist Graminoid–Forb Meadow	7.46	1.57
Alpine Wet Dwarf Shrub–Sedge Scrub	4.27	0.90
Upland Dry Barrens	3.18	0.67
Upland Dry Dwarf Shrub-Lichen Scrub	31.04	6.53
Upland Moist Dwarf Scrub	130.00	27.33
Upland Moist Low Willow Scrub	26.54	5.58
Upland Moist Tall Alder Scrub	29.00	6.10
Upland Moist Tall Willow Scrub	27.09	5.69
Upland and Lowland Spruce Forest	0.03	0.01
Upland and Lowland Moist Mixed Forest	0.24	0.05
Rivers and Streams	1.14	0.24
Rivers and Streams (Anadromous)	1.39	0.29
Riverine Barrens	0.15	0.03
Riverine Wet Graminoid–Shrub Meadow	5.54	1.16
Riverine Low Willow Scrub	6.37	1.34
Riverine Tall Alder or Willow Scrub	10.92	2.30
Riverine Moist Mixed Forest	0.39	0.08
Lakes and Ponds	8.24	1.73
Lacustrine Moist Barrens	0.42	0.09
Lowland Sedge–Forb Marsh	0.44	0.09
Lowland Ericaceous Scrub Bog	9.38	1.97
Lowland Wet Graminoid–Shrub Meadow	13.68	2.87
Lowland Low and Tall Willow Scrub	11.37	2.39
Total	**475.72**	**100.00**

FIGURES

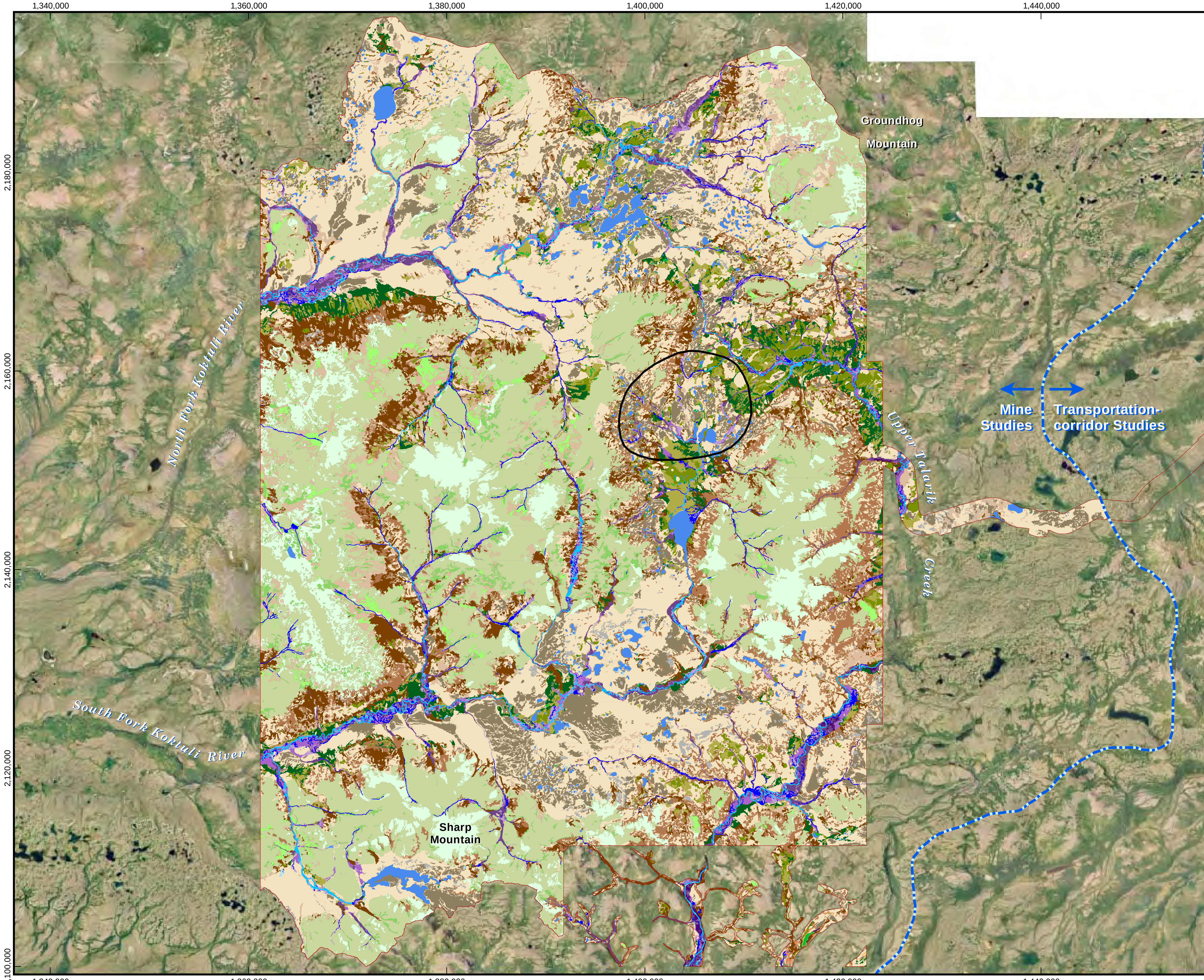

Figure 16.1-1
Overview of Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

- Mapping Area
- General Deposit Location

Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

Miles: 0 0.5 1 1.5 2 2.5
Kilometers: 0 1 2 3 4

Scale 1:120,000

N

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

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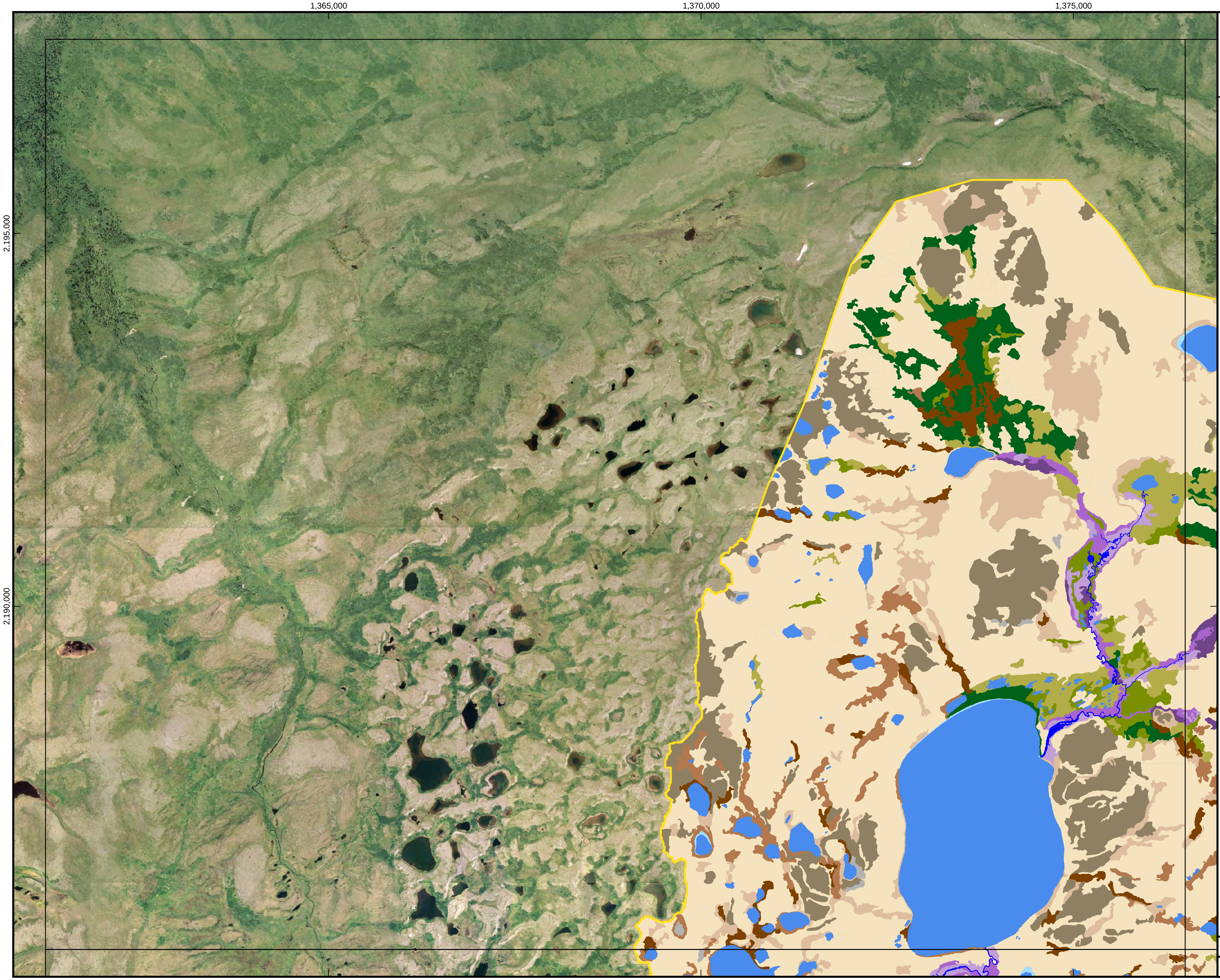

See Tile 5

THE pebble PARTNERSHIP

Figure 16.1-2a Wildlife Habitat Mapping, Mine Study Area

Legend

Wildlife Habitats – Tile 1

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

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Version: 2	Author: ABR-AZC

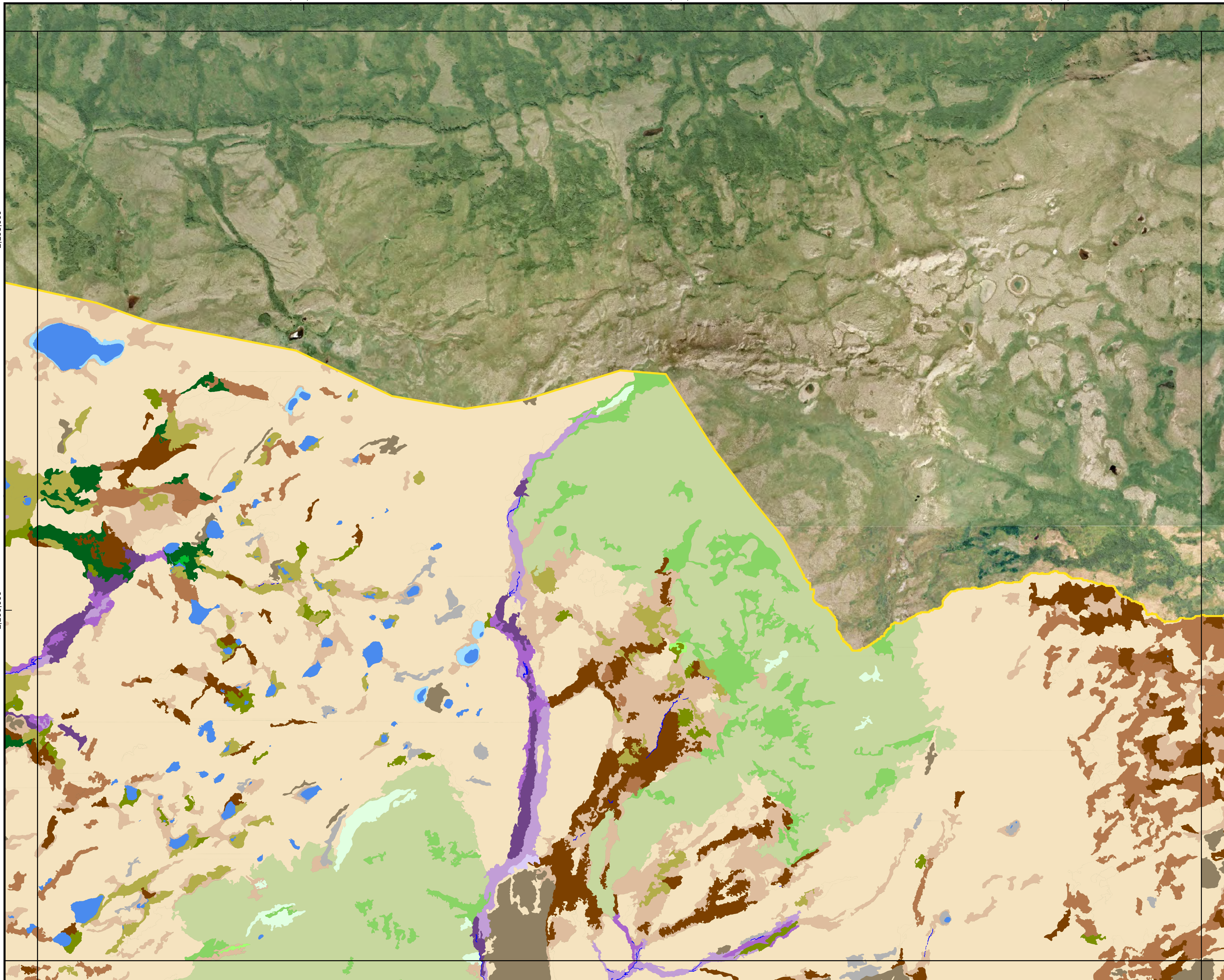


Figure 16.1-2b
Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP

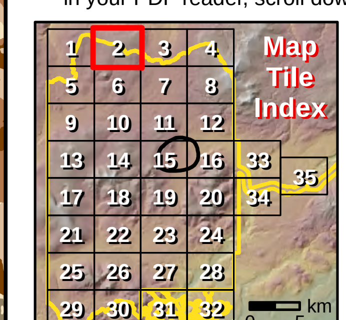
Legend

Wildlife Habitats – Tile 2

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area　Map Tile　General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

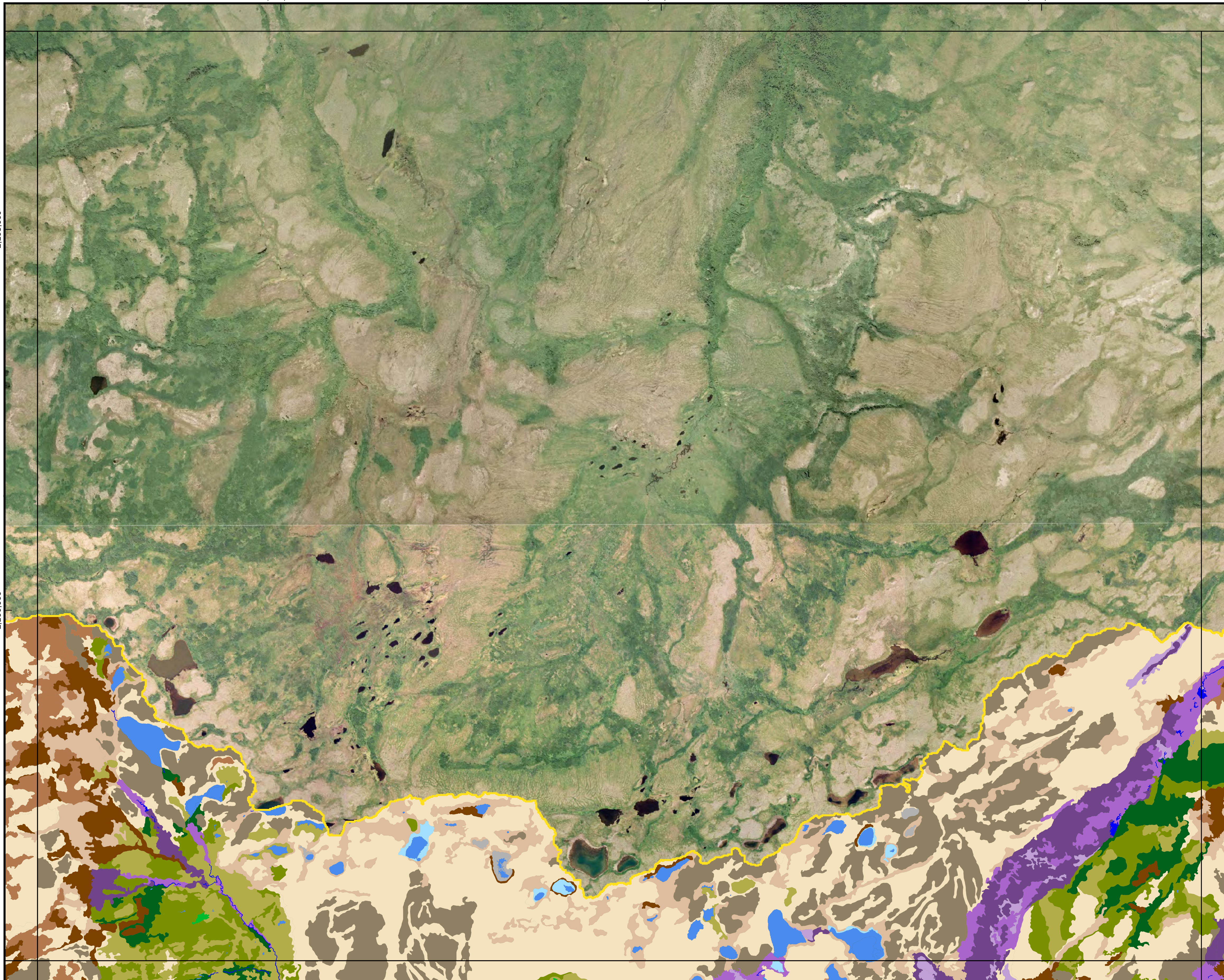


Figure 16.1-2c
Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats – Tile 3

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

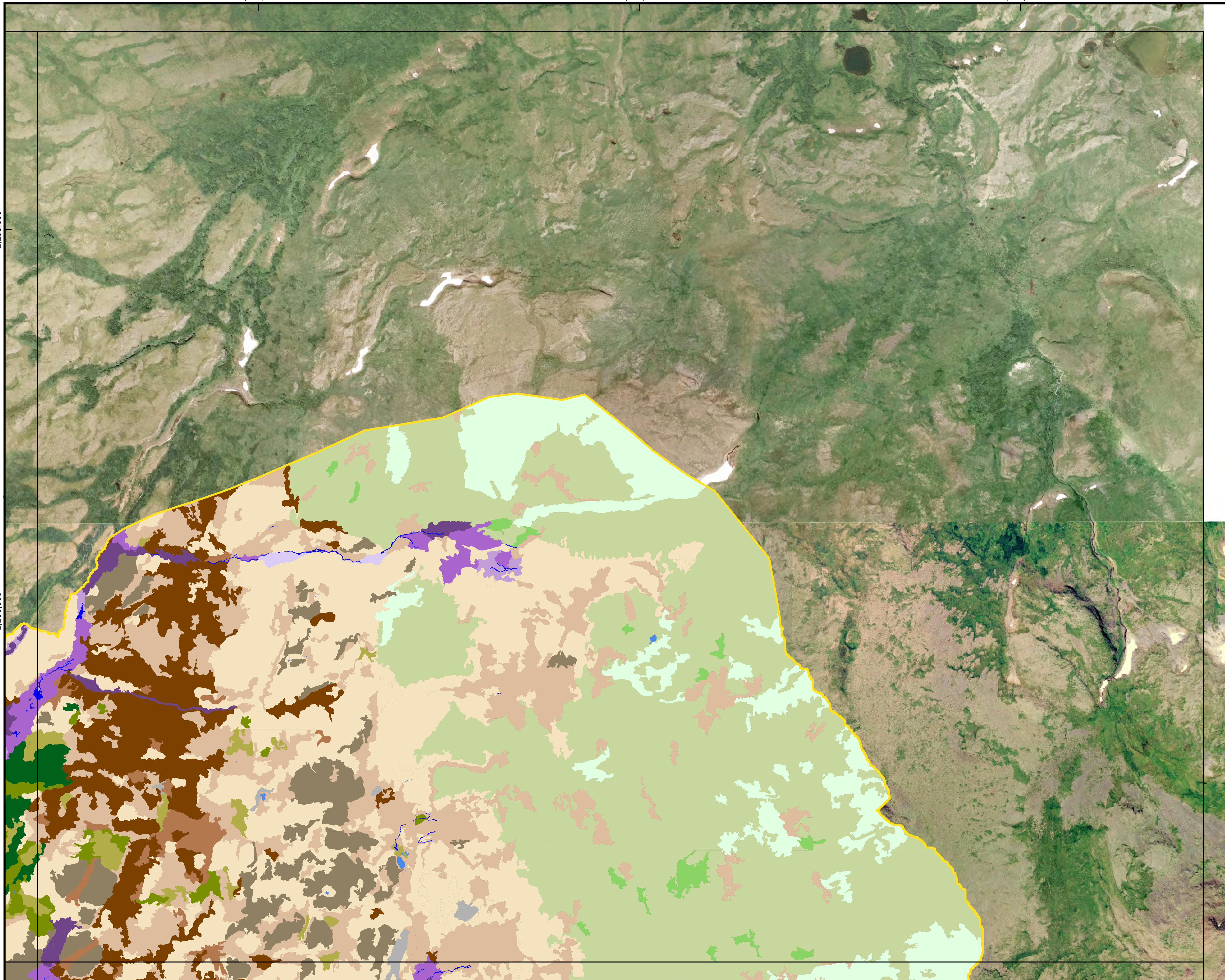
Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

Figure 16.1-2d
Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP



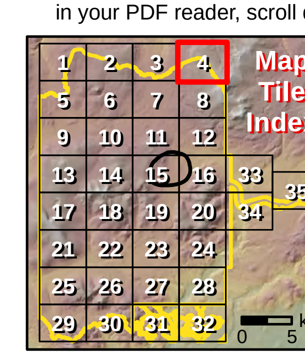
Legend

Wildlife Habitats – Tile 4

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

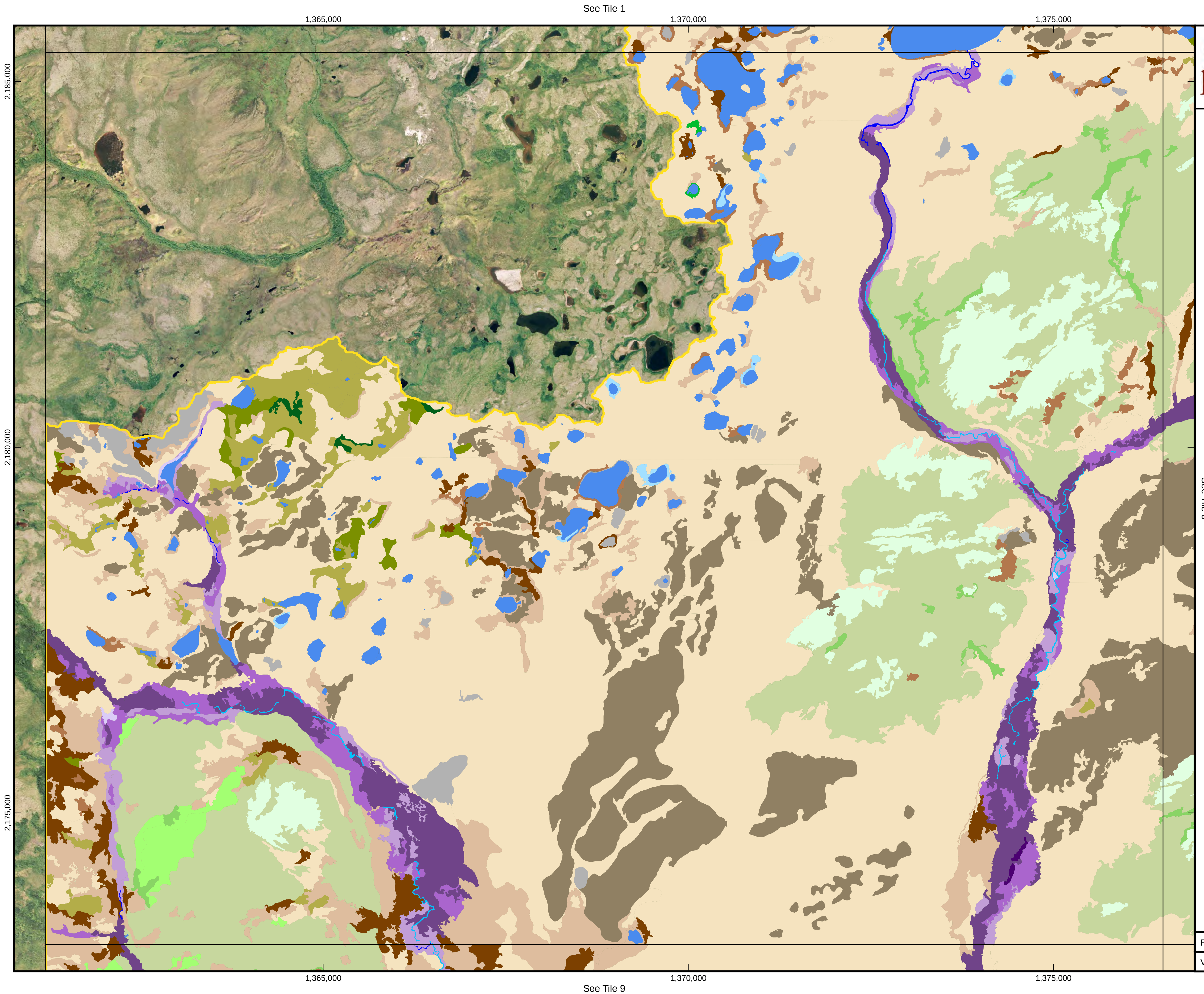
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

Figure 16.1-2e
Wildlife Habitat Mapping, Mine Study Area



Legend

Wildlife Habitats – Tile 5

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0, 500, 1,000, 1,500, 2,000

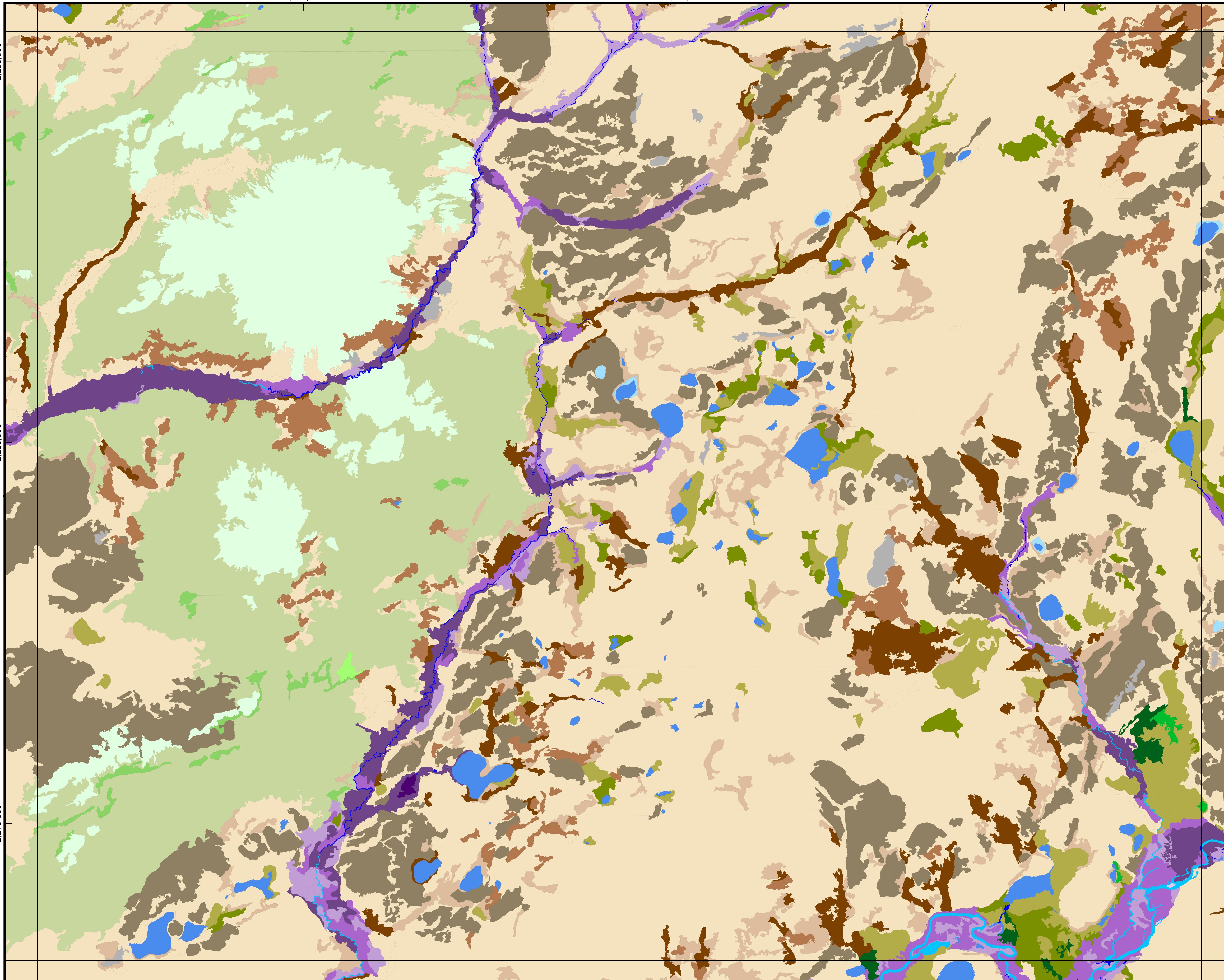
Meters: 0, 200, 400, 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

Figure 16.1-2f
Wildlife Habitat Mapping, Mine Study Area



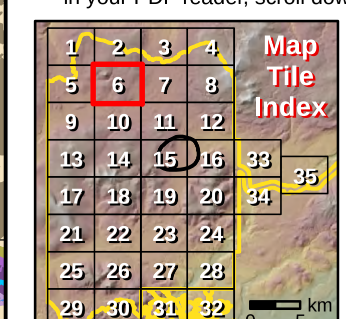
Legend

Wildlife Habitats – Tile 6

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

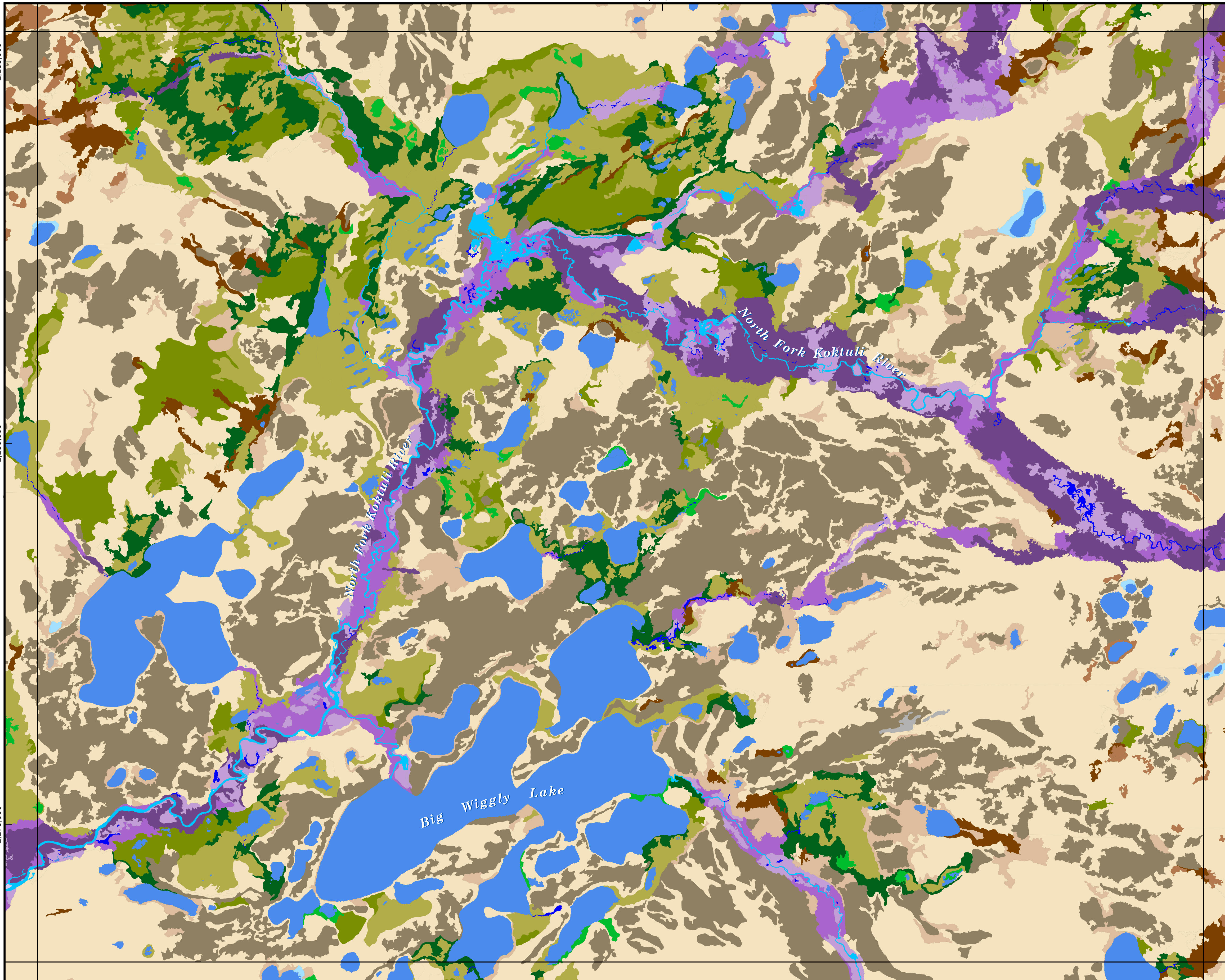
Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.1-2g
Wildlife Habitat Mapping, Mine Study Area

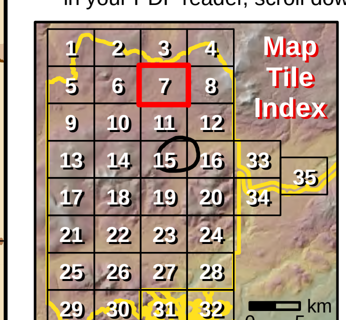
Legend

Wildlife Habitats – Tile 7

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

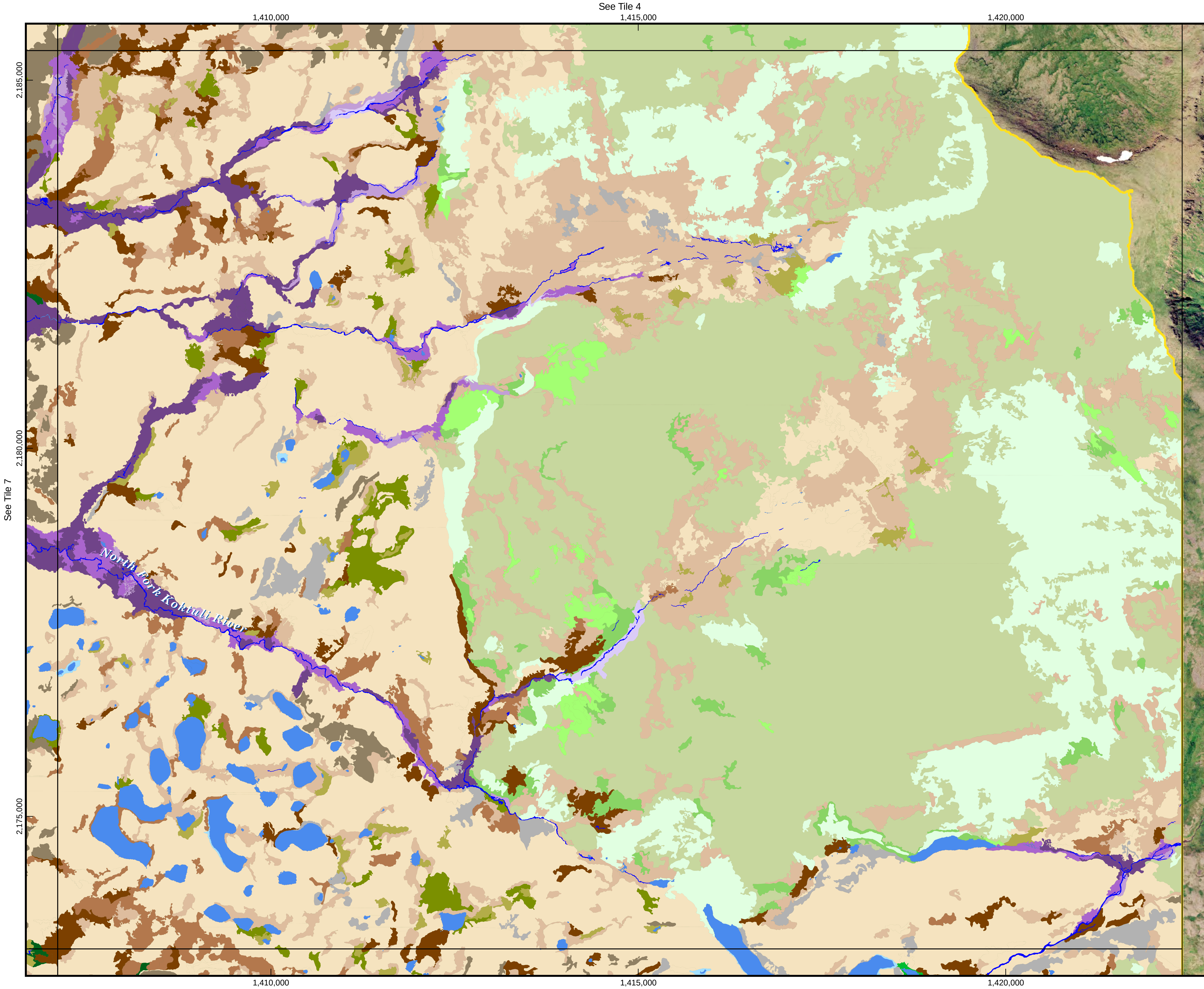


Figure 16.1-2h
Wildlife Habitat Mapping, Mine Study Area

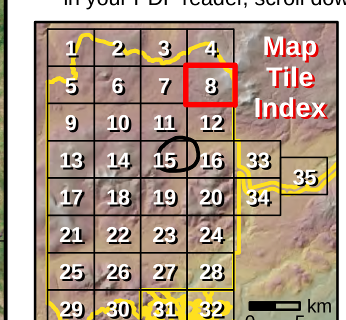
Legend

Wildlife Habitats – Tile 8

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

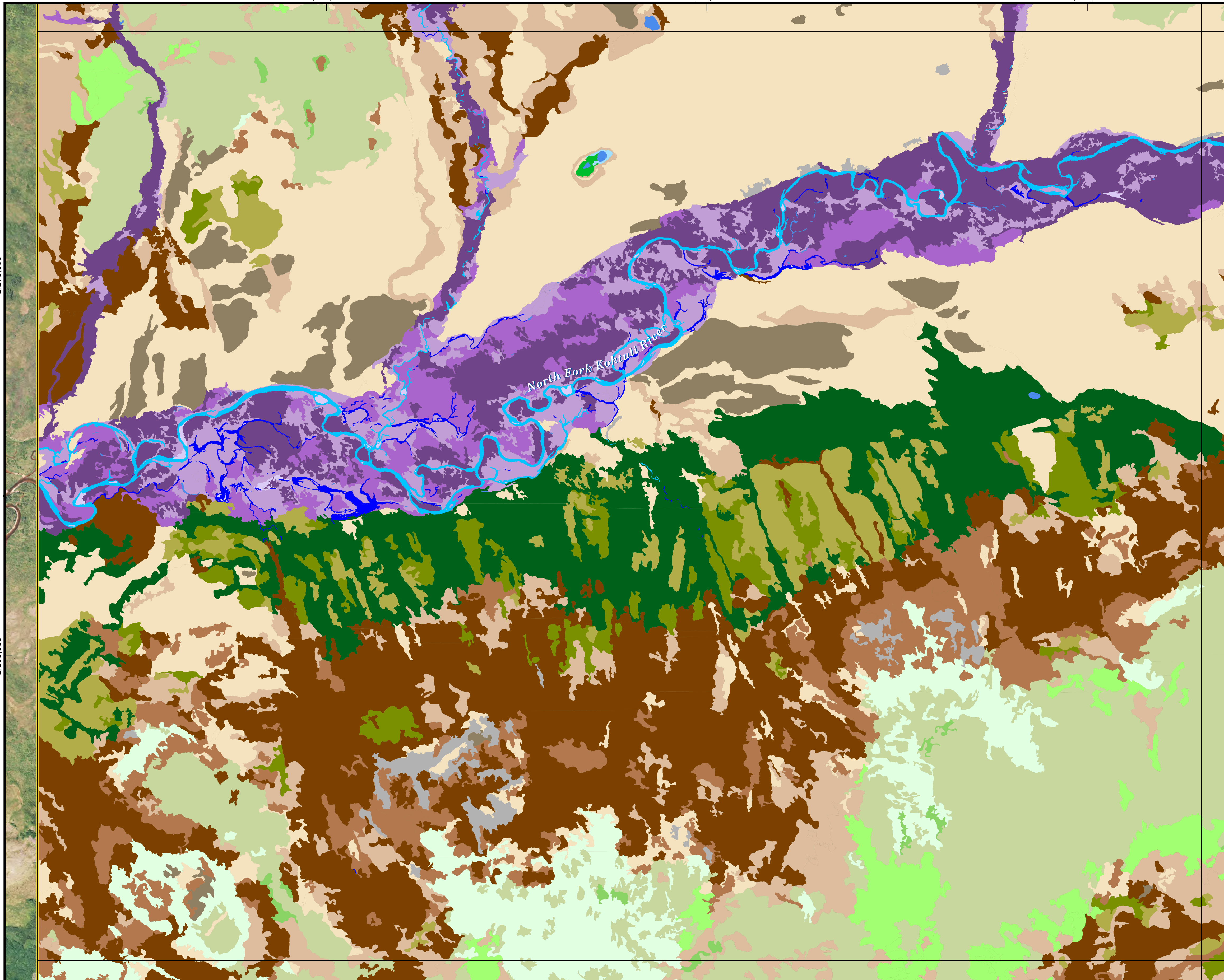
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

See Tile 5



See Tile 13

Figure 16.1-2i Wildlife Habitat Mapping, Mine Study Area

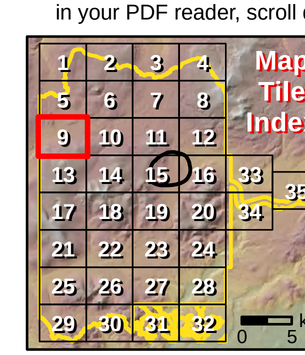
Legend

Wildlife Habitats – Tile 9

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

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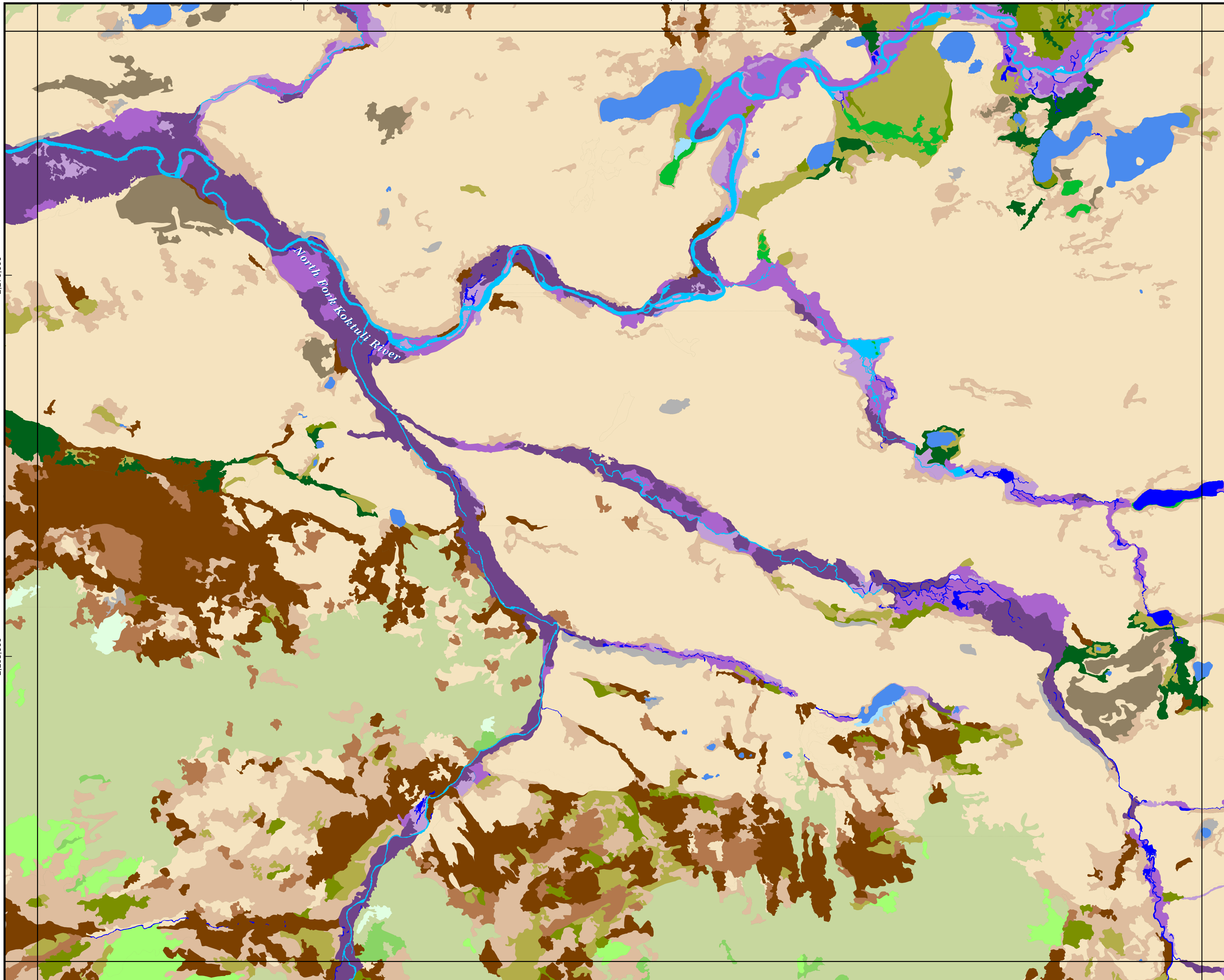
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.1-2j
Wildlife Habitat Mapping, Mine Study Area

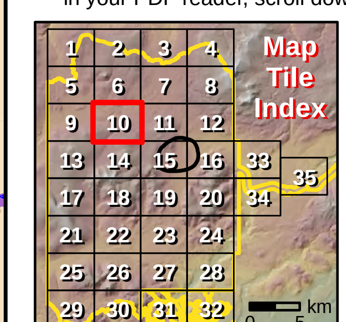
Legend

Wildlife Habitats – Tile 10

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

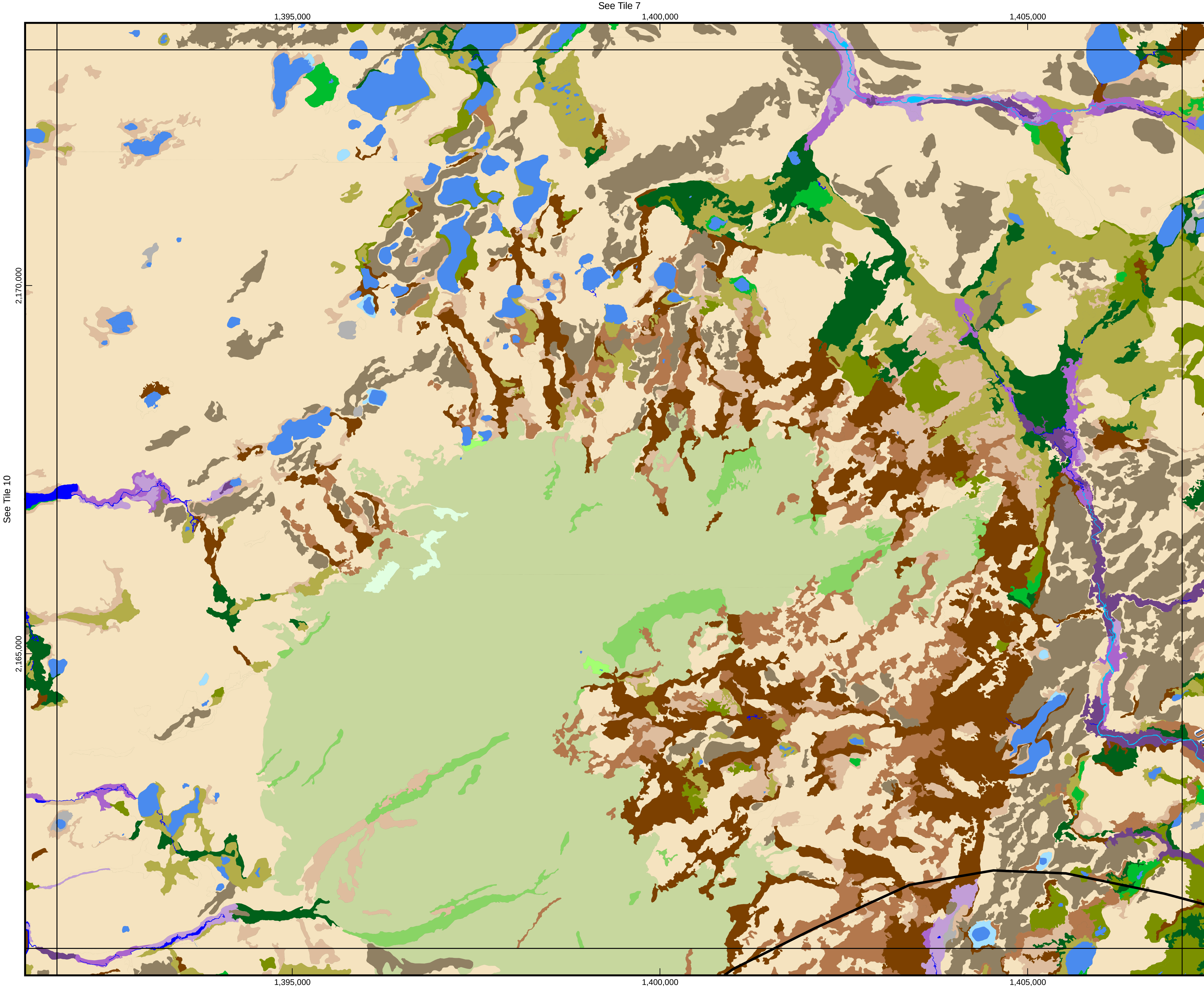
Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.1-2k
Wildlife Habitat Mapping, Mine Study Area

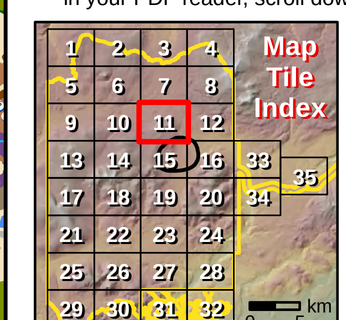
Legend

Wildlife Habitats – Tile 11

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

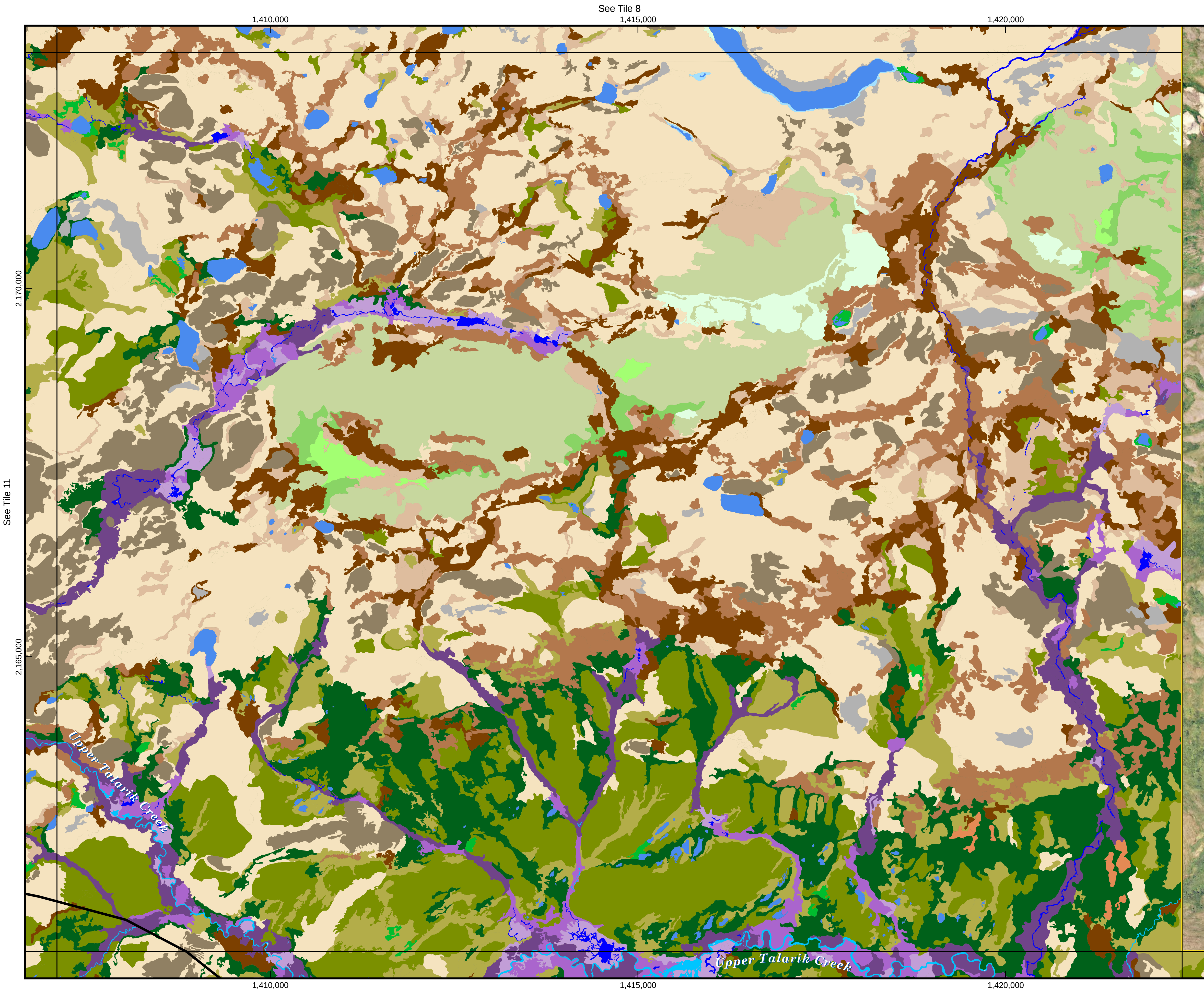
Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.1-2l
Wildlife Habitat Mapping, Mine Study Area

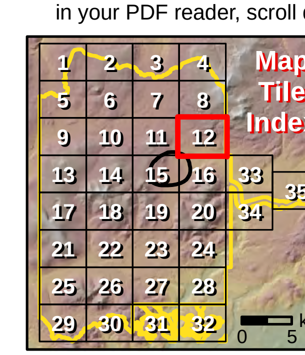
Legend

Wildlife Habitats – Tile 12

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0, 500, 1,000, 1,500, 2,000

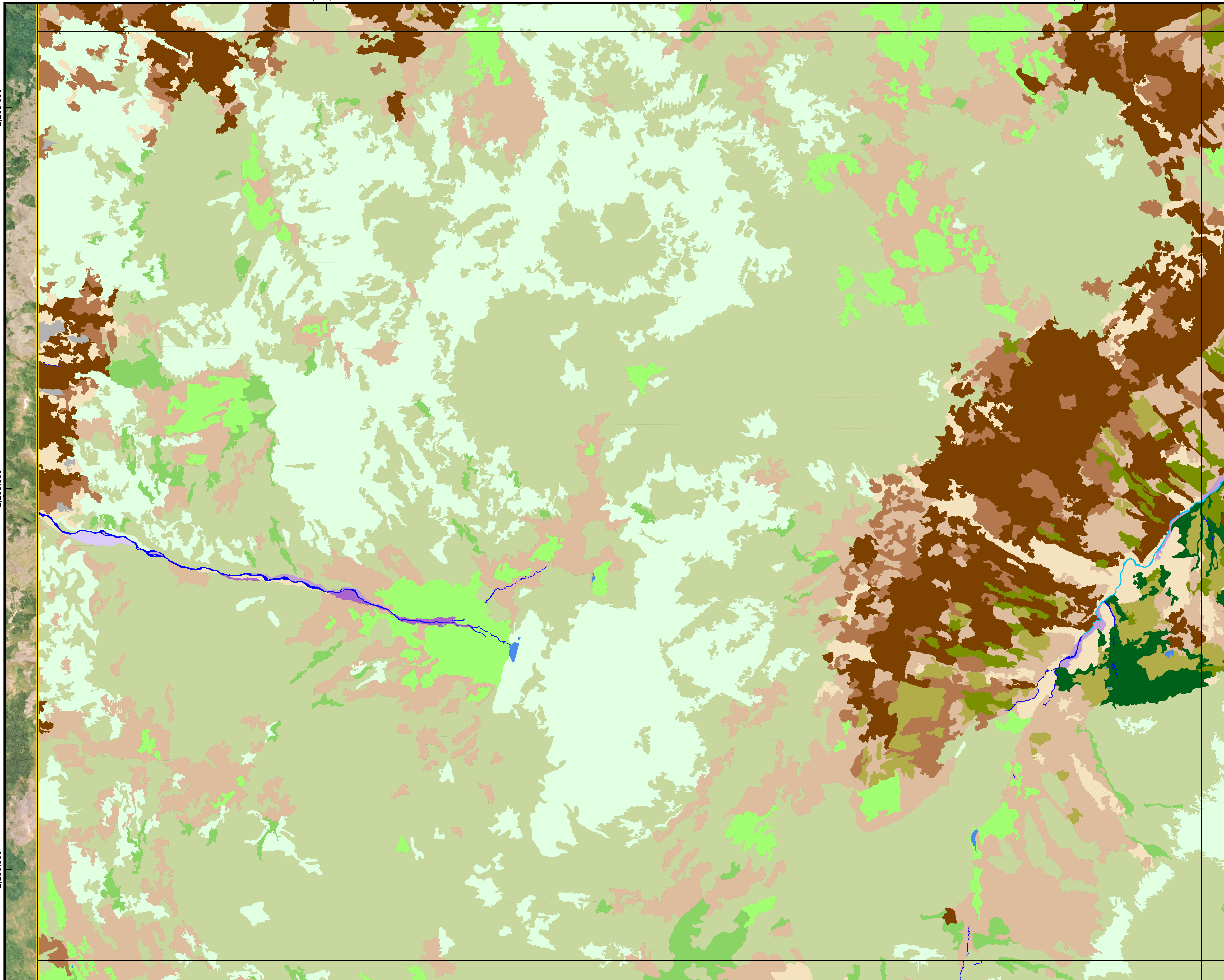
Meters: 0, 200, 400, 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

See Tile 9



See Tile 17

Figure 16.1-2m
Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats – Tile 13

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0, 500, 1,000, 1,500, 2,000
Meters: 0, 200, 400, 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

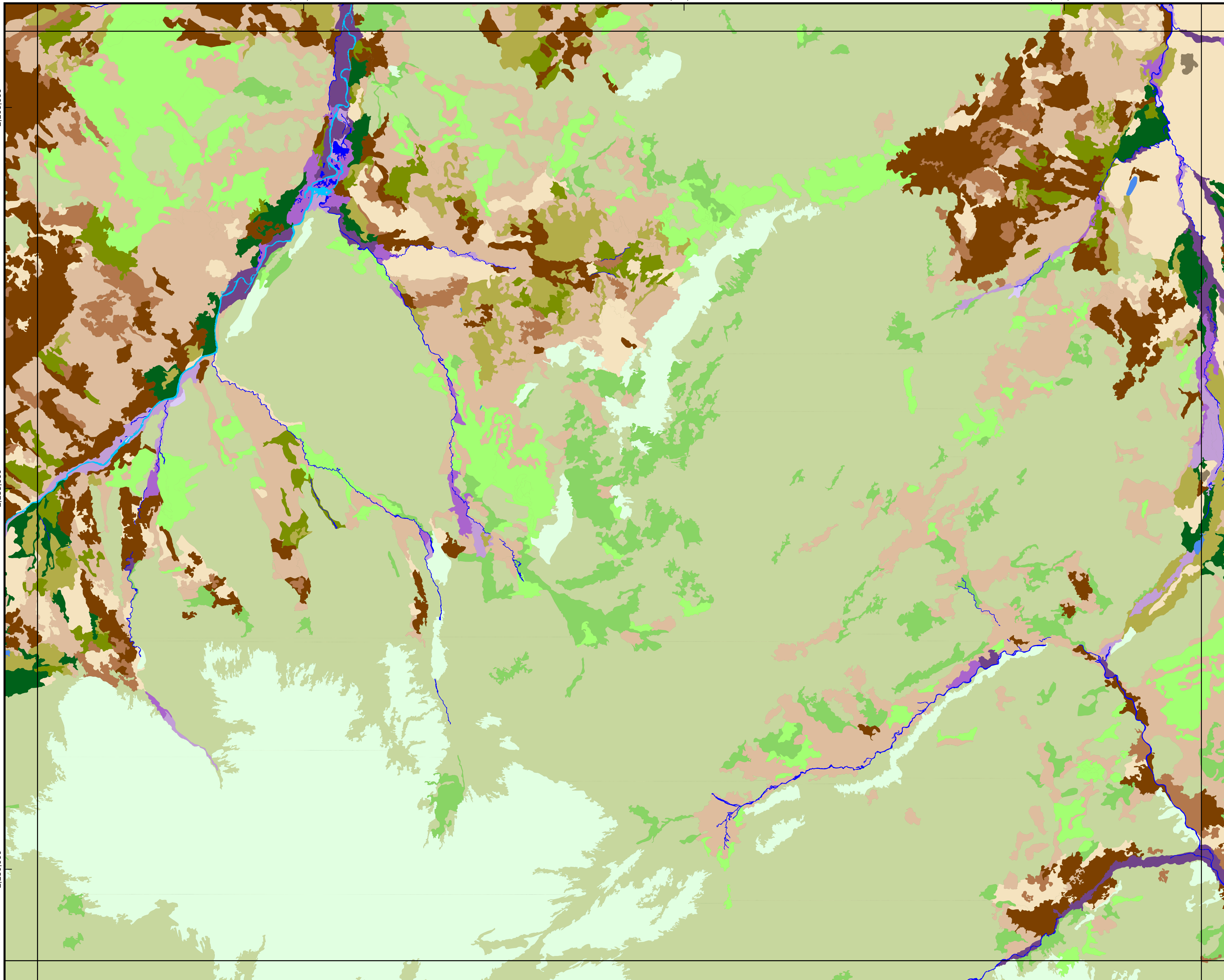


Figure 16.1-2n
Wildlife Habitat Mapping, Mine Study Area

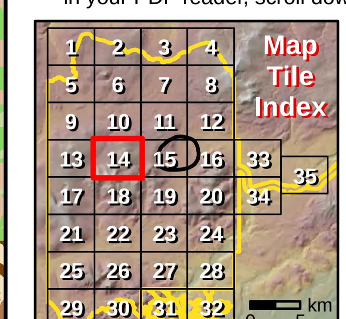
Legend

Wildlife Habitats – Tile 14

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

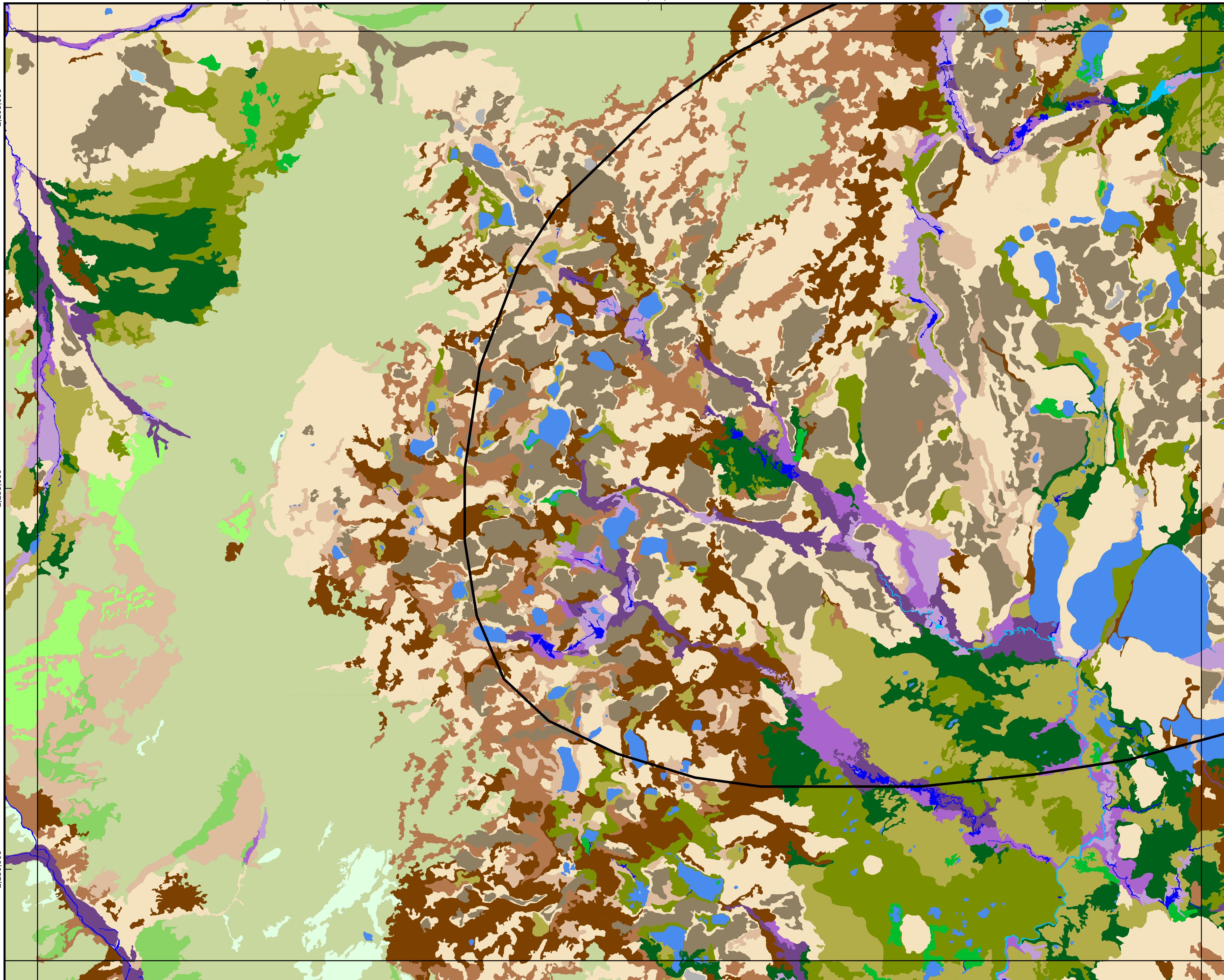


Figure 16.1-2o
Wildlife Habitat Mapping, Mine Study Area

Legend

Wildlife Habitats – Tile 15

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area Map Tile General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

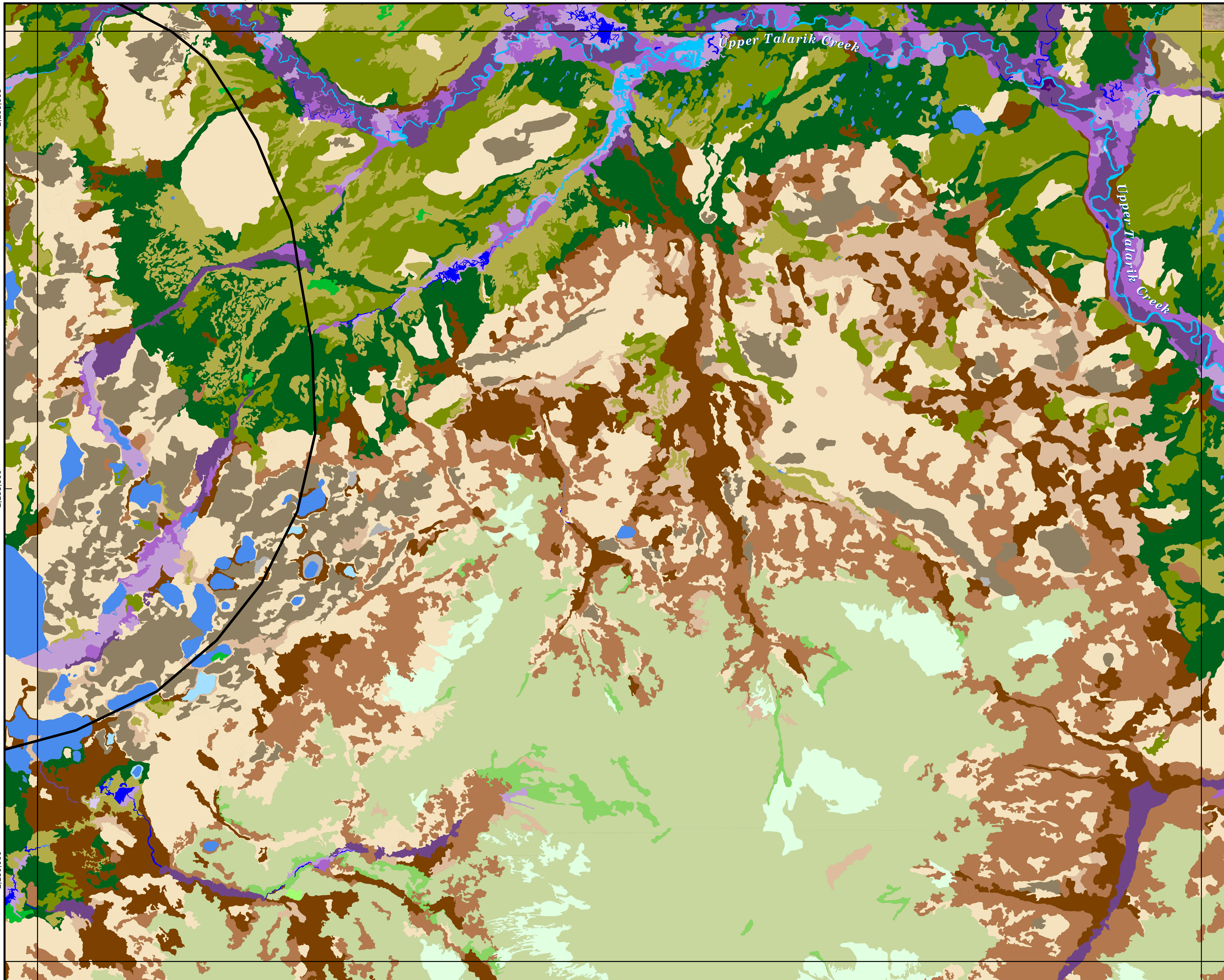
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

See Tile 12



See Tile 20

THE pebble PARTNERSHIP

Figure 16.1-2p Wildlife Habitat Mapping, Mine Study Area

Legend

Wildlife Habitats – Tile 16

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

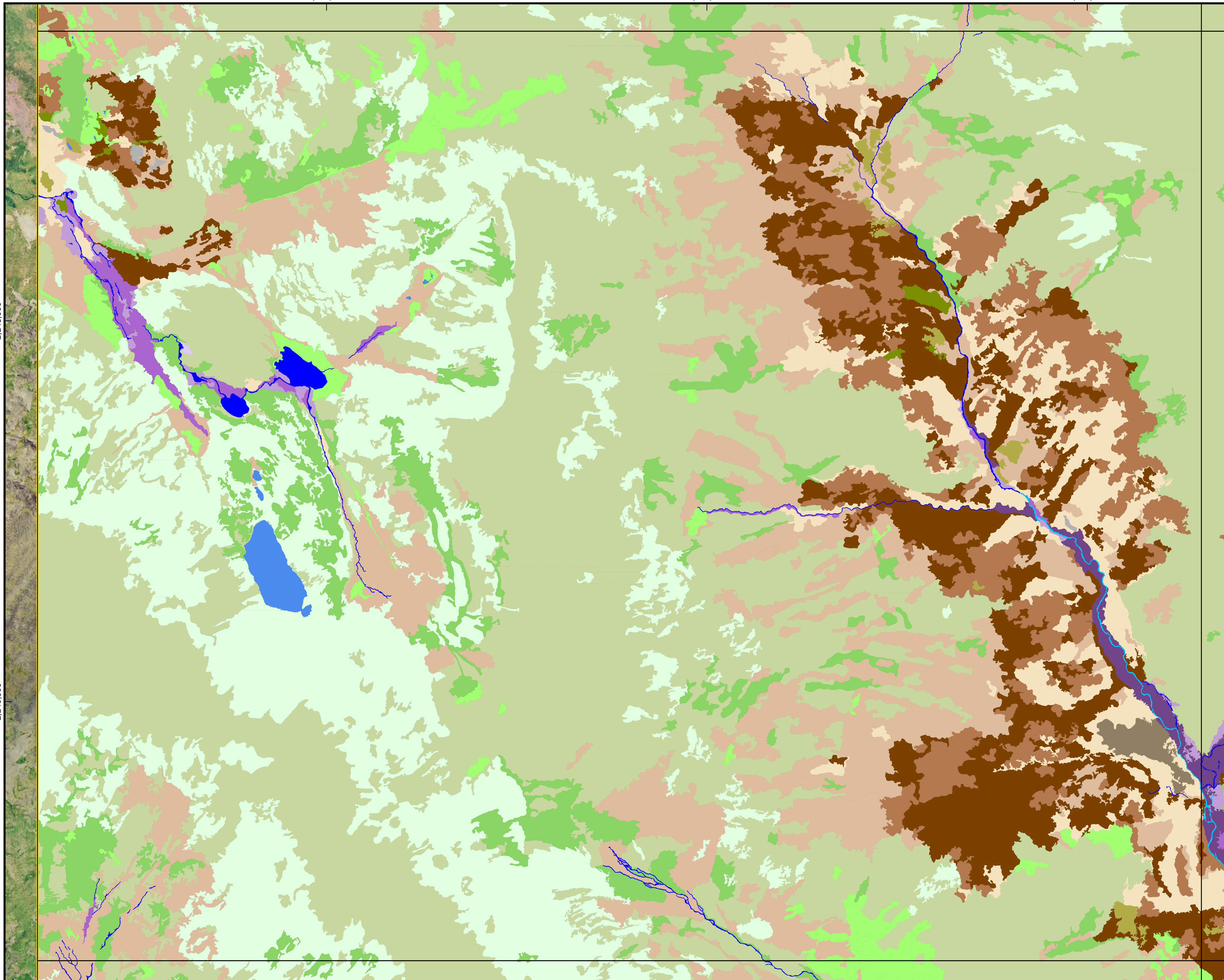
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

See Tile 13



See Tile 21

THE pebble PARTNERSHIP

Figure 16.1-2q
Wildlife Habitat Mapping, Mine Study Area

Legend

Wildlife Habitats – Tile 17

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

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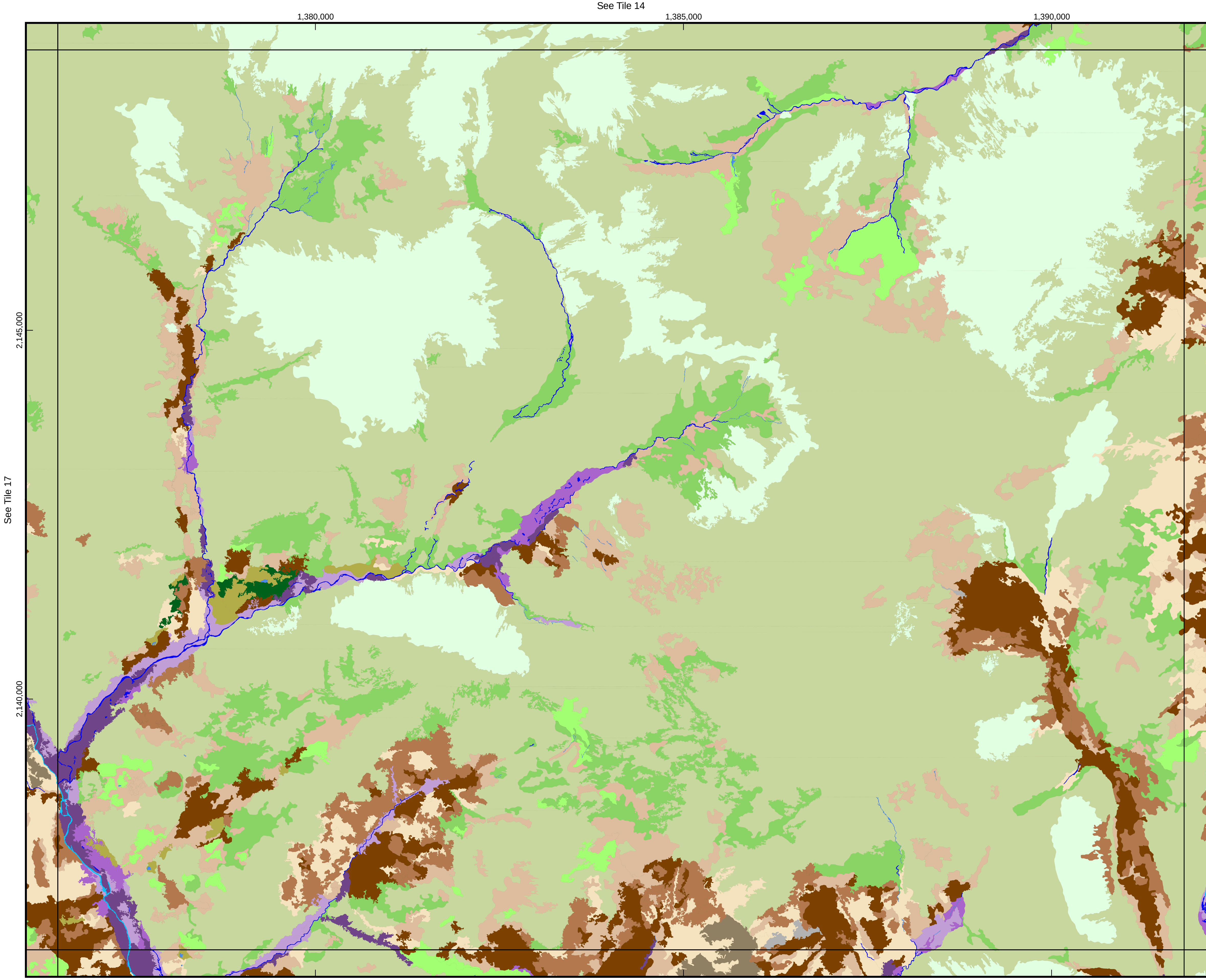
Version: 2	Author: ABR-AZC

See Tile 14



See Tile 22

Figure 16.1-2r
Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP

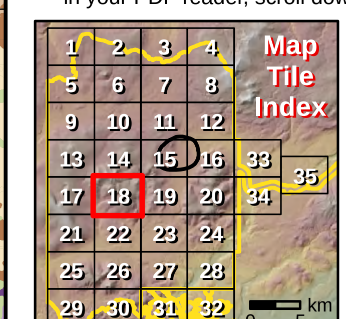
Legend

Wildlife Habitats – Tile 18

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

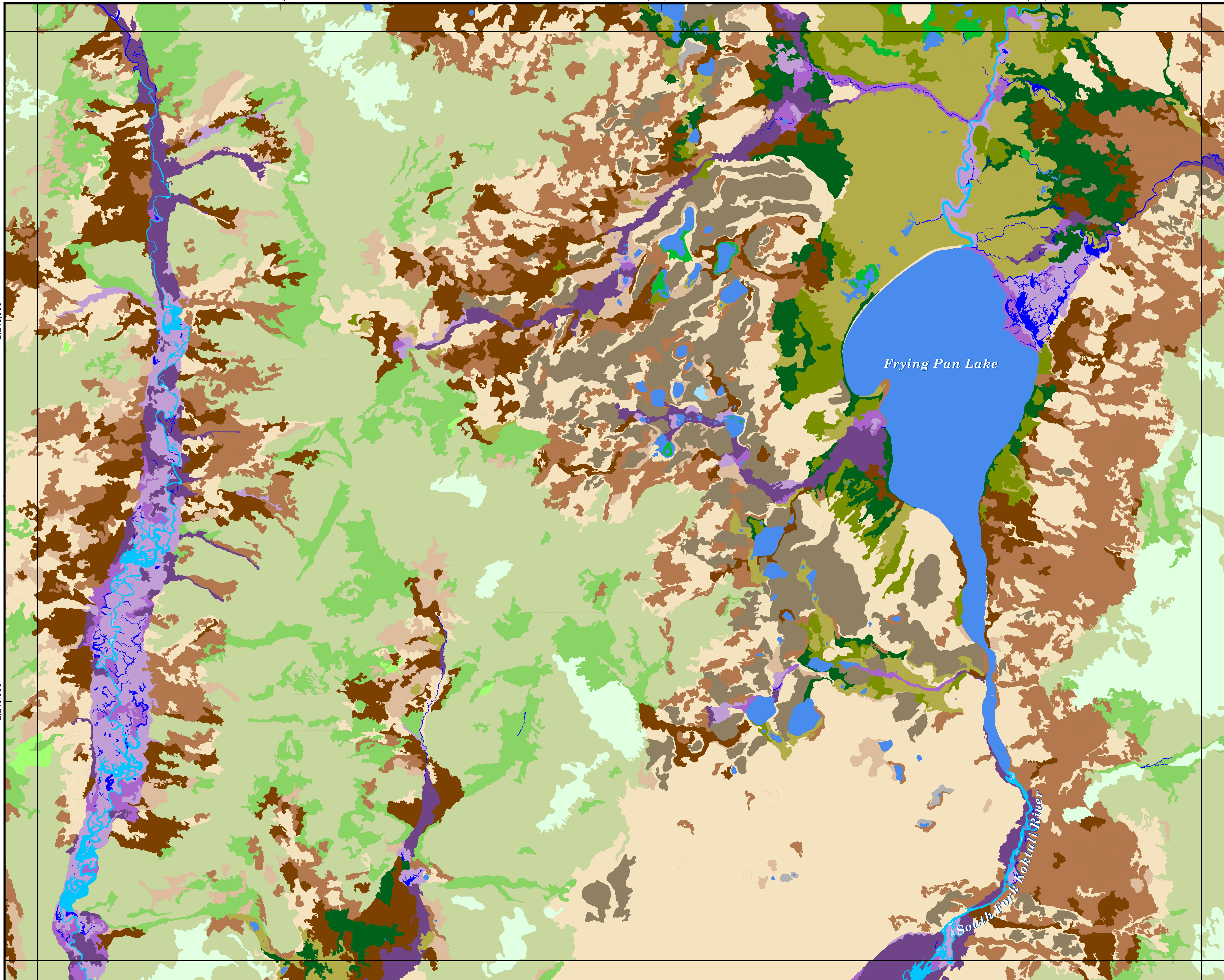
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

See Tile 15



See Tile 23

THE pebble PARTNERSHIP

Figure 16.1-2s Wildlife Habitat Mapping, Mine Study Area

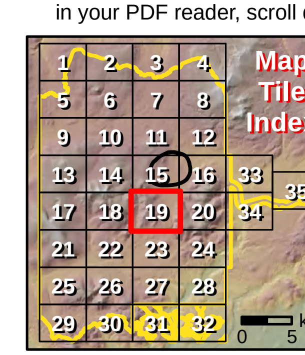
Legend

Wildlife Habitats – Tile 19

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

Scale 1:16,000

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

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Version: 2	Author: ABR-AZC

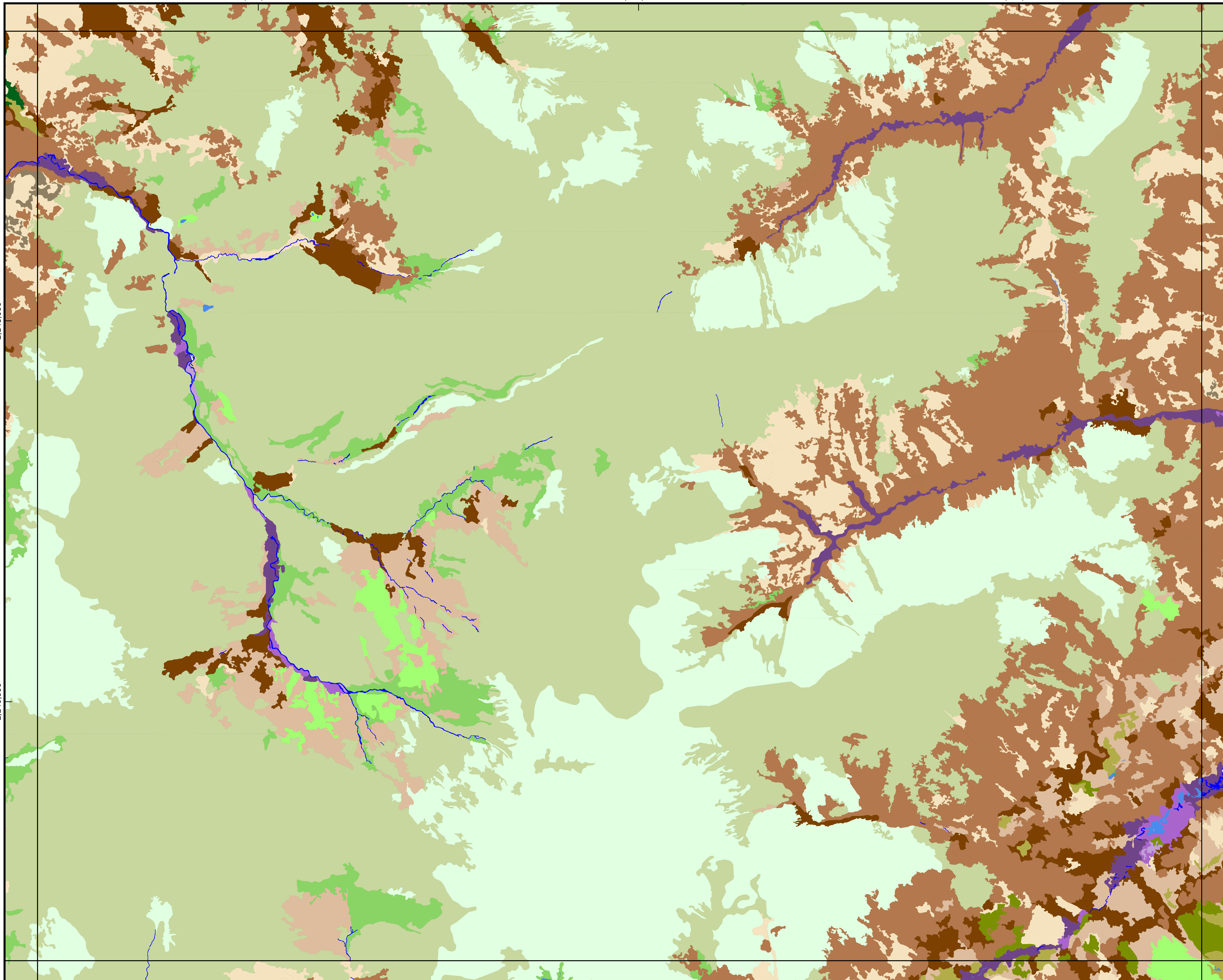


Figure 16.1-2t
Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats – Tile 20

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

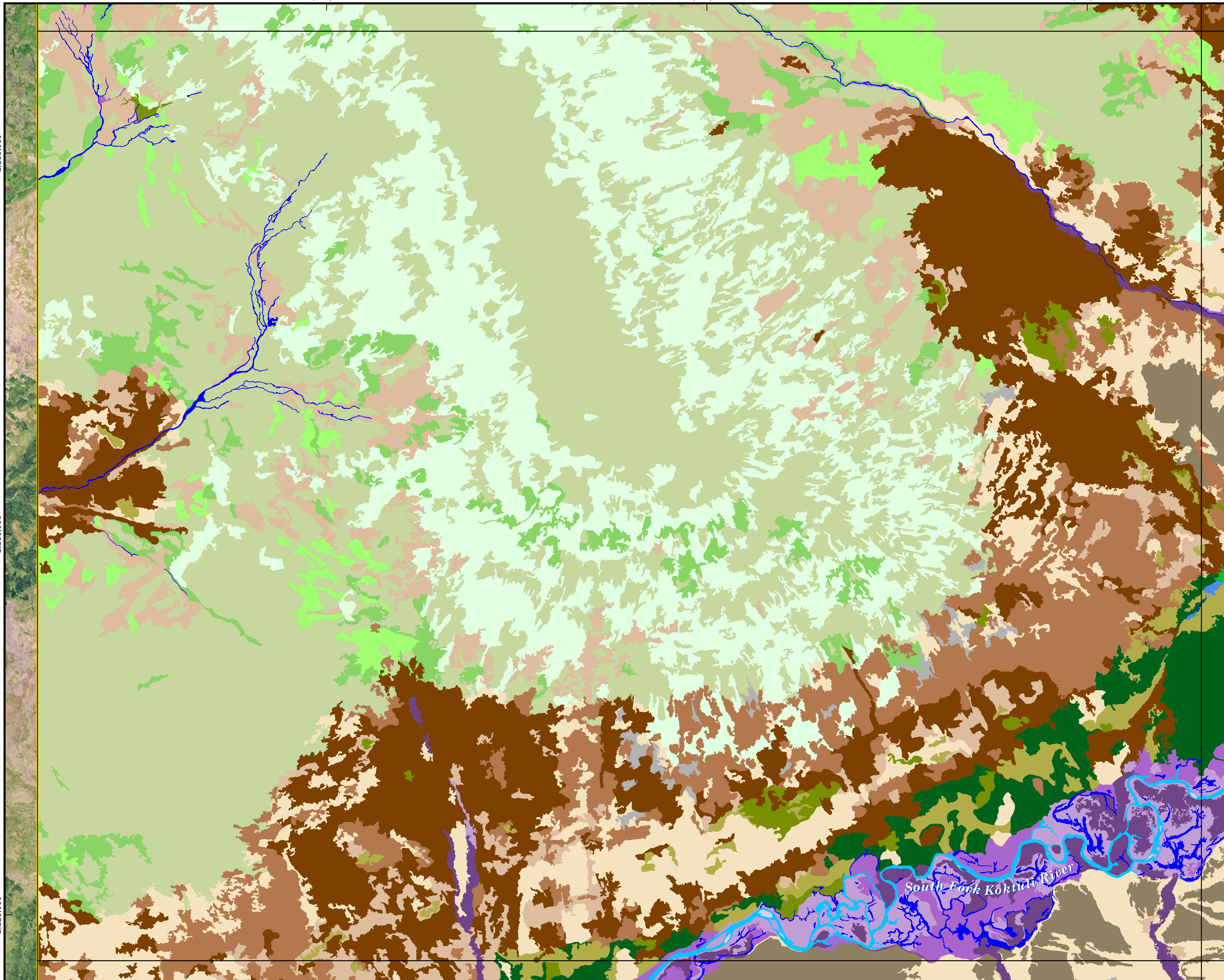
Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.1-2u
Wildlife Habitat Mapping, Mine Study Area

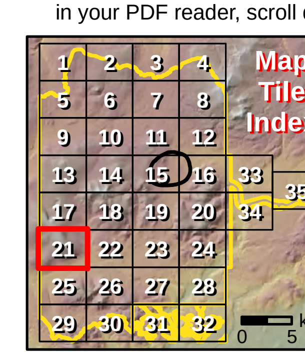
Legend

Wildlife Habitats – Tile 21

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

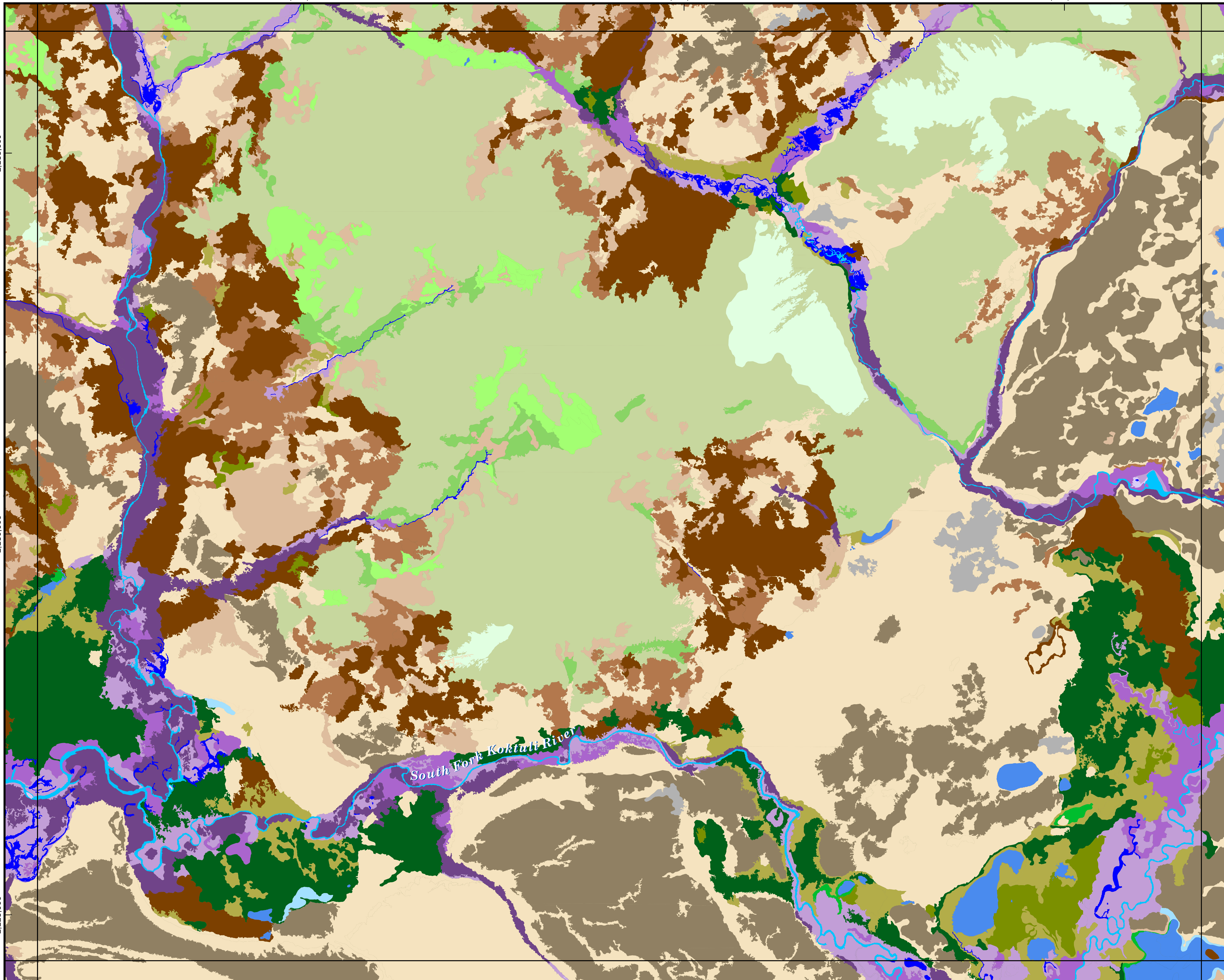
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

See Tile 18



See Tile 26

THE pebble PARTNERSHIP

Figure 16.1-2v
Wildlife Habitat Mapping, Mine Study Area

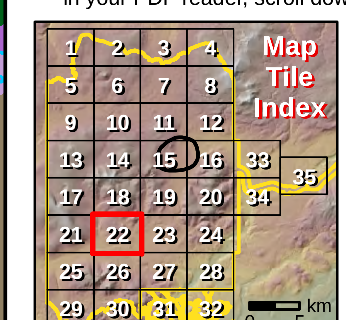
Legend

Wildlife Habitats – Tile 22

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

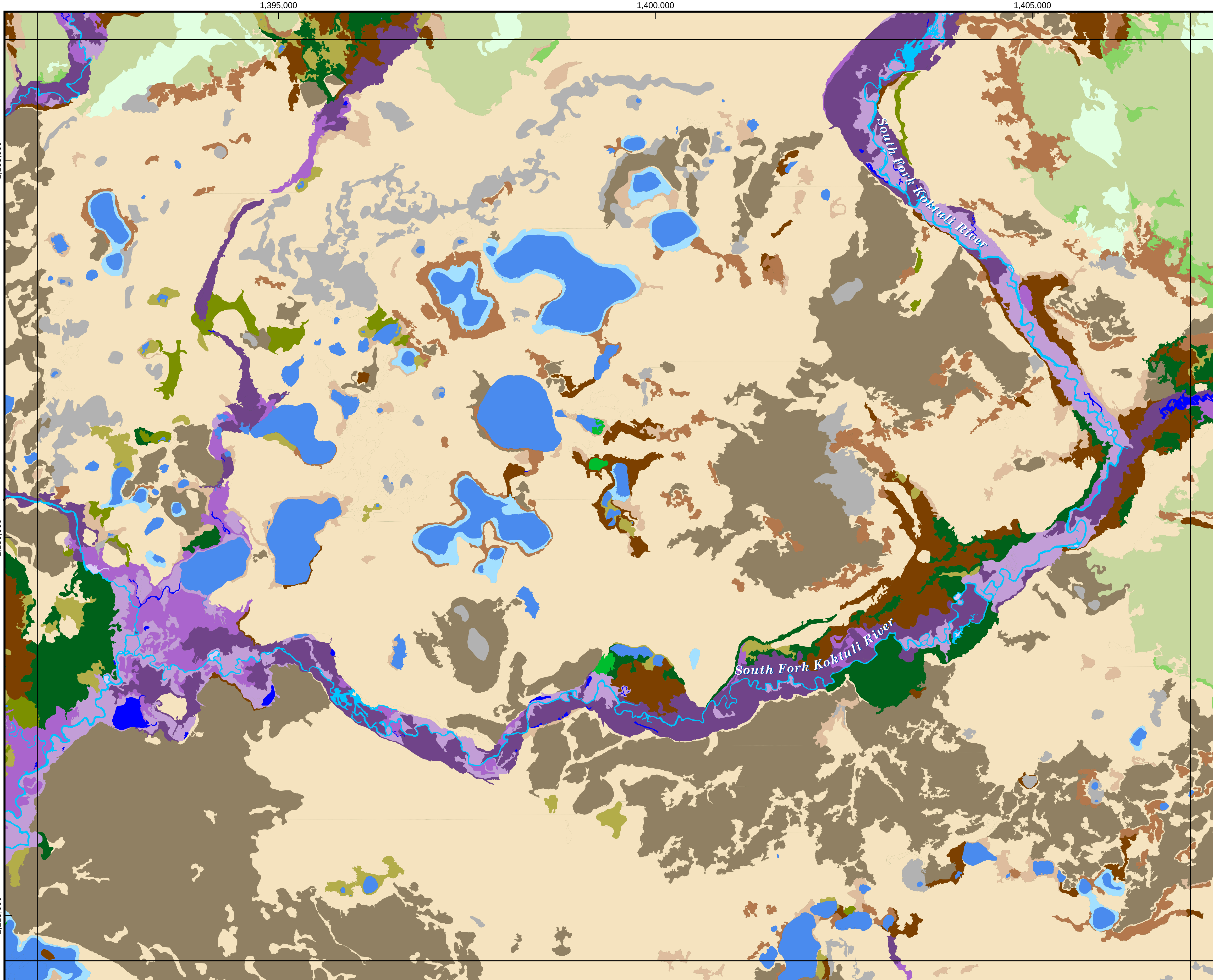
Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

See Tile 19

1,395,000 1,400,000 1,405,000



See Tile 22
See Tile 24

2,135,000
2,130,000
2,125,000

1,395,000 1,400,000 1,405,000

See Tile 27

THE pebble PARTNERSHIP

Figure 16.1-2w
Wildlife Habitat Mapping, Mine Study Area

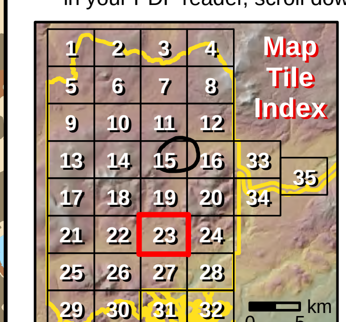
Legend

Wildlife Habitats – Tile 23

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

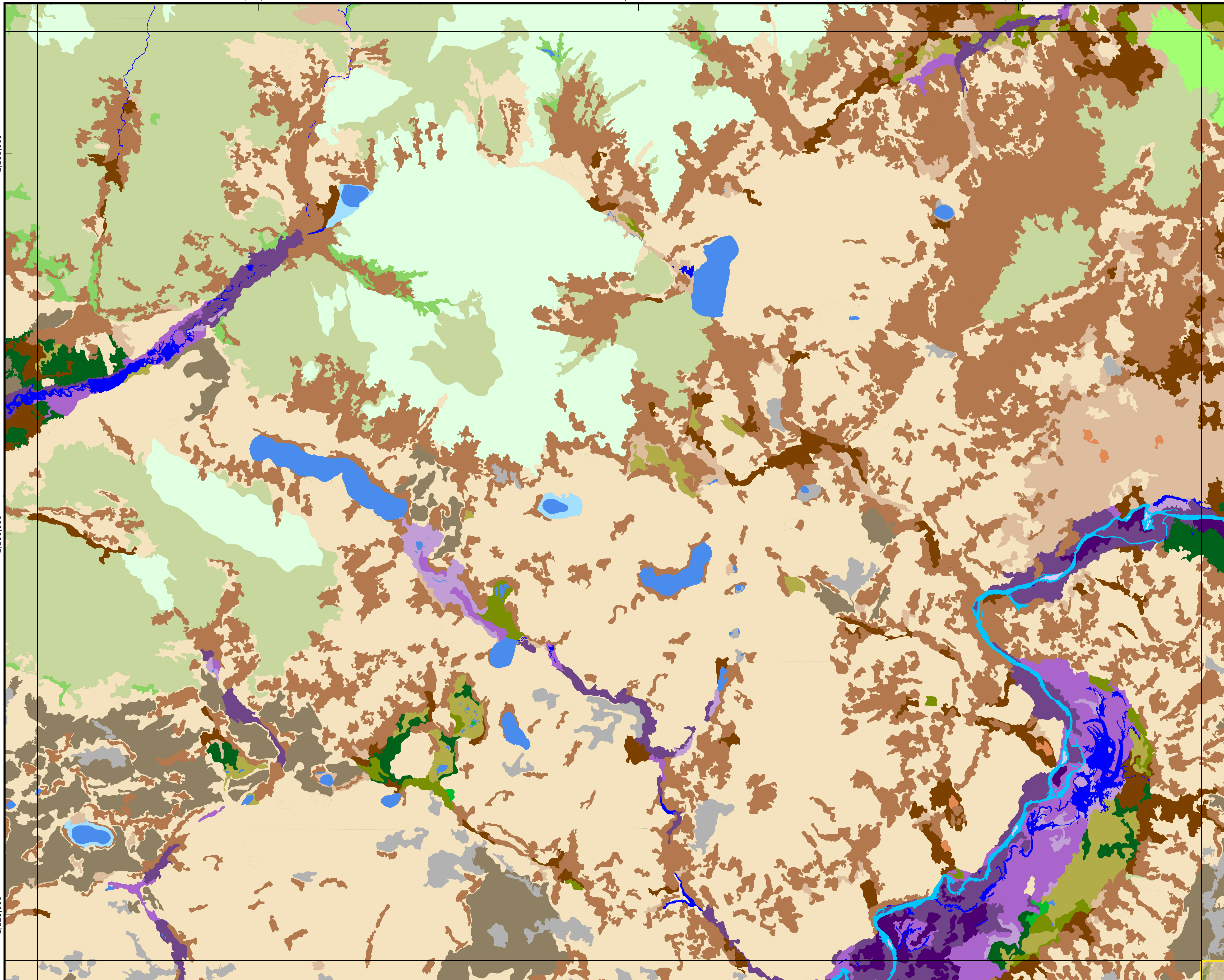


Figure 16.1-2x
Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP

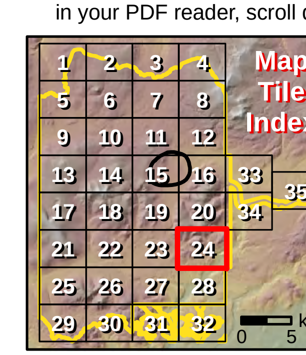
Legend

Wildlife Habitats – Tile 24

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

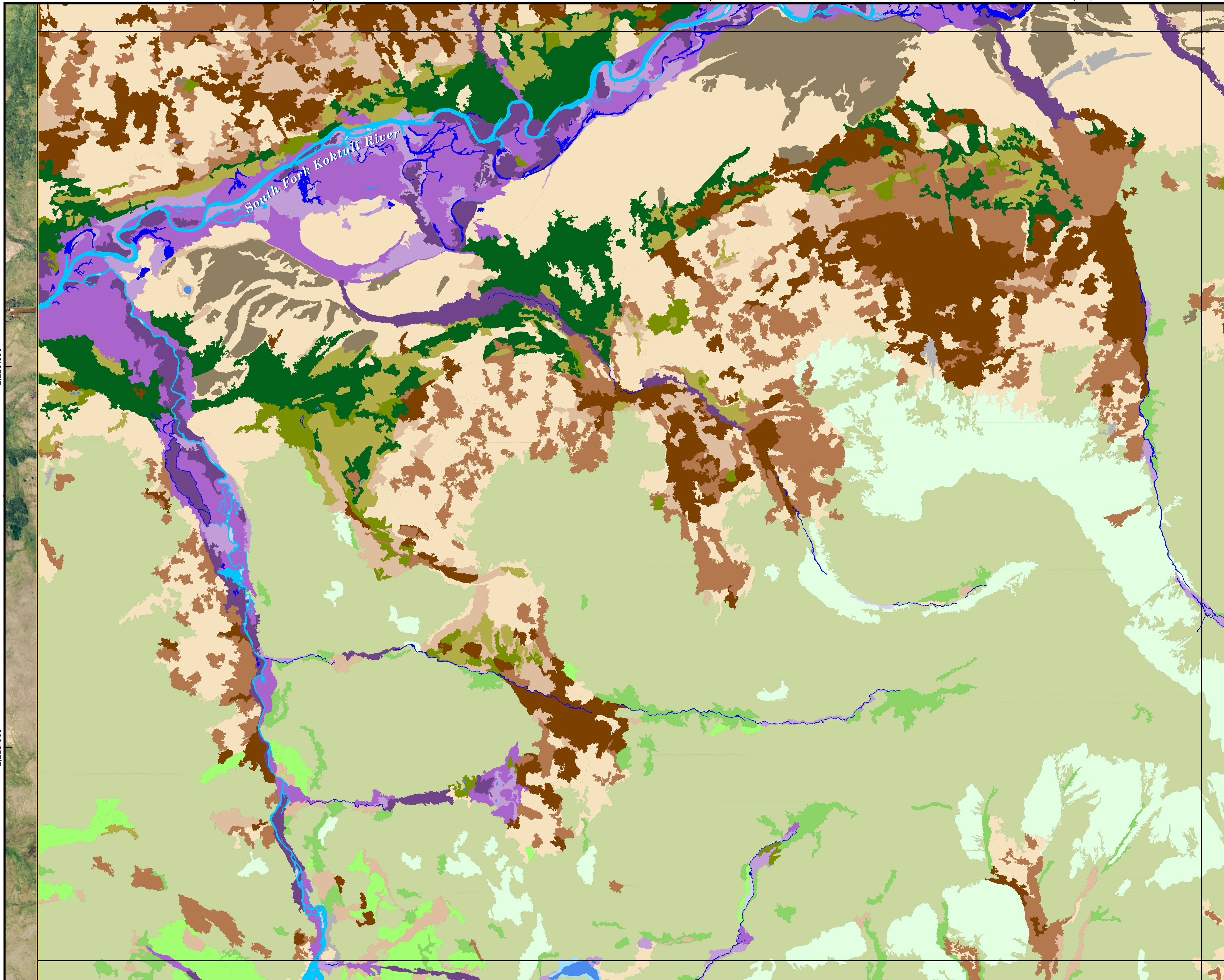
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

See Tile 21



See Tile 29

Figure 16.1-2y
Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP

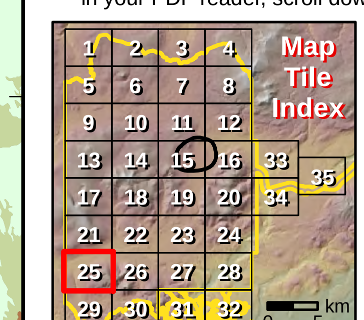
Legend

Wildlife Habitats – Tile 25

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

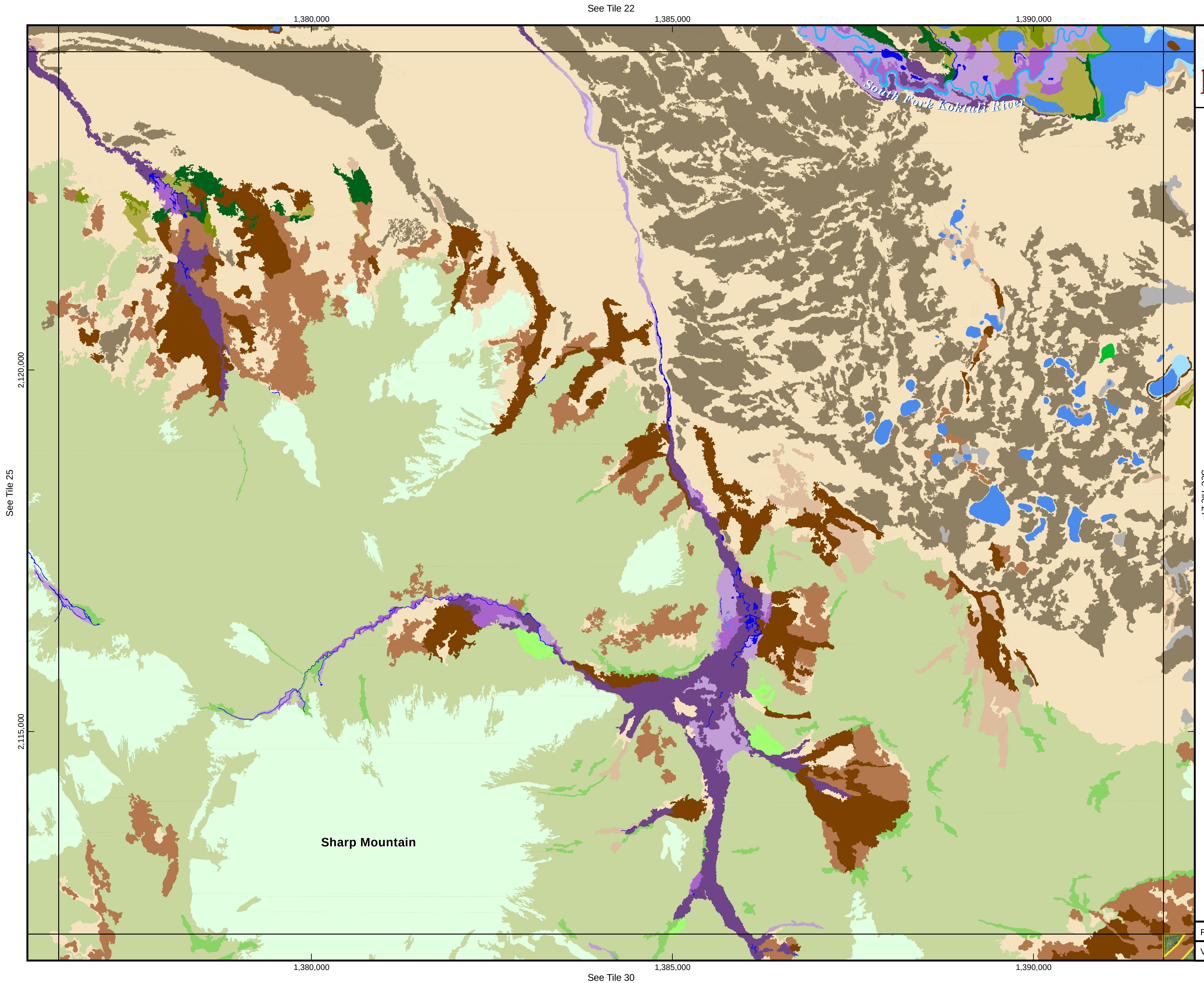
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

Figure 16.1-2z
Wildlife Habitat Mapping, Mine Study Area



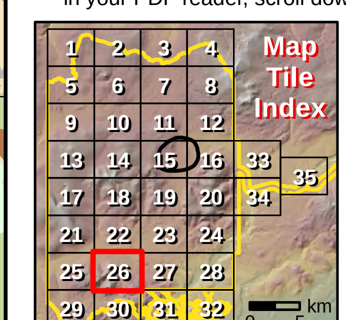
Legend

Wildlife Habitats – Tile 26

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

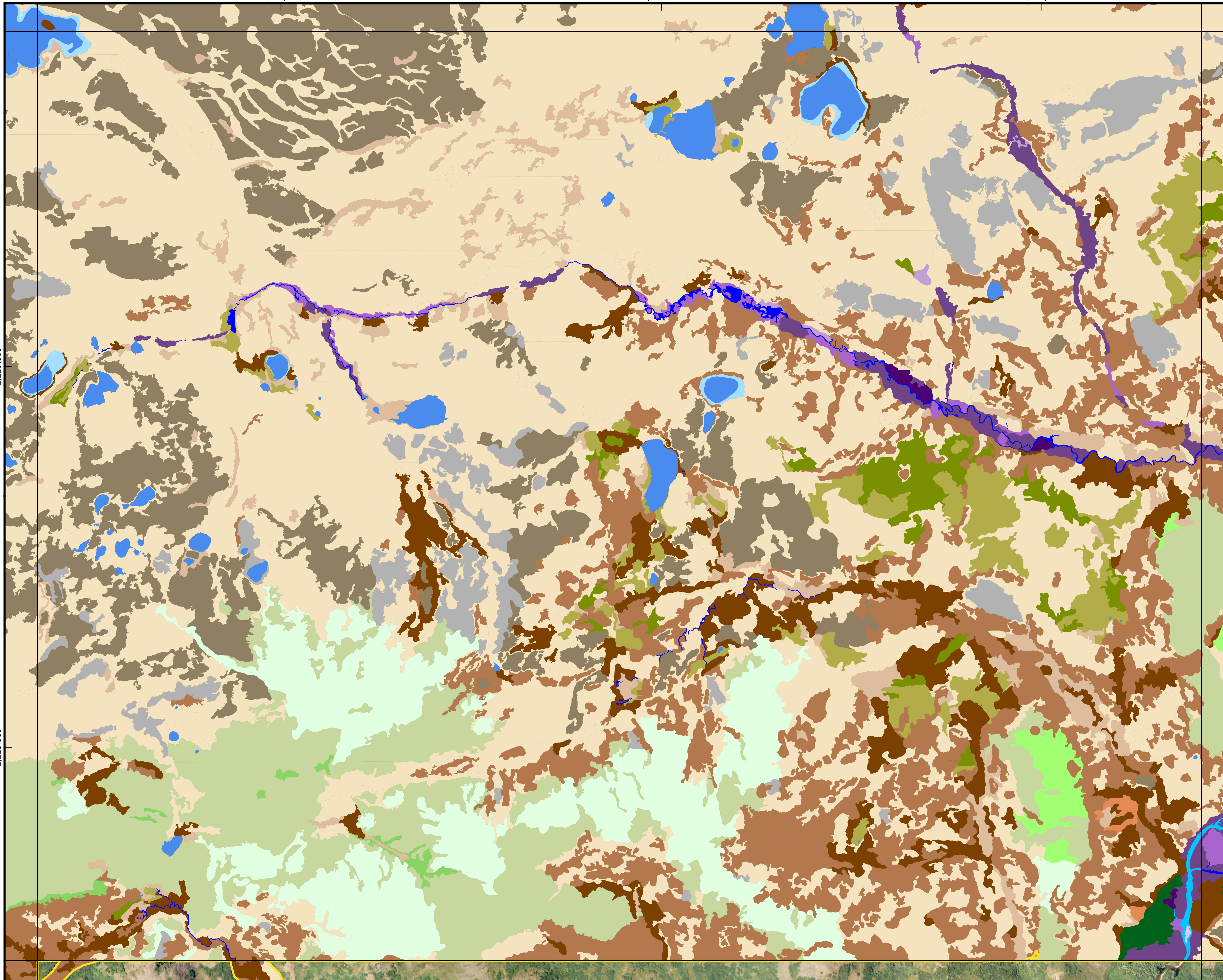


Figure 16.1-2aa Wildlife Habitat Mapping, Mine Study Area

THE pebble PARTNERSHIP

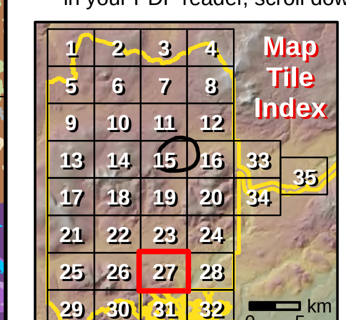
Legend

Wildlife Habitats – Tile 27

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

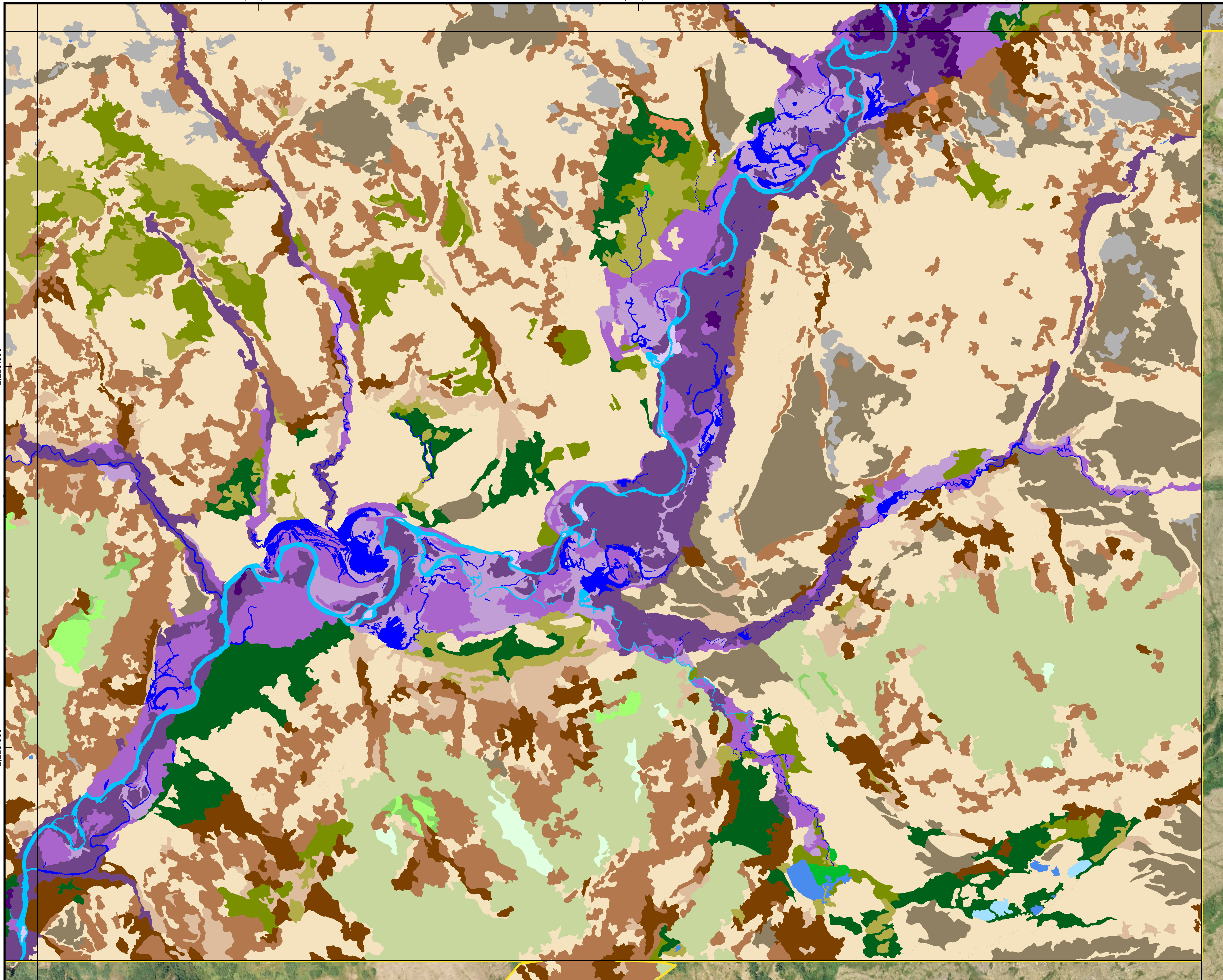
Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.1-2ab
Wildlife Habitat Mapping, Mine Study Area

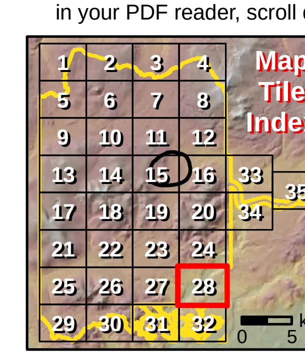
Legend

Wildlife Habitats – Tile 28

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

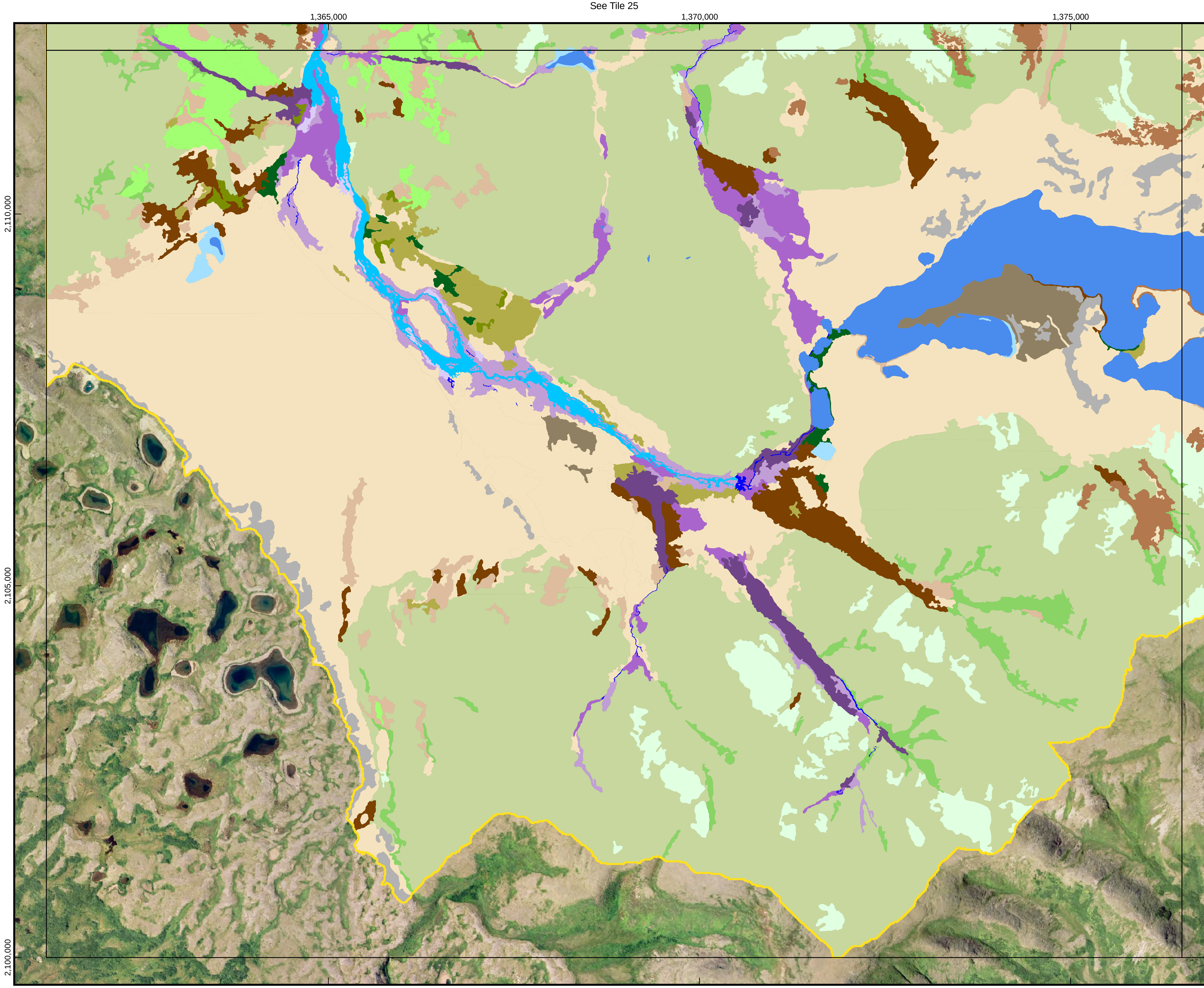
Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.1-2ac
Wildlife Habitat Mapping, Mine Study Area

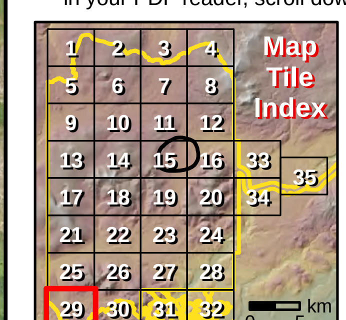
Legend

Wildlife Habitats – Tile 29

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

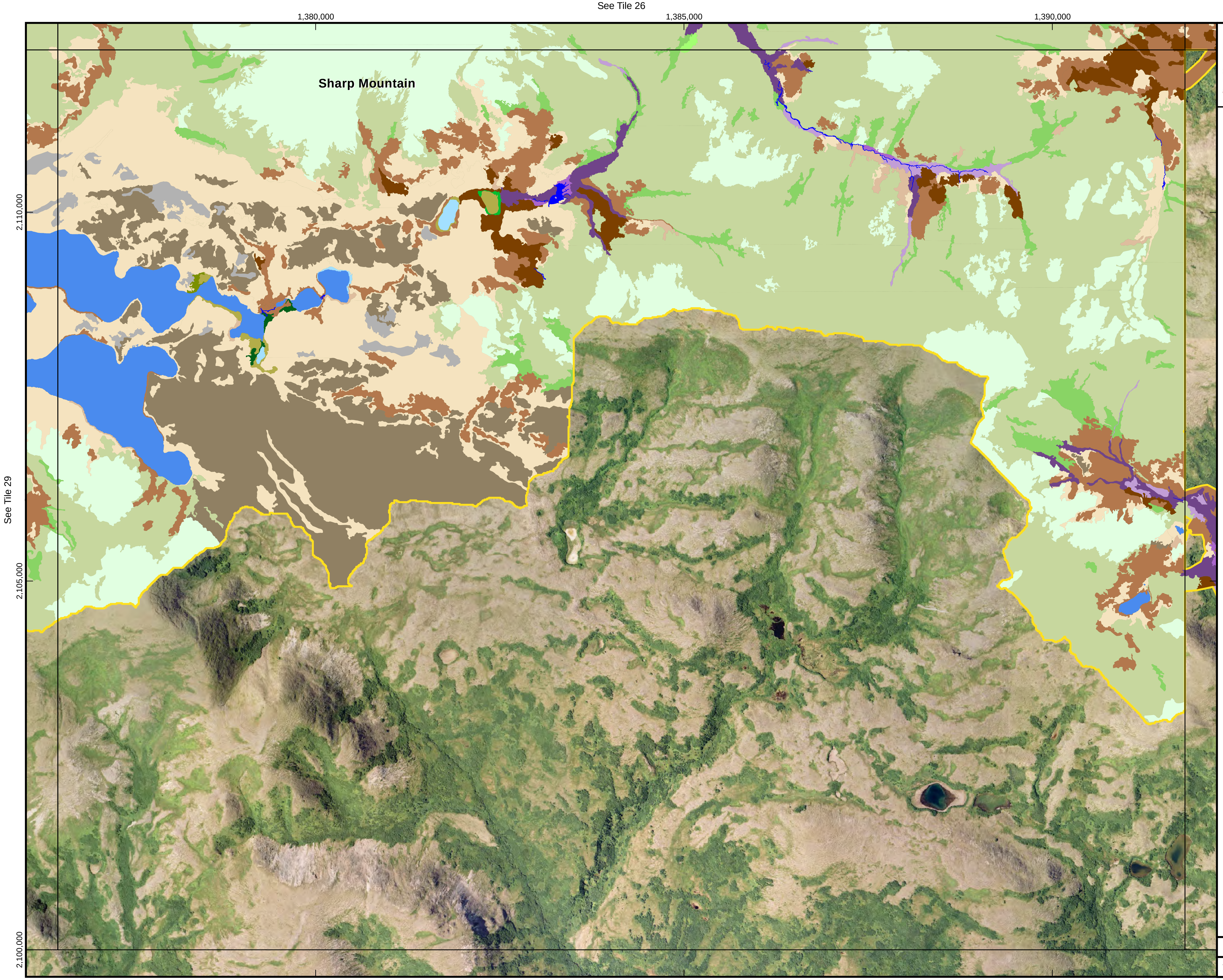
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

Figure 16.1-2ad
Wildlife Habitat Mapping, Mine Study Area



THE pebble PARTNERSHIP

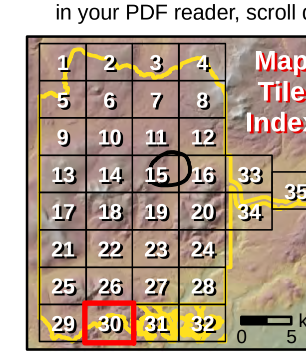
Legend

Wildlife Habitats – Tile 30

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

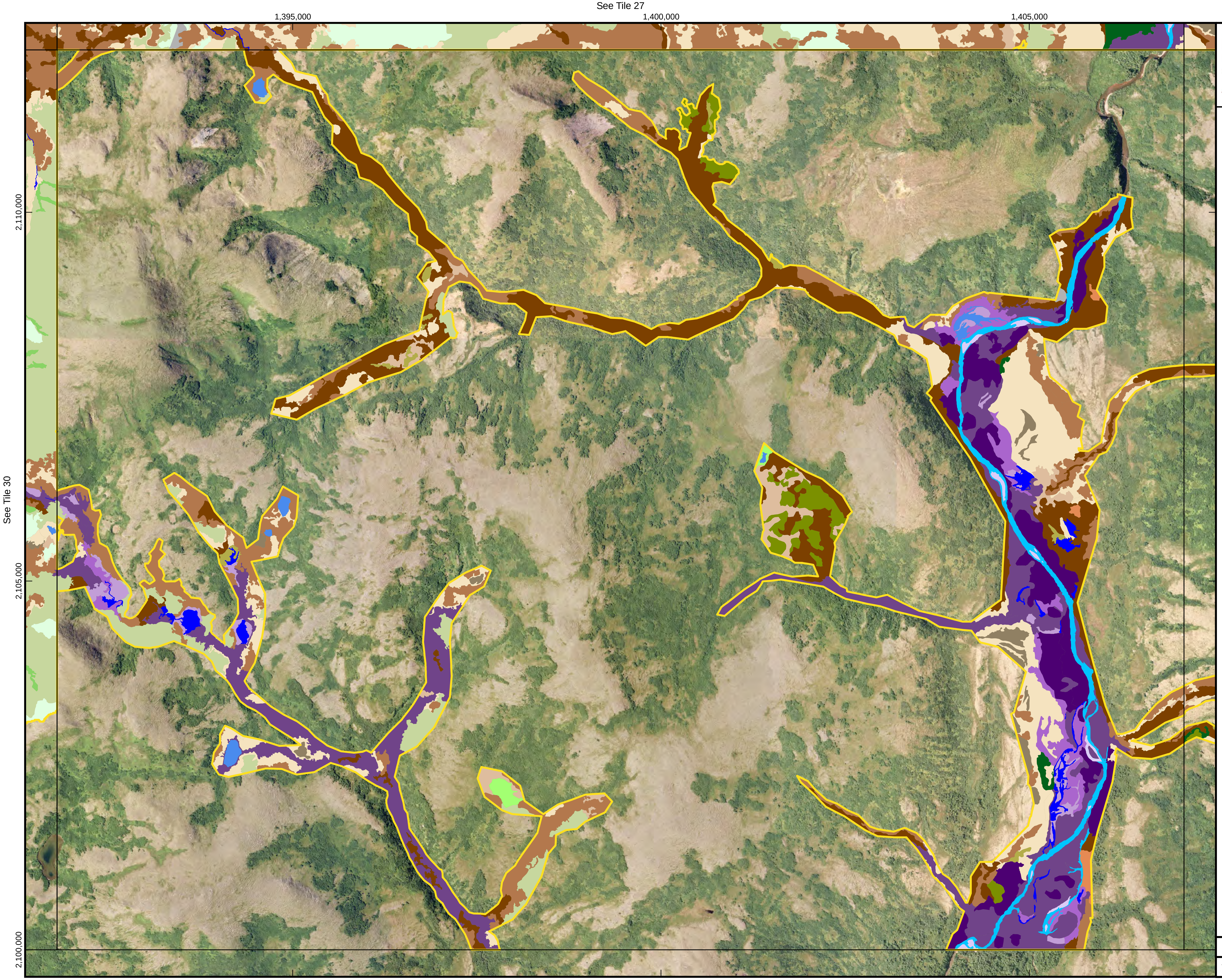
Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

Figure 16.1-2ae
Wildlife Habitat Mapping, Mine Study Area



THE pebble PARTNERSHIP

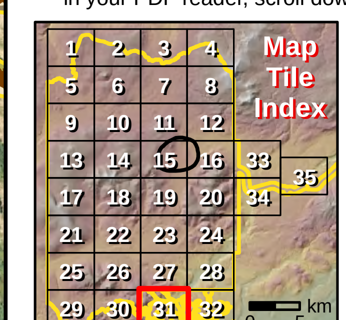
Legend

Wildlife Habitats – Tile 31

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

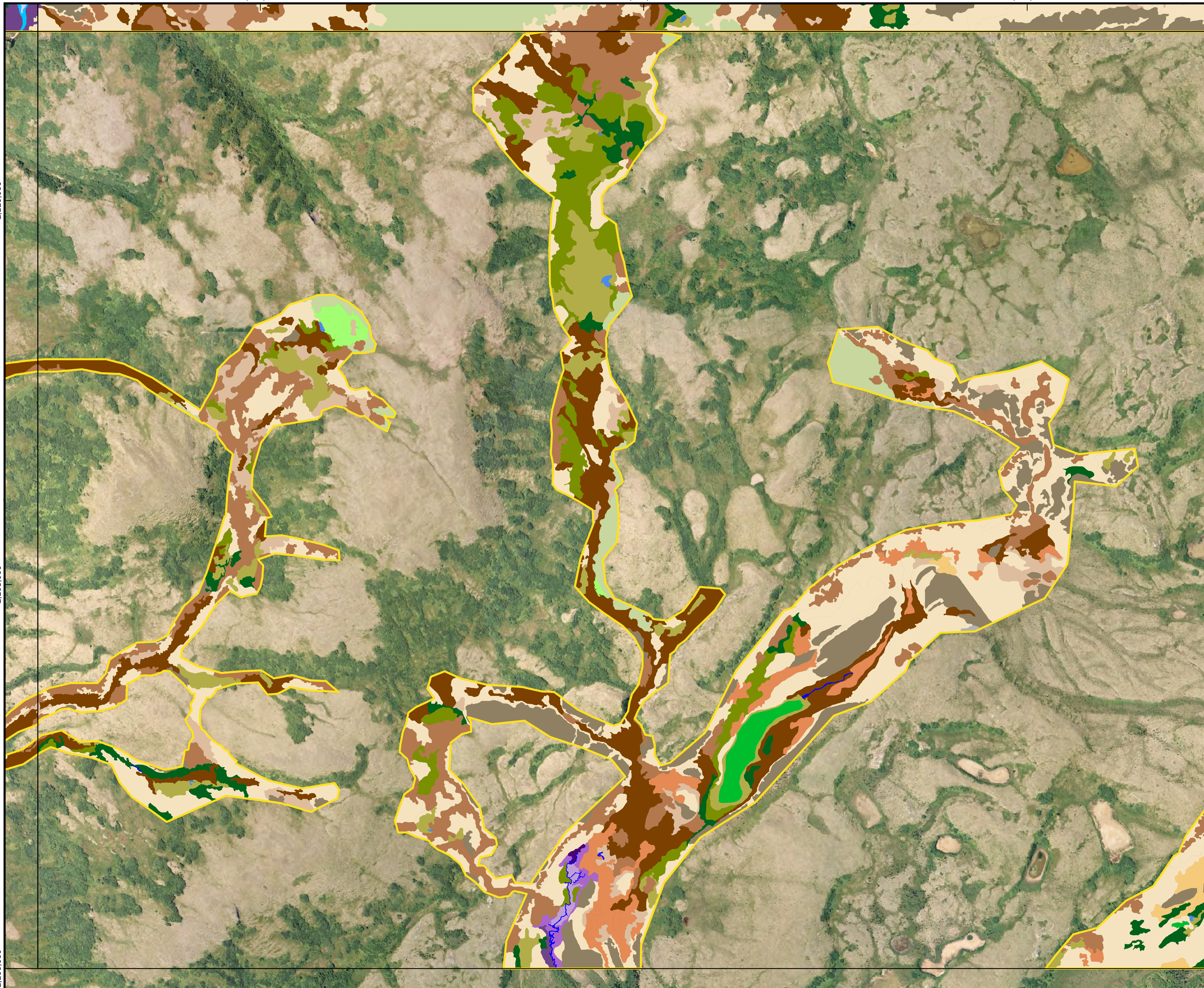
Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.1-2af
Wildlife Habitat Mapping, Mine Study Area

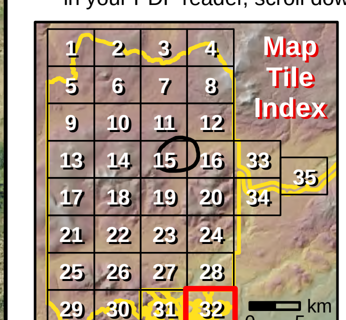
Legend

Wildlife Habitats – Tile 32

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

See Tile 34

Figure 16.1-2ag
Wildlife Habitat Mapping, Mine Study Area

Legend

Wildlife Habitats – Tile 33

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

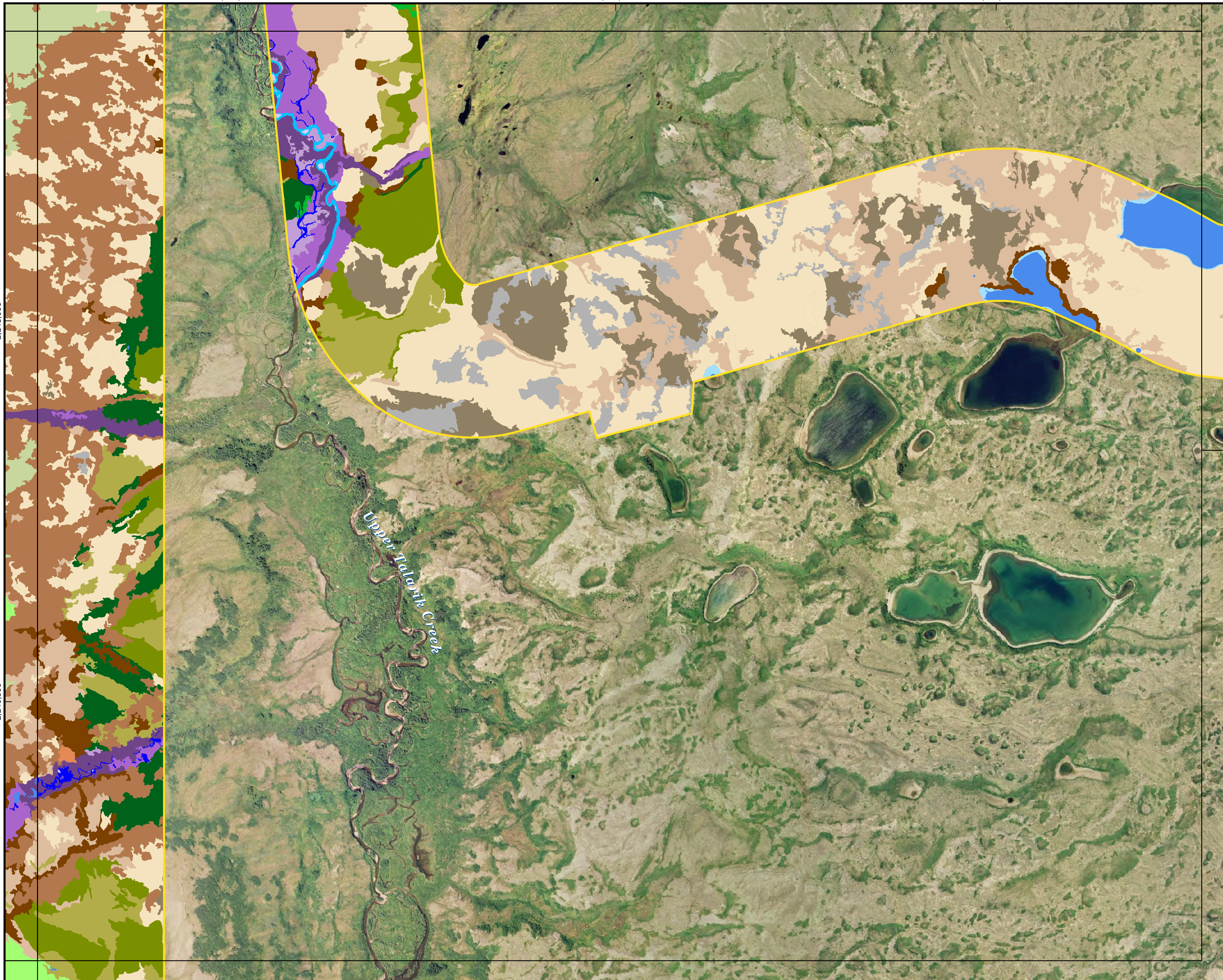
Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

THE pebble PARTNERSHIP

Figure 16.1-2ah
Wildlife Habitat Mapping, Mine Study Area



Legend

Wildlife Habitats – Tile 34

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

Scale 1:16,000

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

File: 16-1-2_HabTiles_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

THE pebble PARTNERSHIP

Figure 16.1-2ai
Wildlife Habitat Mapping, Mine Study Area

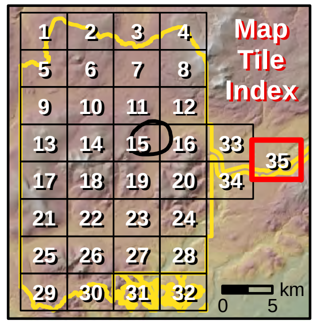
Legend

Wildlife Habitats – Tile 35

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Moist Graminoid–Forb Meadow
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   General Deposit Location

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Imagery notes: Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.

N

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

Scale 1:16,000

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

File: 16-1-2ai_HabTile35_Mine_PLP_EBD_v02.mxd	Date: March 14, 2011
Version: 2	Author: ABR-AZC

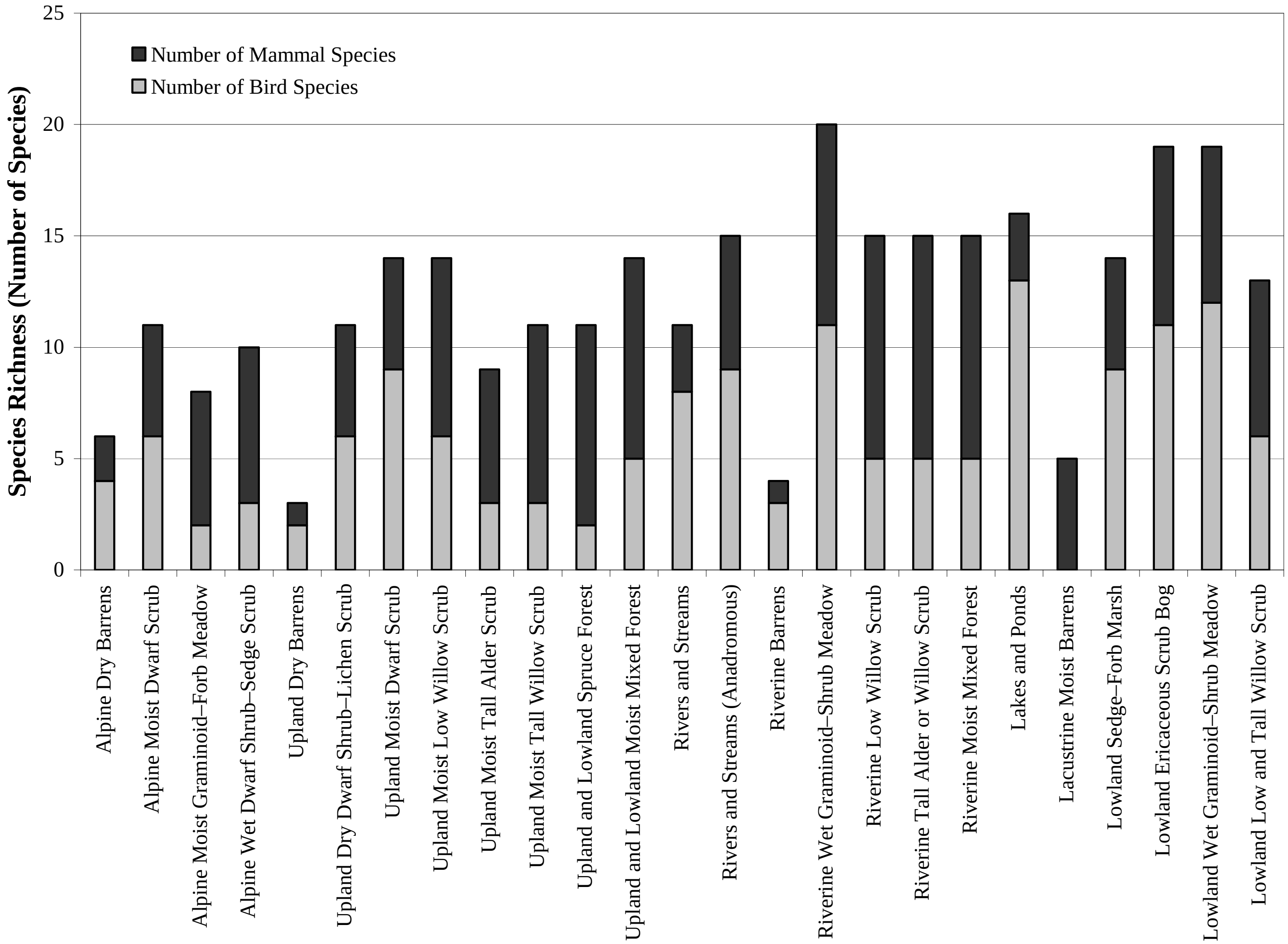
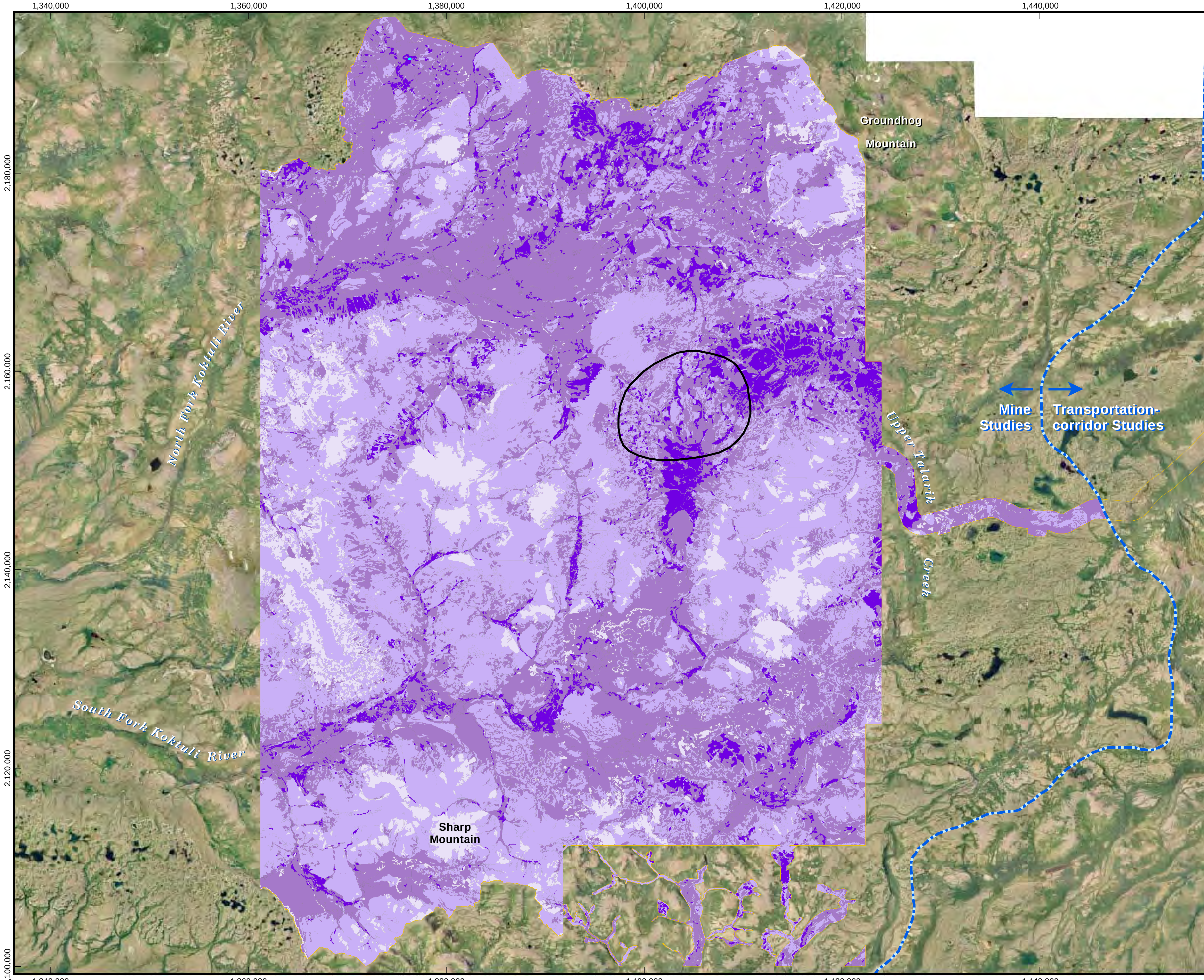


FIGURE 16.1-3
Species Richness of Bird and Mammal Species of Concern with Moderate- or High-value Habitat Rankings in Mapped Wildlife Habitat Types, Mine Study Area



THE pebble PARTNERSHIP

Figure 16.1-4
Species Richness for Bird and Mammal Species of Concern, Mine Study Area

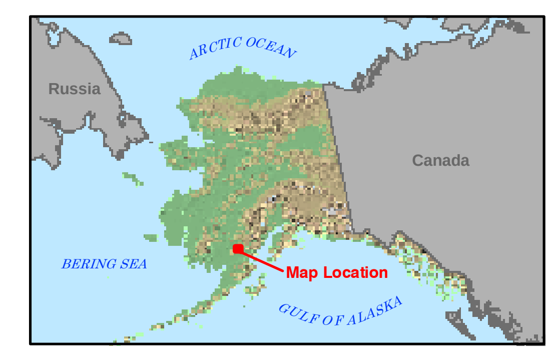
Legend

Number of Species with Moderate or High Habitat-value Rankings

- High (19–20 Species)
- Moderate–High (13–16 Species),
- Low–Moderate (8–11 Species)
- Low (3–6 Species)

- Mapping Area
- General Deposit Location

Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.



Miles: 0 1 2 3 4

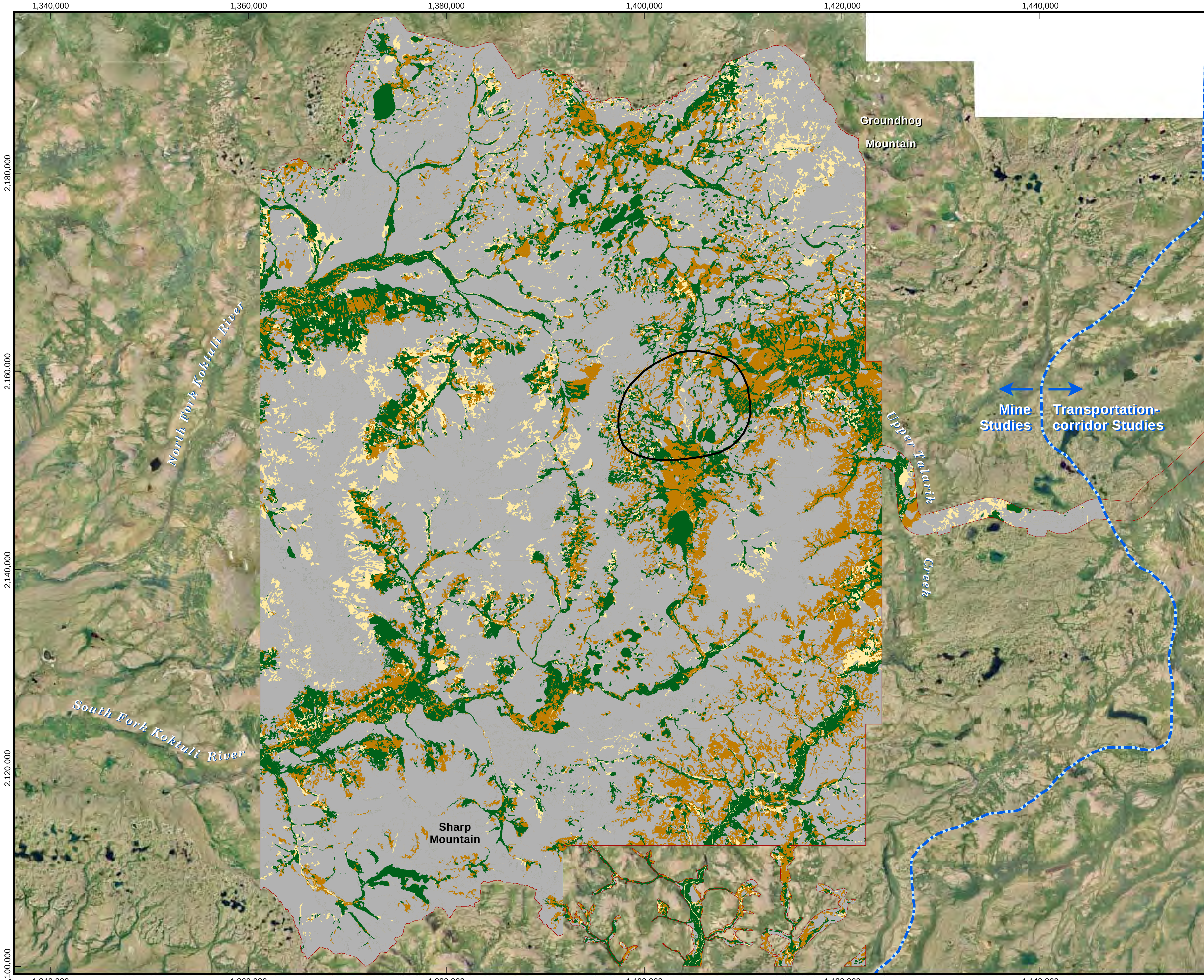
Kilometers: 0 1 2 3 4 5 6

N

Scale 1:120,000

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

File: 16-1-4_Species_Richness_Mine_PLP_EBD_v03.mxd	Date: March 15, 2011
Version: 3	Author: ABR-AZC



THE
pebble
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Figure 16.1-6
Habitat Availability for Moose, Mine Study Area

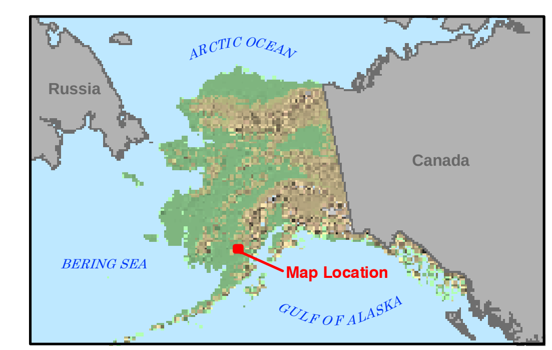
Legend

Habitat Value Category for Moose

- High
- Moderate
- Low
- Negligible

- Mapping Area
- General Deposit Location

Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.



Miles: 0 1 2 3 4

Kilometers: 0 1 2 3 4 5 6

N

Scale 1:120,000

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

File: 16-1-6_Moose_HabAv_Mine_PLP_EBD_v02.mxd	Date: April 19, 2011
Version: 2	Author: ABR-AZC

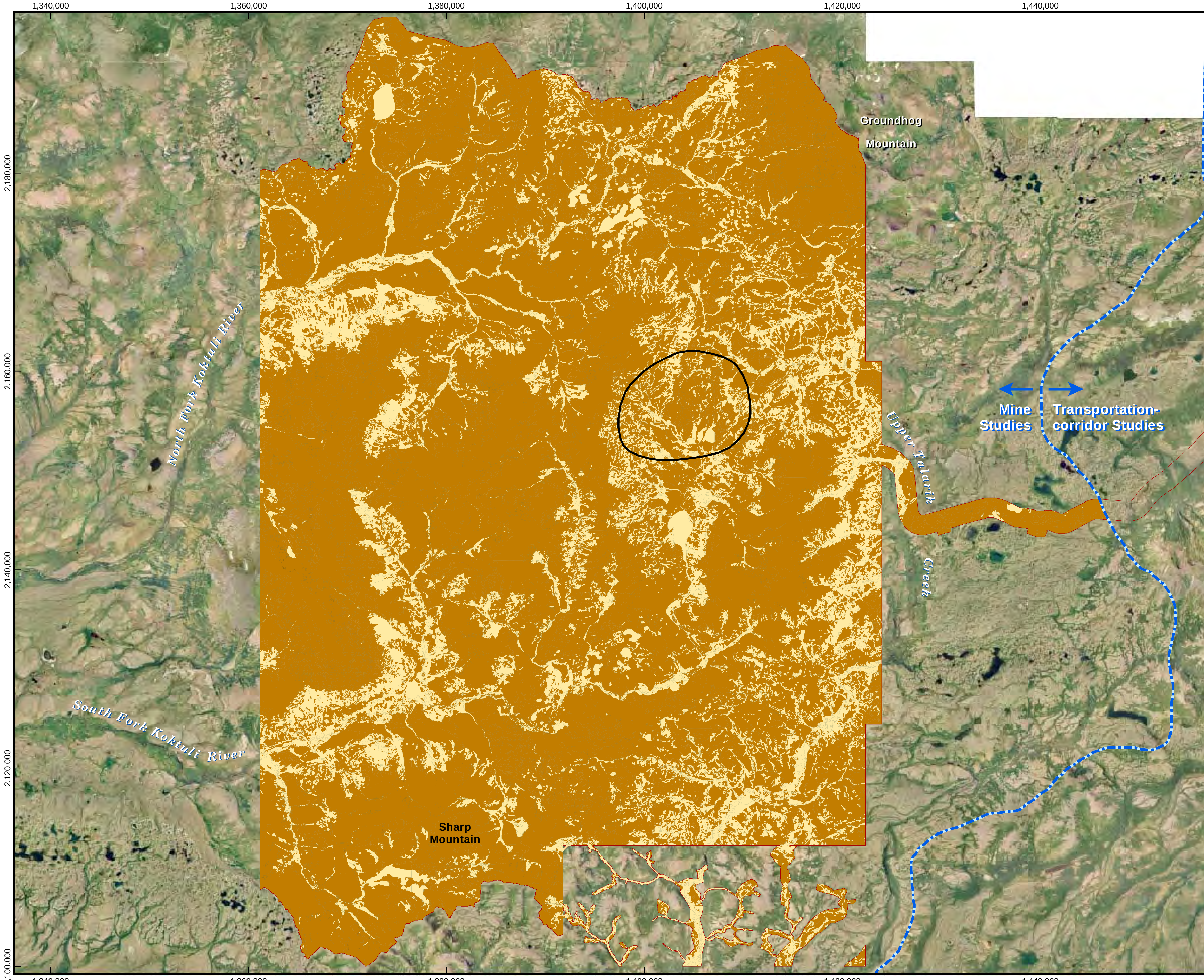


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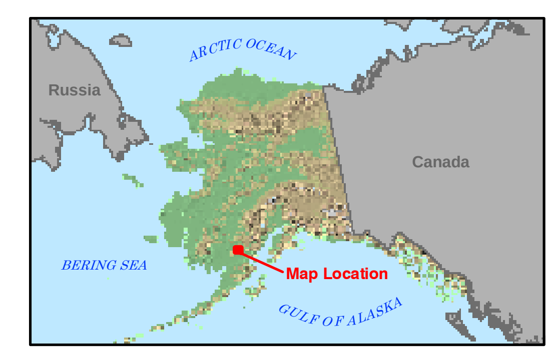
Figure 16.1-7
Habitat Availability for Caribou, Mine Study Area

Legend

Habitat Value Category for Caribou

- Moderate
- Low
- Mapping Area
- General Deposit Location

Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.



Miles: 0 1 2 3 4
Kilometers: 0 1 2 3 4 5 6
N

Scale 1:120,000

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

File: 16-1-7_Caribou_HabAv_Mine_PLP_EBD_v02.mxd	Date: April 20, 2011
Version: 2	Author: ABR-AZC

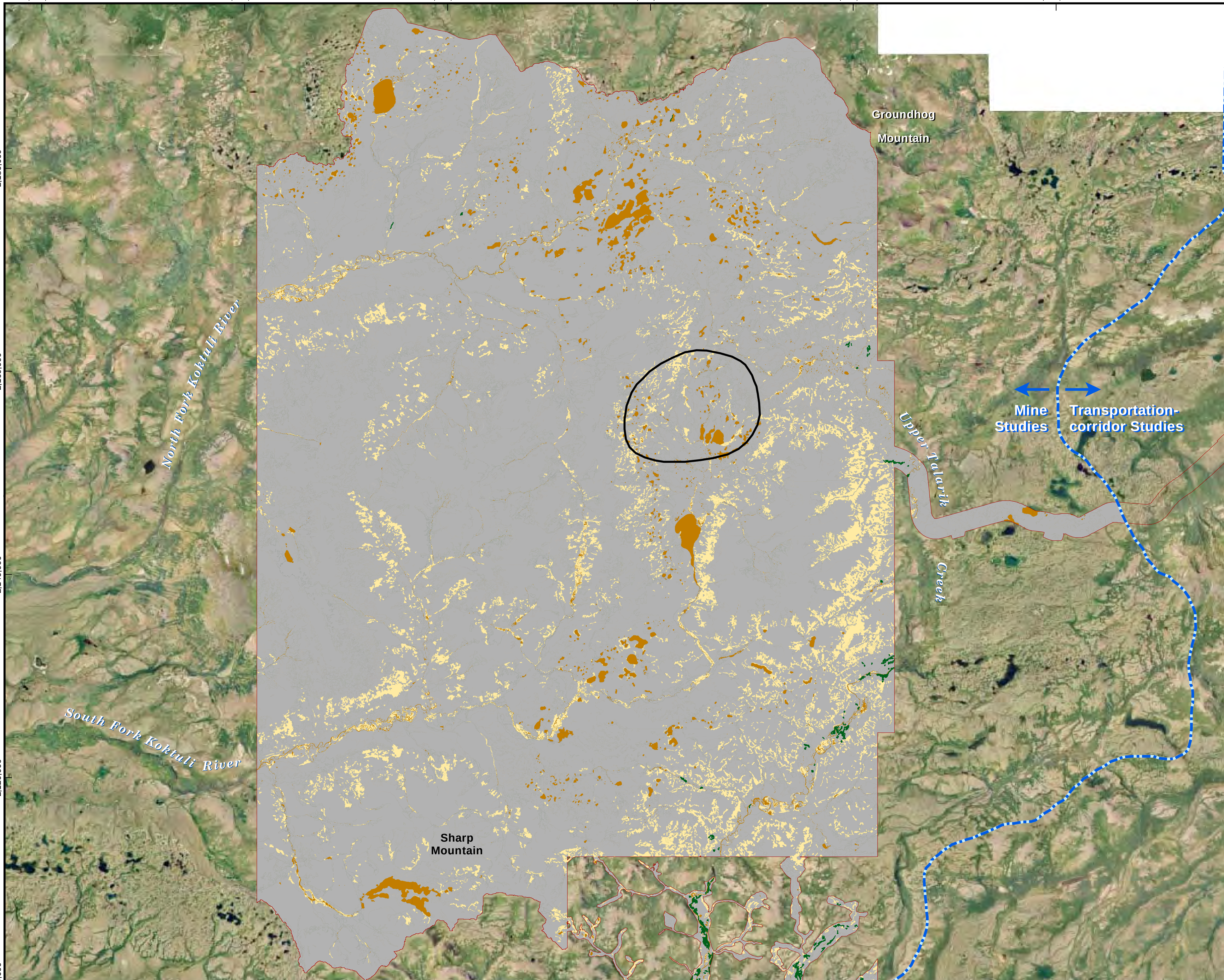


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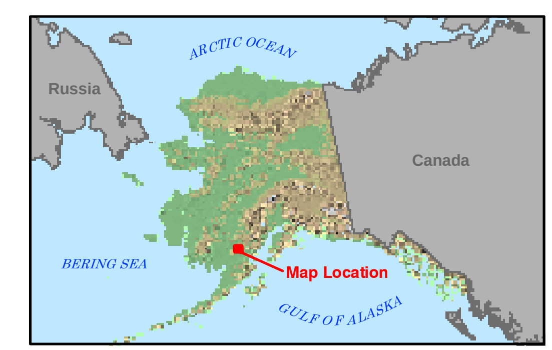
Figure 16.1-8
Habitat Availability for Tree-nesting Raptor Species of Concern, Mine Study Area

Legend

Number of Species with Moderate or High Habitat-value Rankings

- 3–4 Species
- 2 Species
- 1 Species
- 0 Species
- Mapping Area
- General Deposit Location

Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.



Miles: 0 1 2 3 4
Kilometers: 0 1 2 3 4 5 6
N

Scale 1:120,000

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

File: 16-1-8_TreeRaptor_HabAv_Mine_PLP_EBD_v03.mxd	Date: March 18, 2011
Version: 3	Author: ABR-AZC

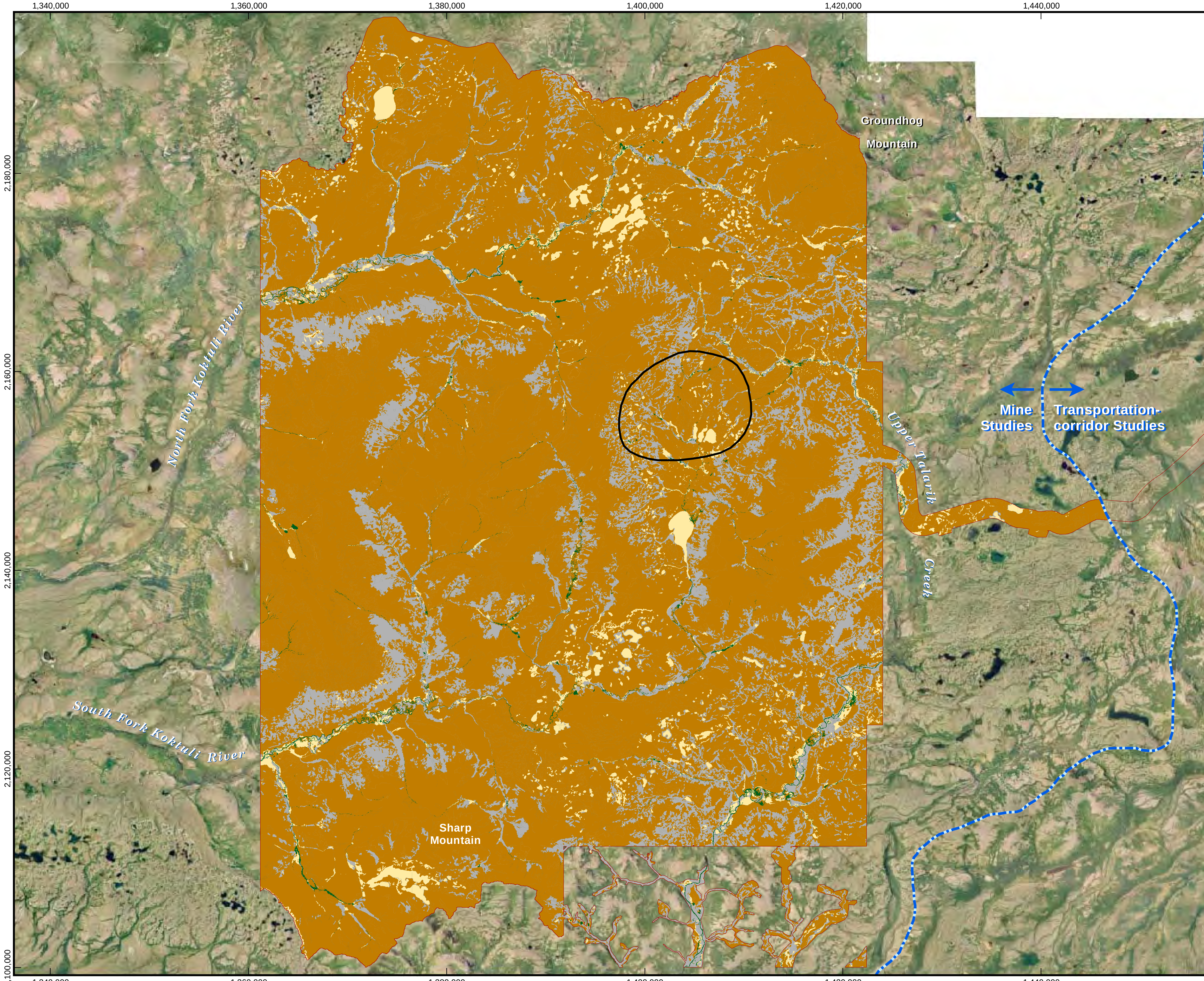


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Figure 16.1-9
Habitat Availability for Cliff-nesting Raptor Species of Concern, Mine Study Area

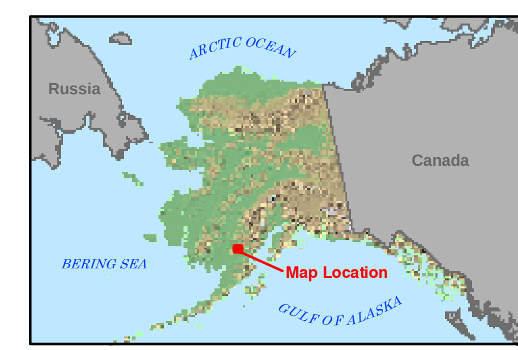
Legend

Number of Species with Moderate or High Habitat-value Rankings

- 3 Species
- 2 Species
- 1 Species
- 0 Species

- Mapping Area
- General Deposit Location

Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.



Miles: 0 1 2 3 4
Kilometers: 0 1 2 3 4 5 6
N

Scale 1:120,000

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

File: 16-1-9_CliffRaptor_HabAv_Mine_PLP_EBD_v02.mxd	Date: March 18, 2011
Version: 2	Author: ABR-AZC

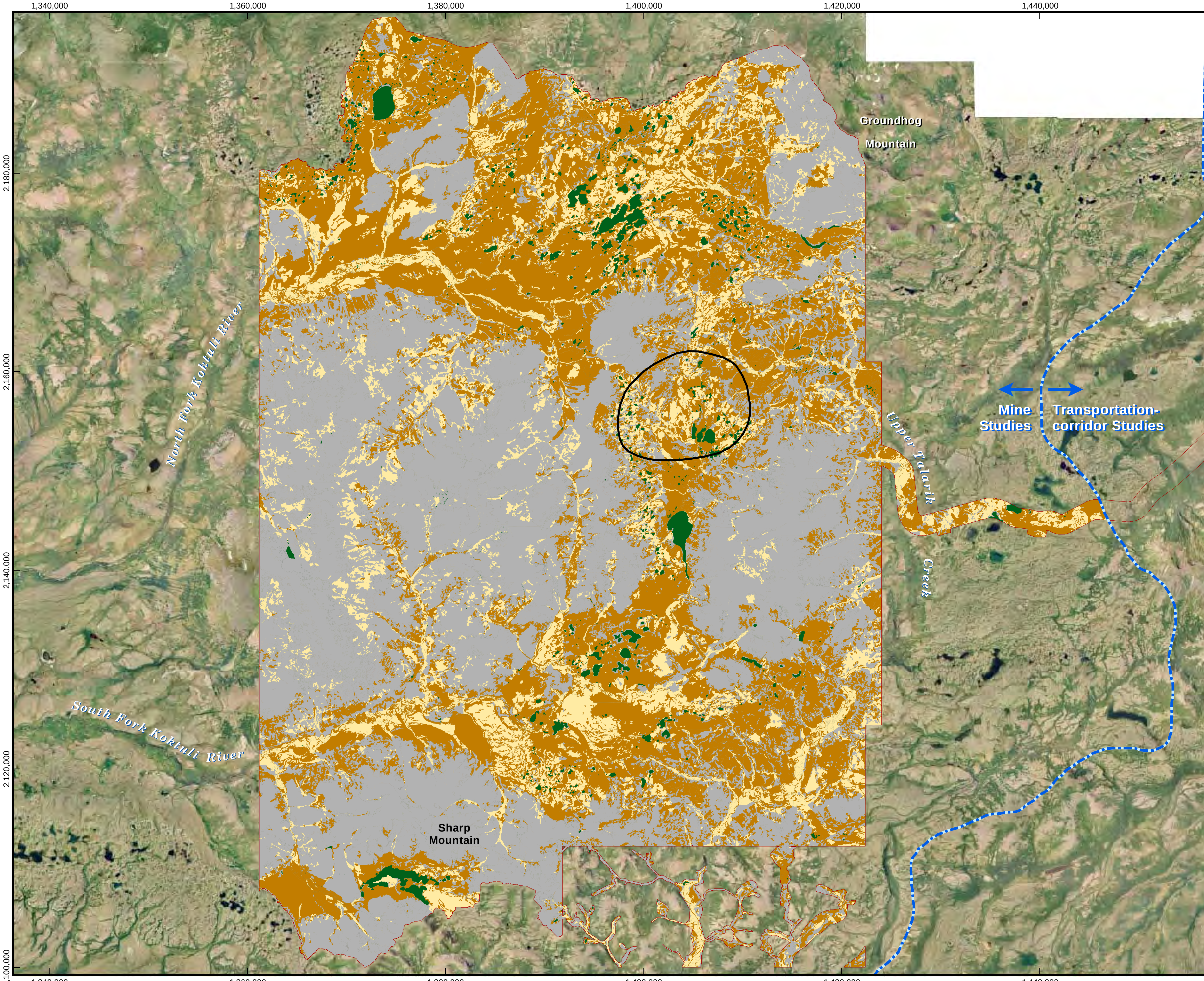


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Figure 16.1-10
Habitat Availability for Waterbird Species of Concern, Mine Study Area

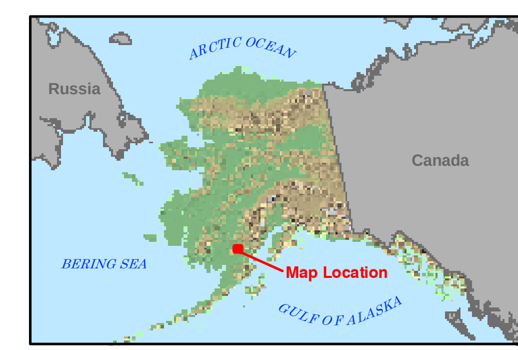
Legend

Number of Species with Moderate or High Habitat-value Rankings

- 7 Species
- 3–5 Species
- 1–2 Species
- 0 Species

- Mapping Area
- General Deposit Location

Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.



Miles: 0 1 2 3 4

Kilometers: 0 1 2 3 4 5 6

Scale 1:120,000

N

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

File: 16-1-10_Waterbirds_HabAv_Mine_PLP_EBD_v03.mxd	Date: April 20, 2011
Version: 3	Author: ABR-AZC

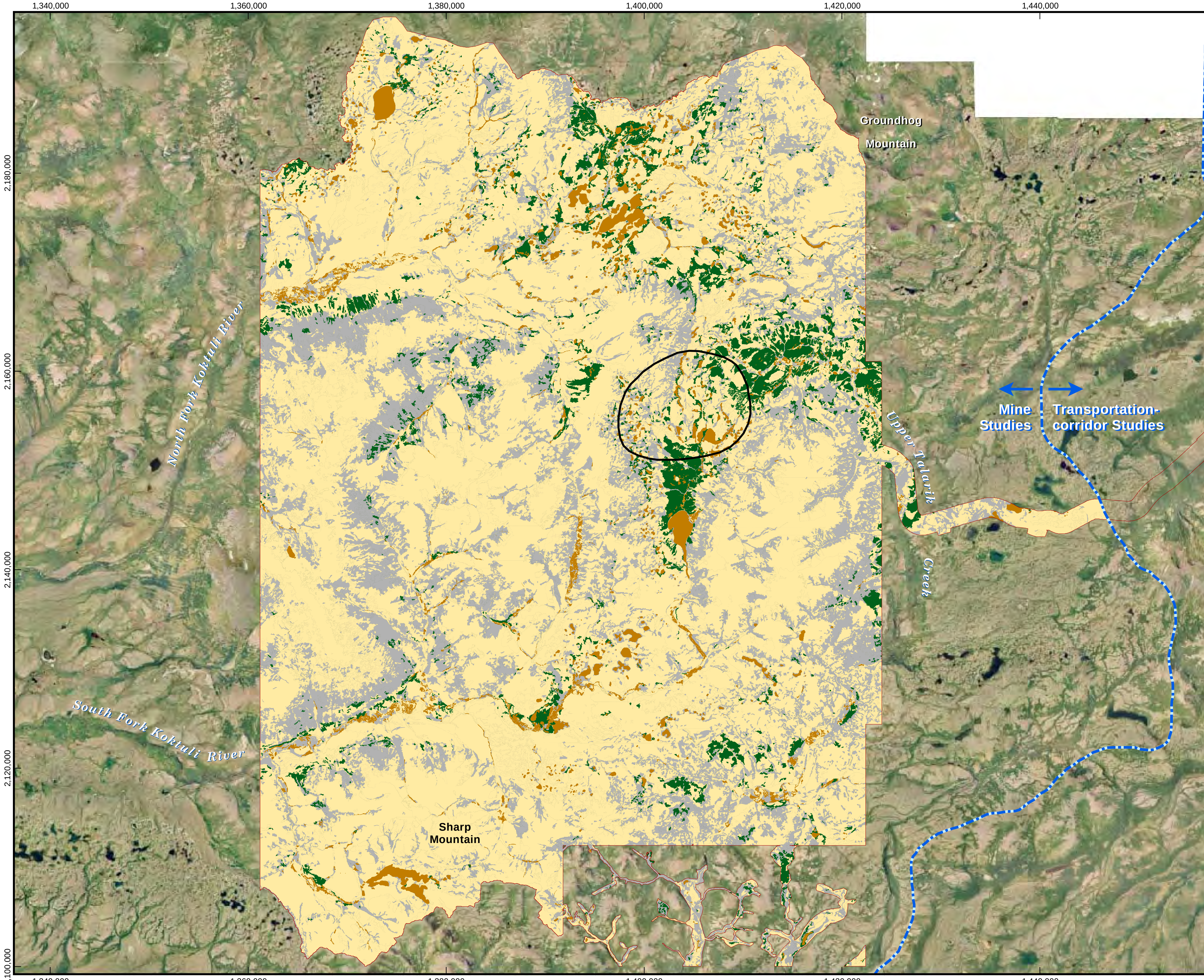


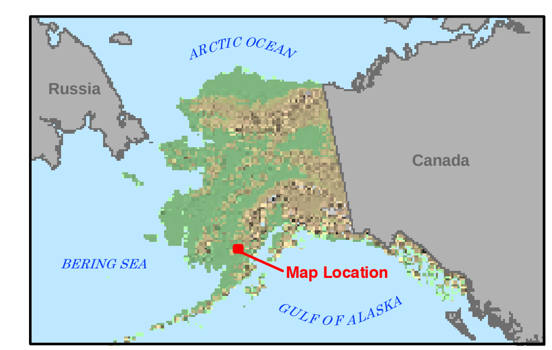
Figure 16.1-11
Habitat Availability for Shorebird Species of Concern, Mine Study Area

Legend

Number of Species with Moderate or High Habitat-value Rankings

- 5 Species
- 3–4 Species
- 1–2 Species
- 0 Species
- Mapping Area
- General Deposit Location

Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.



Miles 0 1 2 3 4

Kilometers 0 1 2 3 4 5 6

N

Scale 1:120,000

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

File: 16-1-11_Shorebirds_HabAv_Mine_PLP_EBD_v02.mxd	Date: April 20, 2011
Version: 2	Author: ABR-AZC

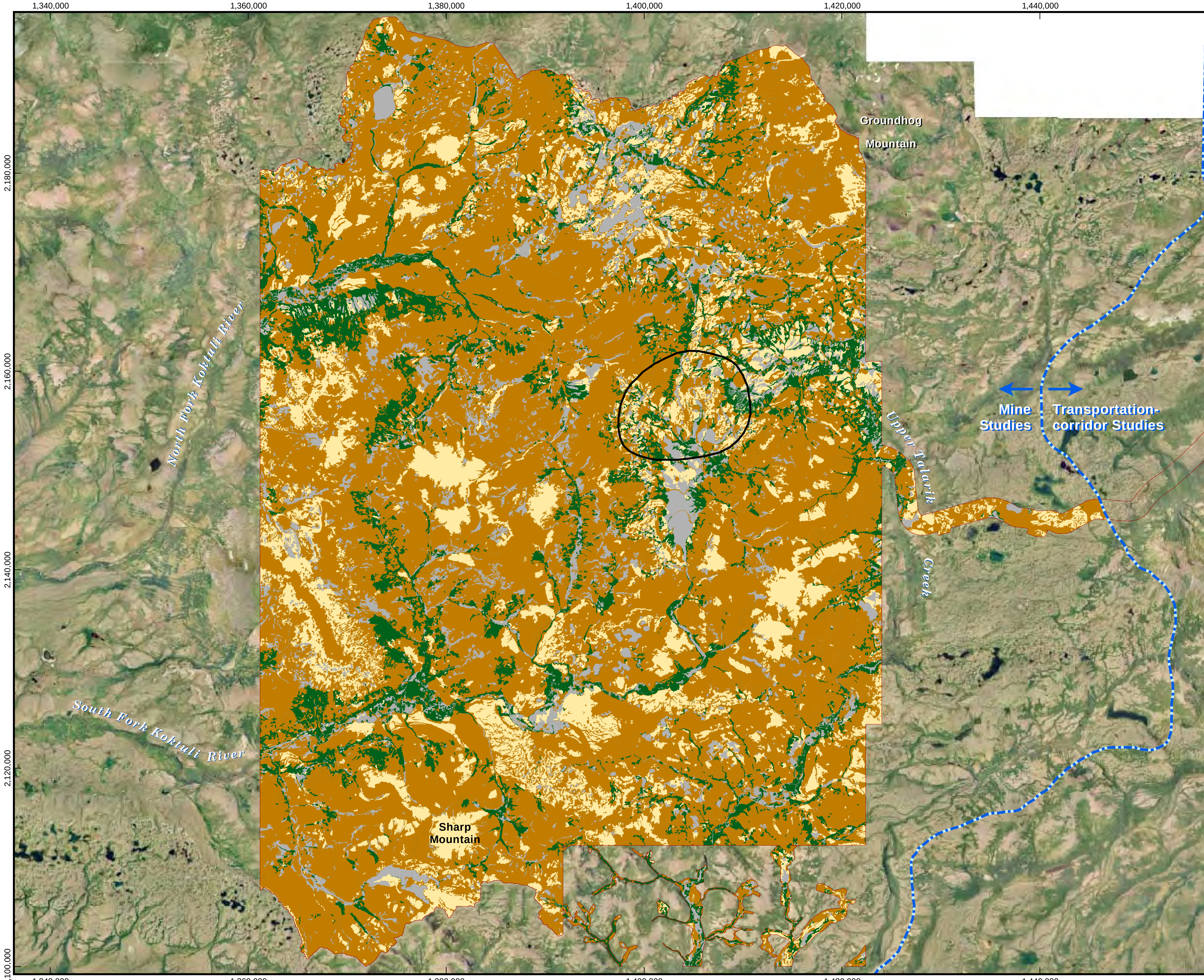


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Figure 16.1-12
Habitat Availability for Landbird Species of Concern, Mine Study Area

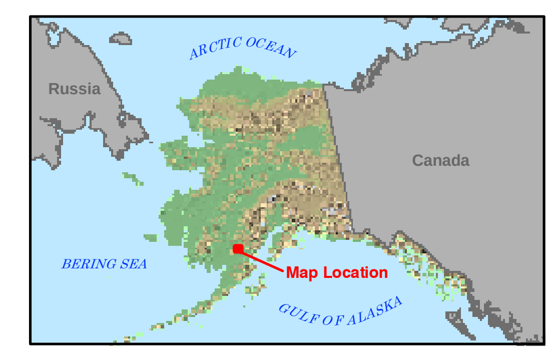
Legend

Number of Species with Moderate or High Habitat-value Rankings

3 Species
2 Species
1 Species
0 Species

Mapping Area
General Deposit Location

Color orthophotography for the mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.



Miles 0 1 2 3 4
Kilometers 0 1 2 3 4 5 6
N
Scale 1:120,000

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

File: 16-1-12_Landbirds_HabAv_Mine_PLP_EBD_v02.mxd	Date: April 20, 2011
Version: 2	Author: ABR-AZC

APPENDICES

APPENDIX 16.1A

AVERAGE OCCURRENCE FIGURES FOR LANDBIRDS AND SHOREBIRDS IN MAPPED WILDLIFE HABITAT TYPES, MINE STUDY AREA, 2010

APPENDIX 16.1A

Average-occurrence Figures [a] for Shorebird and Landbird Species of Concern in Mapped Wildlife Habitat Types, Mine Study Area, 2010

Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Moist Graminoid–Forb Meadow	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
	n=7	*n*=52	*n*=1	*n*=7	*n*=1	*n*=38	*n*=38	*n*=34	*n*=25	*n*=39	*n*=0	*n*=2	*n*=0	*n*=0	*n*=0	*n*=17	*n*=24	*n*=40	*n*=0	*n*=3	*n*=2	*n*=0	*n*=17	*n*=40	*n*=14
Willow Ptarmigan		0.038						0.059																	
Rock Ptarmigan		0.038																							
American Golden-Plover		0.135				0.079	0.079			0.026													0.118		
Lesser Yellowlegs																							0.118		
Whimbrel																							0.235	0.275	
Hudsonian Godwit																							0.059	0.050	
Surfbird		0.096																							
Short-billed Dowitcher																								0.275	
Gray-cheeked Thrush								0.382	1.040	1.179						0.059	0.500	0.775							0.643
Blackpoll Warbler								0.029	0.040	0.231		0.500					0.083	0.550							0.214

Notes:

a. Data from breeding shorebird and landbird surveys conducted in the mine study area in 2004 and 2005; average occurrence = number of bird detections divided by *n* (number of point-counts conducted) (see Section 16.5 for more information). Blanks indicate no observations of that species were made during point-count surveys in that habitat.

APPENDIX 16.1B

DESCRIPTIONS OF WILDLIFE HABITAT TYPES MAPPED IN THE MINE STUDY AREA, 2010

PHOTO 1: Alpine Dry Barrens at plot PM2043 (ABR wildlife habitat dataset), August 2005.

ALPINE DRY BARRENS

Physiography and occurrence:	Alpine: Common on ridge crests, steep upper slopes, rocky cliffs, and talus slopes.
Vegetation structure and composition:	Typically barren (less than 5 percent vegetation cover) or partially vegetated (5–30 percent cover), in a mosaic of barren and vegetated patches. When present, vegetation is composed of scattered dwarf shrubs (less than 0.2 meter in height), alpine cushion plants, and alpine forbs including *Empetrum nigrum, Salix arctica, Vaccinium uliginosum, Salix phlebophylla, Dryas octopetala, Diapensia lapponica,* and *Oxyria digyna*.
Substrate and drainage:	Rocky, extremely well-drained with little or no organic accumulation.

PHOTO 2: Alpine Moist Dwarf Scrub at plot PM410 (ABR wildlife habitat dataset), August 2004.

ALPINE MOIST DWARF SCRUB

Physiography and occurrence:	Alpine: Widely distributed on middle and upper slopes at higher elevations in the mine study area. Typically interspersed with Alpine Moist Graminoid–Forb Meadow.
Vegetation structure and composition:	Vegetation structure is dominated by dwarf shrubs (less than 0.2 meter in height) and lichens. Consists of dwarf-shrub communities variously dominated by *Empetrum nigrum, Vaccinium uliginosum, Loiseleuria procumbens, Luetkea pectinata, Betula nana, Salix reticulata, Dryas octopetala,* and often trace amounts of graminoids such as *Vahlodea atropurpurea* and *Calamagrostis canadensis*. These communities often are dominated by lichens.
Substrate and drainage:	Rocky and well-drained with little organic accumulation.

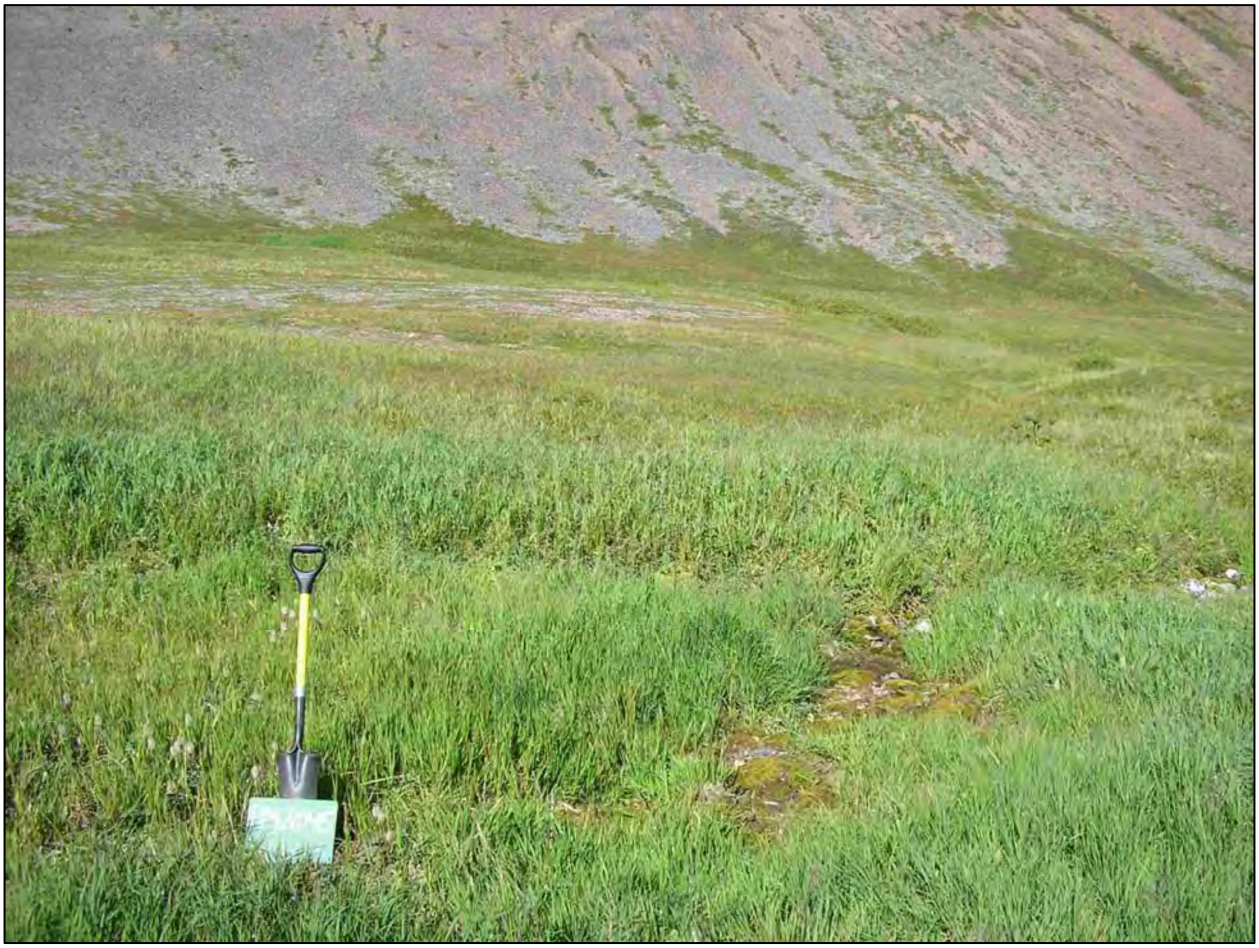


PHOTO 3: Alpine Moist Graminoid–Forb Meadow at plot PM410 (ABR wildlife habitat dataset), August 2004.

ALPINE MOIST GRAMINOID–FORB MEADOW

Physiography and occurrence:	Alpine: Patchy distribution at higher elevations on ridge crests and middle and lower slopes; interspersed with dwarf-scrub and barren vegetation types.
Vegetation structure and composition:	An herbaceous vegetation type composed of graminoids and forbs. Communities are dominated by the grass, *Calamagrostis canadensis*, with co-dominant forbs including *Sanguisorba canadensis, Angelica lucida, Trientalis europaea,* and *Geranium erianthum*. Dwarf and/or low shrubs (less than 0.2 and 0.2–1.5 meters in height, respectively) often are present, but are not dominant; species such as *Vaccinium uliginosum* and *Empetrum nigrum* are typical.
Substrate and drainage:	Moist loamy soils.

PHOTO 4: Alpine Wet Dwarf Shrub–Sedge Scrub at plot PM409 (ABR wildlife habitat dataset), August 2004.

ALPINE WET DWARF SHRUB–SEDGE SCRUB

Physiography and occurrence:	Alpine: Poor fens or bogs occurring in depressions and on low slopes in high alpine valleys.
Vegetation structure and composition:	Mosses (largely *Sphagnum* spp.) are dominant. A dwarf-shrub and graminoid (especially sedge) canopy occurs above the mosses. Dwarf shrubs (less than 0.2 meter in height) include *Vaccinium uliginosum, Betula nana, Andromeda polifolia*, and *Salix fuscescens*. Common sedge species occurring as co-dominants include *Carex aquatilis* and *Carex rariflora*. A common associated forb species is *Comarum palustre*.
Substrate and drainage:	Well-developed and wet organic (peat) layer is present in all cases.

PHOTO 5: Upland Dry Barrens at plot PM416 (ABR wildlife habitat dataset), August 2004.

UPLAND DRY BARRENS

Physiography and occurrence:	Upland: Occurs primarily on glacially modified surfaces including scoured bedrock exposures, dry drained kettle depressions, colluvium deposits, and valley-floor moraine deposits. Artificial fill is included in this type.
Vegetation structure and composition:	Vegetation generally absent (less than 5 percent cover). Where present, vegetation is dominated by foliose and fruticose lichens and trace amounts of dwarf ericaceous shrubs.
Substrate and drainage:	Unconsolidated, extremely well-drained rock and gravel.

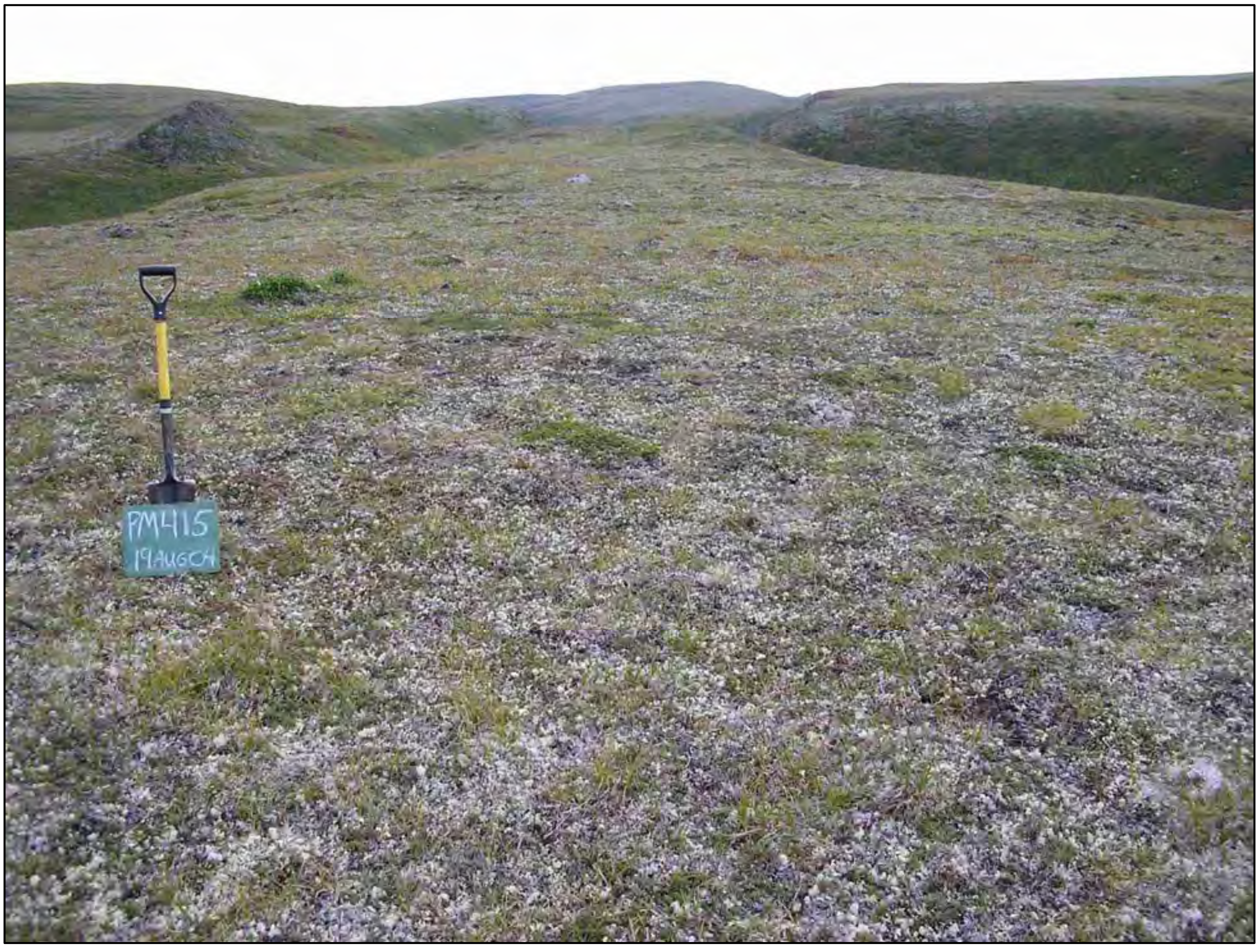


PHOTO 6: Upland Dry Dwarf Shrub–Lichen Scrub at plot PM415 (ABR wildlife habitat dataset), August 2004.

UPLAND DRY DWARF SHRUB–LICHEN SCRUB

Physiography and occurrence: Upland: Occurs primarily on glacially modified surfaces and especially raised ridges within widespread valley-bottom moraine deposits throughout the mine study area.

Vegetation structure and composition: Dwarf ericaceous shrubs (less than 0.2 meter in height) are more or less co-dominant with crustose and foliose lichens; barren patches are common. Dominant dwarf-shrub species include *Dryas octopetala, Empetrum nigrum, Betula nana*, and *Loiseleuria procumbens*. Common, co-dominant lichen species noted were *Cladina stellaris, Flavocetraria nivalis*, and *Cetraria islandica*. Forbs and graminoids occur in trace amounts.

Substrate and drainage: Rocky and well-drained with very little organic accumulation.

PHOTO 7: Upland Moist Dwarf Scrub at plot PM2058 (ABR wildlife habitat dataset), August 2004.

UPLAND MOIST DWARF SCRUB

Physiography and occurrence:	Upland: Occurs primarily on glacially modified surfaces in the mine study area, especially valley-bottom moraine deposits and low mountain slopes.
Vegetation structure and composition:	Dwarf ericaceous shrubs (less than 0.2 meter in height) are strongly dominant. Generally mesic communities variously dominated by *Empetrum nigrum, Betula nana*, or prostrate willows. Co-dominant dwarf shrubs include *Vaccinium uliginosum, Loiseleuria procumbens, Ledum decumbens*, and *Salix glauca*. Mosses and lichens are common.
Substrate and drainage:	Well-drained, often significant organic accumulation over rock or cobbles.

PHOTO 8: Upland Moist Low Willow Scrub at plot PM211 (ABR wildlife habitat dataset), August 2004.

UPLAND MOIST LOW WILLOW SCRUB

Physiography and occurrence: Upland: Occurs primarily on glacially modified surfaces including middle and lower slope concavities and in glacial moraine depressions.

Vegetation structure and composition: Open (25–75 percent cover) to closed (greater than 75 percent cover) canopy of low willows (0.2–1.5 meters in height). Dominated by *Salix pulchra, Salix reticulata*, and *Salix richardsonii* with a largely herbaceous understory including *Equisetum arvense, Geranium erianthum,* and *Heracleum maximum*.

Substrate and drainage: Poorly to moderately well-drained; moist to rarely wet loamy soils.

PHOTO 9: Upland Moist Tall Alder Scrub at plot PM2057 (ABR wildlife habitat dataset), August 2005.

UPLAND MOIST TALL ALDER SCRUB

Physiography and occurrence: Upland: Occurs primarily on glacially modified surfaces, especially low to moderately steep upper and lower slopes throughout the mine study area.

Vegetation structure and composition: Includes open (25–75 percent cover) and closed (greater than 75 percent cover) canopies of tall alders (greater than 1.5 meters in height). Most stands are dominated by *Alnus sinuata*, but some also may have willow co-dominants and patches of low shrub. Understory species include *Salix pulchra, Dryopteris dilatata, Gymnocarpium dryopteris, Oplopanax horridus, Athyrium filix-femina, Spiraea stevenii, Rubus spectabilis*, and *Calamagrostis canadensis*.

Substrate and drainage: Common soils are moderately well-drained loams.

PHOTO 10: Upland Moist Tall Willow Scrub at plot PM2536 (ABR wildlife habitat dataset), August 2005.

UPLAND MOIST TALL WILLOW SCRUB

Physiography and occurrence:	Upland: Occurs primarily on glacially modified surfaces, especially low to moderately steep upper and lower slopes throughout the mine study area.
Vegetation structure and composition:	Includes open (25–75 percent cover) and closed (greater than 75 percent cover) canopies of tall willows (greater than 1.5 meters in height); occasionally includes patches of low willows (0.2–1.5 meters in height). Dominant willow species include *Salix pulchra, Salix richardsonii*, and *Salix barclayi*. Understory species include *Alnus sinuata, Oplopanax horridus*, and *Calamagrostis canadensis*.
Substrate and drainage:	Soils are moderately well-drained loams.

PHOTO 11: Upland and Lowland Spruce Forest at plot PR2169 (ABR wildlife habitat dataset), August 2005.

UPLAND AND LOWLAND SPRUCE FOREST

Physiography and occurrence:	Occurs in both Upland and Lowland areas in the mine studies region. Found rarely in the mine study area; concentrated in the east near the boundary with the transportation-corridor, Bristol Bay drainages study area.
Vegetation structure and composition:	Generally a woodland type (less than 25 percent cover), but includes patches of open forest (25–75 percent cover). Dominant tree species is *Picea glauca*. In some cases, *Betula kenaica* or *Betula occidentalis* occur as tall shrubs or small trees in the woodland openings; rarely dwarf *Picea glauca* occur. The understory is dominated by *Ledum decumbens* and *Empetrum nigrum*. Foliose lichens such as *Cladina stellaris* may be present. In lowland and less well-drained areas, *Picea mariana* can occur in mixed stands with *Picea glauca*.
Substrate and drainage:	Well-developed surface organics over loam or sandy loam.

PHOTO 12: Upland and Lowland Mixed Forest at plot PR2575 (ABR wildlife habitat dataset), August 2005.

UPLAND AND LOWLAND MOIST MIXED FOREST

Physiography and occurrence:	Occurs in both Upland and Lowland areas in the mine studies region. Upland: Found rarely in the mine study area; concentrated in the east on raised moraine deposits near the boundary with the transportation-corridor, Bristol Bay drainages study area. Lowland: Abandoned or inactive floodplains or kettle depressions to the east of the mine study area.
Vegetation structure and composition:	Upland: Includes open (25–60 percent cover) and closed (60–100 percent cover) forest types; generally dominated by *Betula kenaica,* with *Populus balsamifera, Populus trichocarpa*, and *Picea glauca* as co-dominants. Common understory shrubs include *Alnus sinuata, Menziesia ferruginea, Vaccinium uliginosum, Empetrum nigrum*, and *Cornus suecica*. Lowland: Includes open (25–60 percent cover) and woodland (less than 25 percent cover) forest types as well as dwarf-tree forests. Typically dominated by *Picea glauca*, but may include *Picea mariana* in wetter sites. Common understory shrubs include *Betula nana, Menziesia ferruginea, Myrica gale, Empetrum nigrum*, and *Ledum groenlandicum*.
Substrate and drainage:	Well-developed surface organics over loam or sandy loam.

PHOTO 13: Rivers and Streams (Anadromous) at plot PM19, North Fork Koktuli River (ABR avian point count dataset), June 2004.

RIVERS AND STREAMS; RIVERS AND STREAMS (ANADROMOUS)

Physiography and occurrence:	Riverine: Permanently flooded river channels.
Vegetation structure and composition:	Stream channel morphology varies significantly throughout the mine study area. Anadromous stream designation is based on data from the Alaska *Anadromous Waters Catalog* (ADF&G, 2010), which lists the presence of salmon by stream section.
Substrate and drainage:	Permanently flooded channels with bottoms of unconsolidated fine sediments, gravel, cobbles, or larger rocks.

PHOTO 14: Riverine Barrens at plot 3PP8047 (photo courtesy of Three Parameters Plus, Inc.), July 2006.

RIVERINE BARRENS

Physiography and occurrence:	Riverine: Discrete areas on point bars or interfluvial islands; typically along larger stream channels.
Vegetation structure and composition:	Vegetation absent or nearly so (less than 5 percent cover) or partially vegetated (5–30 percent cover).
Substrate and drainage:	Extremely well-drained sands and gravels.

PHOTO 15: Riverine Wet Graminoid–Shrub Meadow at plot PM239 (ABR wildlife habitat dataset), August 2004.

RIVERINE WET GRAMINOID–SHRUB MEADOW

Physiography and occurrence:	Riverine: Bordering rivers and streams throughout the mine study area; occurs in active floodplains.
Vegetation structure and composition:	Strongly dominated by graminoid plants. Grass-dominated communities have extensive cover of *Calamagrostis canadensis*, but also include *Carex aquatilis, Salix pulchra, Chamerion angustifolium*, and *Equisetum arvense*. Sedge-dominated communities, often on wetter sites, include *Carex utriculata, Carex lyngbyei*, *Comarum palustre, Calmagrotis canadensis, Salix fuscescens*, and *Salix pulchra*.
Substrate and drainage:	Soils are wet and loamy with substantial organic accumulation.

PHOTO 16: Riverine Low Willow Scrub at plot PM238 (ABR wildlife habitat dataset), August 2004.

RIVERINE LOW WILLOW SCRUB

Physiography and occurrence:	Riverine: Commonly occurs on interfluvial islands or flat banks within active floodplains throughout the mine study area.
Vegetation structure and composition:	Most occurrences of this type have an open canopy (25–75 percent cover) of low shrubs (0.2–1.5 meters in height). The most common willow species include *Salix pulchra, Salix barclayi, Salix richardsonii*, and *Salix alaxensis*. Understory species include graminoids and herbs: *Calamagrostis canadensis, Carex utriculata, Equisetum arvense*, and *Comarum palustre*. This type also includes plant communities dominated by low *Myrica gale* instead of willows; the vegetation structure is the same in the two communities.
Substrate and drainage:	Soils are moderately well-drained loams to sandy loams.

PHOTO 17: Riverine Tall Alder or Willow Scrub at plot PM2188 (ABR wildlife habitat dataset), September 2005.

RIVERINE TALL ALDER OR WILLOW SCRUB

Physiography and occurrence:	Riverine: Occurs in active floodplains throughout the mine study area.
Vegetation structure and composition:	Generally consists of a closed canopy (greater than 75 percent cover) of tall-shrubs (greater than 1.5 meters in height); may have 5–10 percent cover of overtopping broadleaf tree species in some sites, especially to the east of the mine study area. Alder sites are dominated by *Alnus sinuata*. Willow sites are dominated by *Salix alaxensis, Salix pulchra, Salix barclayi*, and *Salix richardsonii*. Other broadleaf woody species include *Populus balsamifera*, *Populus trichocarpa*, and *Betula kenaica*. Herbs commonly present are *Chamerion angustifolium, Athyrium filix-femina*, and *Artemisia tilesii*.
Substrate and drainage:	Soils are moderately well-drained sands and gravels, frequently found with evidence of flooding.

PHOTO 18: Riverine Moist Mixed Forest at plot PR2640 (ABR wildlife habitat dataset), September 2005.

RIVERINE MOIST MIXED FOREST

Physiography and occurrence:	Riverine: Occurs in active floodplains along Upper Talarik Creek.
Vegetation structure and composition:	Variously dominated by *Populus balsamifera* and *Populus trichocarpa* or *Betula kenaica* with *Picea glauca* as a co-dominant. Understory species include *Alnus sinuata, Salix barclayi, Gymnocarpium dryopteris*, and *Calamagrostis canadensis*.
Substrate and drainage:	Soils are well-drained with layered sands and often buried organic layers indicative of flooding events.

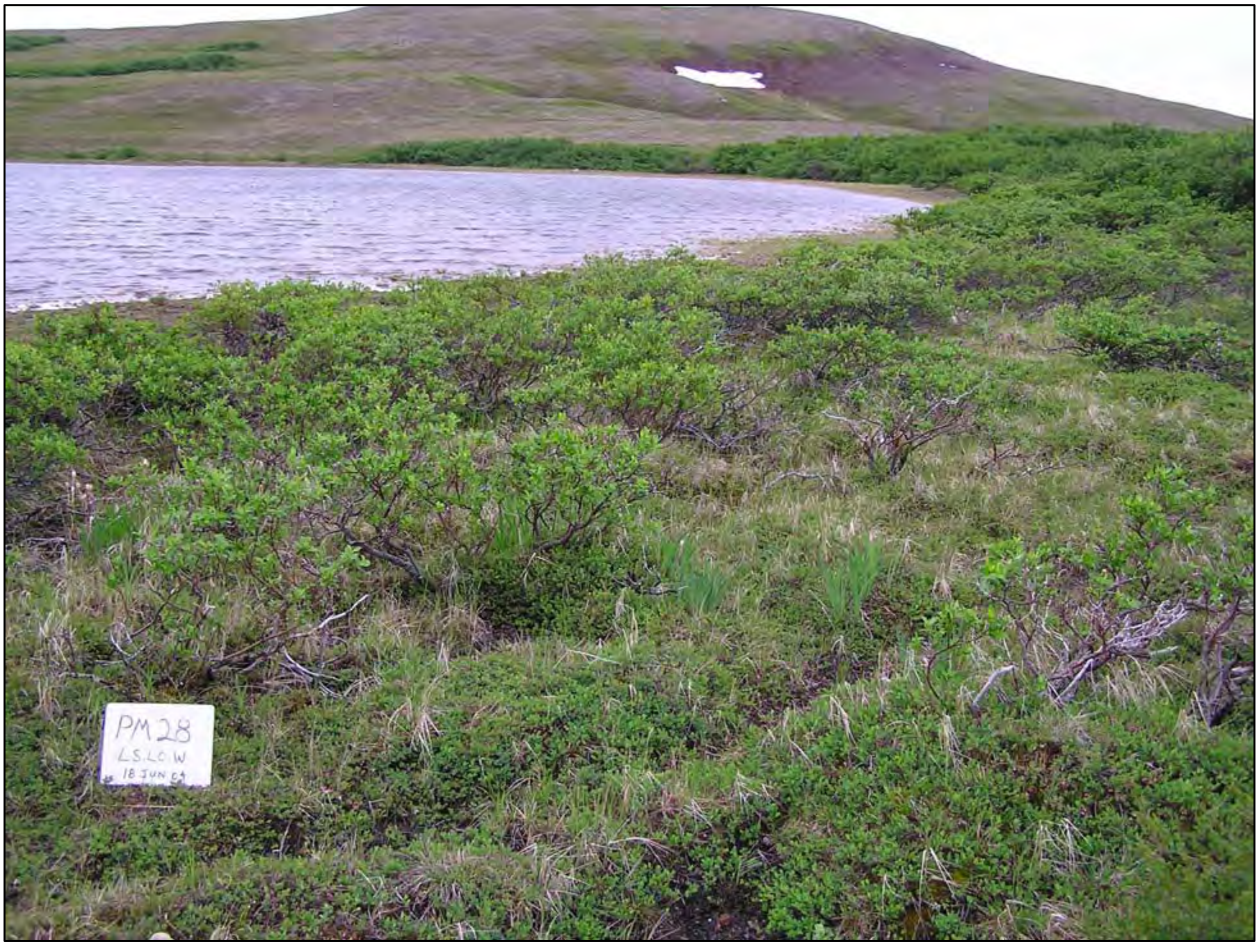


PHOTO 19: Lakes and Ponds at plot PM029a (ABR avian point count dataset), June 2005.

LAKES AND PONDS

Physiography and occurrence:	Lacustrine: Kettle lakes and ponds and alpine lakes throughout the mine study area.
Vegetation structure and composition:	None
Substrate and drainage:	Permanently flooded to seasonally flooded shallow waterbodies (some small ponds drain in late summer; see Lacustrine Moist Barrens below).

PHOTO 20: Lacustrine Moist Barrens at plot PM2054 (ABR wildlife habitat dataset), August 2005.

LACUSTRINE MOIST BARRENS

Physiography and occurrence:	Lacustrine: Occurring on pond margins and in basins of seasonally flooded ponds in kettle depressions throughout the region of moraine deposits in the mine study area.
Vegetation structure and composition:	Vegetation absent or nearly so (less than 5 percent cover) or partially vegetated (5–30 percent cover).
Substrate and drainage:	Seasonally flooded, well-drained with no organic accumulation.

PHOTO 21: Lowland Sedge–Forb Marsh at plot PM2194 (ABR wildlife habitat dataset), September 2005.

LOWLAND SEDGE–FORB MARSH

Physiography and occurrence:	Lowland: Permanently flooded depressions found in lowland areas or along the margins of kettle lakes.
Vegetation structure and composition:	Herbaceous-dominated type. May be graminoid or forb-dominated with various plant communities. Common species include *Carex aquatilis, Carex rostrata, Carex utriculata, Arctophila fulva, Equisetum fluviatile, Hippuris vulgaris*, and *Menyanthes trifoliata*.
Substrate and drainage:	Flooded organics.

PHOTO 22: Lowland Ericaceous Scrub Bog at plot PM2096 (ABR wildlife habitat dataset), August 2005.

LOWLAND ERICACEOUS SCRUB BOG

Physiography and occurrence: Lowland: Occurs in depressions and on low slopes throughout the mine study area; sometimes adjacent to riverine floodplains.

Vegetation structure and composition: Wet communities typically dominated by ericaceous dwarf and low shrubs (less than 0.2 and 0.2–1.5 meters in height, respectively). Plant communities dominated by ericaceous shrubs or *Myrica gale*, or occasionally, these shrubs are co-dominant with sedge tussocks. Common species include *Vaccinium uliginosum, Empetrum nigrum, Ledum decumbens, Salix fuscescens, Betula nana, Myrica gale*, and *Andromeda polifolia*. Commonly occurring graminoids include *Calamagrostis canadensis, Carex aquatilis, Carex rariflora*, and *Eriophorum vaginatum*. Various *Sphagnum* moss species are common.

Substrate and drainage: Organic accumulation is moderate with peat layers often occurring above rocky substrates. Surface water is common; poorly drained.

PHOTO 23: Lowland Wet Graminoid–Shrub Meadow at plot PM224 (ABR wildlife habitat dataset), August 2004.

LOWLAND WET GRAMINOID–SHRUB MEADOW

Physiography and occurrence: Lowland: Occurs on low-lying features such as concave toe-slopes and kettle depressions; common within valley-bottom wetland complexes.

Vegetation structure and composition: Graminoids and dwarf shrubs (less than 0.2 meter in height) are co-dominant. Common graminoid species include *Carex aquatilis, Trisetum caespitosum, Calamagrostis canadensis*, and *Eriophorum chamissonis*. Common dwarf shrubs include *Empetrum nigrum* and *Betula nana*. Associated forbs include *Eriophorum angustifolium* and *Comarum palustre*. *Sphagnum* moss species are common and sometimes provide substantial cover. Rarely included in this type are patches of more well-drained, moist meadows dominated by graminoids and dwarf shrubs.

Substrate and drainage: Soils are wet to moist, with substantial organic accumulation. Surface water is generally present.

PHOTO 24: Lowland Low and Tall Willow Scrub at plot PM228 (ABR wildlife habitat dataset), August 2004.

LOWLAND LOW AND TALL WILLOW SCRUB

Physiography and occurrence:	Lowland: Often occurs in swales and other low-lying areas bordering active or inactive riverine features.
Vegetation structure and composition:	Shrub canopy ranges from open (25–75 percent cover) to closed (greater than 75 percent cover). Shrub heights are mixed with both low (0.2–1.5 meters) and tall (greater than 1.5 meters) shrubs occurring. Dominant willow species include *Salix barclayi, Salix alaxensis, Salix pulchra* and *Salix richardsonii*. The understory is commonly herbaceous and includes *Calamagrostis canadensis, Aconitum delphinifolium, Chamerion angustifolium*, and *Heracleum maximum*.
Substrate and drainage:	Soils are moist and loamy; moderately well-drained.

APPENDIX 16.1C

WILDLIFE HABITAT VALUES FOR A SELECTED SET OF BIRD AND MAMMAL SPECIES OF CONCERN, MINE STUDY AREA, 2010

Wildlife Habitat Values for a Selected Set of Bird and Mammal Species of Concern, Mine Study Area, 2010 [a, b]

Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Moist Graminoid–Forb Meadow	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
Birds																									
Tundra Swan [c]	0	0	0	0	0	**3**	**3**	1	0	0	0	0	**2**	**2**	0	**2**	1	0	0	**3**	0	**3**	**2**	**3**	1
Harlequin Duck [c]	0	0	0	0	0	0	0	0	0	0	0	0	**3**	**3**	**2**	3	3	2	2	*1*	0	*1*	*1*	*1*	*1*
Surf Scoter [c]	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	**3**	0	0	0	0	0
Black Scoter [c]	0	0	0	0	0	*1*	3	2	0	0	0	0	0	0	0	*1*	*1*	0	0	**3**	0	3	3	3	*1*
Long-tailed Duck [c]	0	0	0	0	0	2	3	3	0	0	0	0	1	1	0	*2*	*2*	0	0	**3**	0	3	3	3	*1*
Willow Ptarmigan	0	**3**	0	0	0	0	**3**	**3**	**3**	**3**	0	0	0	0	0	1	2	2	0	0	0	0	**2**	1	**3**
Rock Ptarmigan	3	**3**	0	0	2	**2**	**2**	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-throated Loon	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	**2**	0	1	0	1	0
Common Loon	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**3**	0	**3**	1	3	0
Bald Eagle	*0*	1	1	1	*0*	1	1	1	0	0	1	1	**2**	**3**	2	1	1	*0*	**3**	**2**	1	1	1	1	*0*
Northern Goshawk	*0*	*0*	*0*	*0*	*0*	*0*	*0*	1	*0*	*0*	1	2	1	1	1	1	1	1	3	1	0	1	1	1	1
Golden Eagle	**3** [d]	**2**	**2**	**2**	**2**	**3**	**3**	**3**	1	1	1	2	**2** [d]	**2** [d]	1	2	1	1	1	*1*	1	2	2	2	2
Merlin	*1*	1	1	1	*1*	1	1	1	2	1	2	2	2	**2**	1	2	1	1	**3**	2	1	1	1	1	1
Gyrfalcon	**3** [d]	3	2	2	1	3	2	2	*0*	*0*	1	1	**2** [d]	**2** [d]	1	2	2	1	1	1	1	2	2	2	2
Peregrine Falcon	*1*	0	0	0	*1*	1	1	1	0	0	1	1	2 [d]	2 [d]	1	1	1	1	1	2	*1*	1	1	1	1
American Golden-Plover	0	**3**	0	2	0	**3**	**3**	0	0	**1**	0	0	0	0	0	0	0	0	0	0	*1*	0	**3**	3	0
Lesser Yellowlegs	0	0	0	0	0	0	0	0	0	0	2 [e]	0	2	2	0	2	1	2	0	3	*1*	3	**3**	3	2
Whimbrel	0	0	0	0	0	0	**2**	1	0	0	0	0	0	0	0	2	1	0	0	0	0	0	**3**	**3**	**1**
Hudsonian Godwit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0	**3**	**3**	**3**	0
Surfbird	**3**	**3**	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Short-billed Dowitcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0	**3**	**3**	**3**	0
Arctic Tern	0	0	0	0	0	0	0	0	0	0	0	0	1	**3**	2	2	0	0	0	**3**	0	0	1	2	0
Great Horned Owl	0	0	0	0	0	0	0	0	0	0	1	2	1	1	0	0	1	0	**3**	0	0	0	1	1	0
Gray-cheeked Thrush	0	0	0	0	0	0	0	**2**	**3**	**3**	0	0	0	0	0	**1**	**2**	**2**	0	0	0	0	0	0	**2**
Blackpoll Warbler	0	0	0	0	0	0	0	**1**	**1**	**2**	0	**2**	0	0	0	0	**1**	**3**	0	0	0	0	0	0	**2**
Mammals																									
Wolf	1	**2**	2	2	1	2	**2**	2	1	2	2	2	1	2	1	2	2	**2**	2	1	2	1	2	2	2
Red fox	1	1	1	2	1	1	1	2	1	2	2	2	1	2	1	2	2	2	2	1	1	1	2	2	2
River otter	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	2	2	2	2	**3**	2	1	1	1	1
Wolverine	1	**2**	2	2	1	**2**	2	2	2	2	2	2	1	2	1	2	2	2	**2**	1	1	2	2	2	2

Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Moist Graminoid–Forb Meadow	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
Brown bear	**1**	**2**	**2**	2	1	**2**	**2**	**2**	**2**	**2**	2	**2**	**2**	**3**	1	2	**2**	**2**	**2**	**1**	2	2	**2**	**2**	2
Moose	0	0	0	0	0	0	0	1	**2**	**3**	**2**	**2**	1	1	1	2	**3**	3	3	**3**	2	2	2	2	**3**
Caribou	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	2	1	**1**	1	1	**2**	**1**	**1**	1	**1**	2	2	**2**	**2**	**1**
Arctic ground squirrel	2	2	2	2	1	3	2	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Red squirrel	0	0	0	0	0	0	0	0	*1*	0	3	3	0	0	0	0	0	*1*	2	0	0	0	0	0	0
Beaver	0	0	0	0	0	0	0	0	0	0	0	**2**	**3**	**3**	**1**	**3**	**3**	**3**	**3**	**2**	**1**	0	0	**1**	**1**
Northern red-backed vole	0	1	1	1	0	1	1	2	2	2	3	3	0	0	0	1	2	2	3	0	0	1	2	1	1
Tundra vole	0	1	3	2	0	0	1	2	2	2	1	1	0	0	0	3	2	2	1	0	0	2	2	3	2
Snowshoe hare	0	0	0	0	0	0	1	2	2	2	3	2	0	0	0	0	2	3	2	0	0	0	1	0	3

Notes:

a. See Methods text (Section 16.1.6.3) and Table 16.1-1 for information on how species of concern were selected.

b. Key to habitat-value codes: 3 = high, 2 = moderate, 1 = low, 0 = negligible; data quality indicated by font type as data-supported from project-specific data and scientific literature (bold), partially data-supported from literature only (regular), and professional judgment (italic).

c. Nesting by these waterfowl species in upland and lowland habitats occurs more commonly when those habitats occur in association with lacustrine waterbodies.

d. Nesting by these raptor species can occur in these habitats only in areas where suitable cliffs occur.

e. Breeding by Lesser Yellowlegs in Upland and Lowland Spruce Forest will occur only in wetter, lowland settings.

16.2 Terrestrial Mammals—Mine Study Area

16.2.1 Introduction

Based on historical reports (Osgood, 1904; Schiller and Rausch, 1956; Cahalane, 1959) and recent field inventories (Cook and MacDonald, 2004a, 2004b; Jacobsen, 2004; MacDonald and Cook, 2009), 40 species of mammals are known (or are strongly suspected) to occur in the geographic region of the Bristol Bay drainages in which the Pebble mine study area is located (Appendix 16.2A).

The caribou is the most abundant large mammal in the region of the Bristol Bay drainages and is harvested in the largest numbers by both subsistence and sport hunters. The mine study area is located within the annual range of the Mulchatna Caribou Herd (MCH), one of the larger herds in the state. Other species of large mammals are ecologically and economically important inhabitants of the region. Brown bears are abundant in southwestern Alaska, and black bears occur in the northern portion of the region in lower densities. Moose occur throughout the region in low densities, and winter concentrations have been noted previously in the Upper Talarik Creek drainage on the east side of the mine study area (Alaska Department of Fish and Game [ADF&G], 1985). These species were of primary interest for the Pebble Project surveys, but all mammal species encountered incidentally, such as gray wolf and other large species of furbearers, were recorded. Another source of mammal observations was incidental sightings during surveys of waterfowl, raptors, and breeding birds, also conducted for the Pebble Project.

No surveys were conducted specifically for furbearers (except for beavers) or small mammals because of the availability of furbearer harvest data (Schwartz, 2006) and recent inventory surveys conducted in Lake Clark and Katmai national parks and preserves for the National Park Service (NPS; Cook and MacDonald, 2004a, 2004b) and in the area northwest of Iliamna Lake and in the Kvichak and Nushagak river drainages for the Bureau of Land Management (BLM; Jacobsen, 2004).

The following discussion summarizes the terrestrial mammal surveys conducted in the mine study area for the Pebble Project during 2004 through 2010.

16.2.2 Study Objective

The study objective established for terrestrial mammal surveys was to characterize the distribution and abundance of caribou, bears, moose, and other species of large mammals in the study area at various biologically important times of the year, including estimation of the population densities of bears and moose.

16.2.3 Study Area

The study area for the mammal studies varied depending upon the target species. Some studies were focused on the mine study area which encompasses the drainages of the north and south forks of the Koktuli River and Upper Talarik Creek. Other studies extended along the transportation corridor which generally follows the northern shore of Iliamna Lake east to the Chigmit Mountains, and some studies were more regional in nature. Specific study areas are explained below.

Large mammals were studied within the mine study area along aerial strip-transect surveys (Figure 16.2-1A) established in a 477-square-kilometer (km^2) area that encompassed the deposit area. The transect-survey area was chosen when surveys began in April 2004. Several survey transects were lengthened in 2005 to square up the eastern side of the transect-survey area. Active beaver colonies were surveyed throughout the mine study area in October 2005. Surveys covered the drainages of Upper Talarik Creek and the north and south forks of the Koktuli River (downstream to their confluence), as well as tundra ponds within the mine study area (Figure 16.2-1A).

Bear were surveyed along salmon-spawning streams in and south of the mine study area in August 2004 (Figure 16.2-1B). The stream-survey area included the north and south forks of the Koktuli River and extended from the mine study area south to Iliamna Lake, and east to the Newhalen River. This coverage provided a broad perspective on bear abundance in the area surrounding the Pebble Deposit by taking advantage of the occurrence of seasonal congregations of brown bears feeding along anadromous fish streams.

An aerial survey for moose density was conducted in April 2010 in the mine and transportation corridor study areas (Figure 16.2 -1B). The entire survey area was divided into 146 sample units that were approximately equal in size (5 minutes of longitude by 2 minutes of latitude, totaling 17.4 km^2) using a regional grid developed by ADF&G (Kellie and DeLong, 2006). Areas considered to be unsuitable as winter moose habitat were excluded from the survey area including Iliamna Lake and high-elevation terrain above 915 meters (3,000 feet). Lands within Lake Clark National Park and Preserve were excluded and sample units near the communities of Iliamna, Newhalen, Nondalton, and Pedro Bay were removed from the survey area because of concerns about aircraft disturbance to local communities.

Line-transect survey methods were used to estimate the population density of bears in the region surrounding Iliamna Lake (Becker, 2010). The study area was delineated by the northern and southern edges of the Iliamna Lake watershed, the spine of the Chigmit Mountains on the east, and an unnamed watershed and the Koktuli watershed on the west (Figure 16.2-1B).

For depiction and analysis of radio-telemetry data for the Mulchatna Caribou Herd (MCH), an area somewhat larger than the mine study area—called the greater mine study area—was used, encompassing the area west of the Newhalen River in the upper portions of both forks of the Koktuli River drainage, the Upper Talarik Creek drainage, and the headwaters of Kaskanak Creek (Figure 16.2-2).

The mine study area includes portions of two state Game Management Units (GMUs): 17B and 9B. The boundary between the two units is the watershed divide between the Koktuli River and Upper Talarik Creek drainages.

16.2.4 Previous Studies

Most of the available information on the distribution and abundance of mammals in the mine study area comes from studies done by or for government resource agencies, such as population survey and inventory studies by the ADF&G (e.g., ADF&G, 1985; Butler, 2006, 2007a, 2007b, 2008; Woolington, 2006, 2007a, 2007b, 2010) and NPS studies nearby (e.g., Bennett, 1996; unpublished file reports at Lake Clark National Park and Preserve). Under an agreement with Cominco Alaska Exploration, ADF&G surveys focused specifically on the area of the Pebble Deposit in the early 1990s (Boudreau et al., 1992; Van Daele and Boudreau, 1992; Van Daele, 1994). Some other surveys (Smith, 1991) were conducted for

Cominco at that time when the Pebble Deposit was first being evaluated. Other studies in the region in recent years were conducted as part of broad-scale species inventories by NPS and BLM, emphasizing small mammals (Cook and MacDonald, 2004a, 2004b; Jacobsen, 2004); the BLM study included several sites near the mine study area.

16.2.5 Scope of Work

Field surveys were conducted periodically during April through November 2004, March through December 2005, May through July and in December 2006, June through July 2007, May 2009, and April 2010. The mammal surveys were conducted by Brian Lawhead and Alexander Prichard, supported by various other biologists from ABR, Inc. Raymond Wassillie and James Lamont of Newhalen provided the benefit of their local knowledge as participants in surveys in August and October 2004 and in May 2005. Earl Becker of ADF&G designed and led the bear population survey in May 2009, using observers from both ADF&G and ABR.

The bear survey in 2009 and moose survey in 2010 were designed to estimate the density of those species in their respective study areas. Other aerial surveys were intended to obtain information on distribution, relative abundance, and general patterns of use of the study area by large mammals, rather than to derive detailed population estimates. Regional population estimation is conducted by ADF&G and requires substantially greater survey effort over larger areas for a meaningful assessment. Thus, the surveys described here complement, rather than duplicate, ADF&G population surveys.

Specific work elements included the following tasks:

- Collection and review of relevant literature on all species of mammals inhabiting the region around the deposit.
- Acquisition and analysis of radio-telemetry data for the MCH.
- Aerial strip-transect surveys within the mine study area during late winter, caribou calving, caribou postcalving, caribou rut/fall migration, and early winter.
- Aerial line-transect survey to estimate the population density of bears in the Iliamna Lake region.
- Aerial survey of brown bears along salmon-spawning streams and examination of dens of brown bears and gray wolves in and near the mine study area.
- Aerial quadrat survey to estimate the population density of moose in the mine and transportation corridor study areas.
- Aerial survey of beaver colonies throughout the mine study area.
- Collection of wildlife observations by other Pebble Project personnel.

16.2.6 Methods

16.2.6.1 Analysis of Telemetry Data on Mulchatna Caribou Herd

Telemetry Data Set

For about 30 years, radio-telemetry data have been collected through cooperative survey efforts involving state and federal agencies: ADF&G, Togiak National Wildlife Refuge (NWR), Yukon Delta NWR, NPS, and BLM (Hinkes et al., 2005). Most of those data consisted of point locations of caribou that were collared with standard VHF (very high frequency) radio transmitters, which were tracked by agency biologists flying in small airplanes. In later years, some satellite collars were deployed; those collars broadcast signals that were received by polar-orbiting satellites. Permission to analyze the MCH telemetry data set for this Pebble baseline characterization was obtained from the MCH Technical Working Group (MCHTWG) at its annual meeting in Dillingham in January 2005. The MCHTWG data set used for this analysis totaled 21,128 locations, comprising 10,430 locations of VHF (very high frequency)-collared caribou, 4,141 locations of satellite-collared caribou, and 6,557 locations of uncollared caribou observed during radio-tracking flights. Of the 14,571 telemetry locations (VHF and satellite samples combined), 2,373 collared caribou locations were excluded for various reasons: 1,169 were from the Kilbuck Herd or unknown herd animals before 1995 (see below), 351 were capture locations, 561 were known or suspected mortality locations, 252 had no latitude and longitude coordinates, and 40 were satellite-collar locations with low accuracy ratings. Excluding those locations left a total of 12,198 locations of radio-collared caribou to be used in spatial analyses for this report.

The VHF-collar sample comprised 468 caribou (373 females and 95 males) collared from March 1981 through October 2009, averaging 17.6 good locations and 2.7 years per collar. The satellite-collar sample comprised caribou collared in 1990 (five caribou, of which one was a male; two other collars had only one location each), 2005 (ten females), 2006 (three females), 2007 (seven females), 2008 (three females), and 2009 (six females).

The observations of uncollared caribou were recorded during aerial telemetry surveys. Because the latter observations were not collected systematically and did not include known individuals, they were not used in the spatial analysis described under the next heading. They did provide useful anecdotal observations of large groups of caribou in and near the greater mine study area, however.

Spatial Analysis of Distribution and Range Use

One location was selected for each collared caribou (VHF or satellite) from the MCH during the calving period, and one location per month was selected for all other seasons. The fixed-kernel distribution analysis for calving was conducted using adult (>1-year-old) females only, whereas all other fixed-kernel distributions were conducted on all collared caribou. The data set was reduced somewhat by removing all locations recorded as mortalities, all observations of uncollared caribou, and all data from the Kilbuck Herd to the west (Hinkes et al., 2005) or recorded as “unknown herd.” Kilbuck and unknown herd animals were included after 1994 when those herds joined with the larger MCH, except that four animals that continued to follow typical Kilbuck Herd patterns were excluded (Aderman, 2008).

One location per month was selected to ensure that no autocorrelation occurred among locations and because the number of relocations varied widely among caribou and years. By selecting only one location for each animal per month, no single individual could have an undue influence on the results just because it was relocated more frequently than other individuals (e.g., satellite-collar locations were gathered much more frequently than were VHF-collar locations). VHF-collar relocation flights did not always locate every caribou, but most collared caribou were likely to have been located at least once during a season.

Fixed-kernel distributions of radio-collar locations were calculated using the Home Range Tools Extension for the computer geographic information system (GIS) software *ArcMap™ 9.2* (Rodgers et al., 2007). In that procedure, least-squares cross-validation was not used to find the smoothing factor because it failed to converge or resulted in significant overfitting of the home range in many cases; consequently, the reference smoothing factor was used instead. This smoothing factor may result in seasonal ranges that are underfitted (larger than desired for home-range analysis), but for this application it was judged better to err on the side of larger range estimates. Because the distribution of the MCH changed dramatically and range use expanded as the herd reached its peak in the mid-1990s (Hinkes et al., 2005), the herd distribution was characterized for three different decades (1980s, 1990s, and 2000s), as well as for all years combined. A year was divided into five seasons (following Hinkes et al., 2005): spring (April 1 through May 14), calving (May 15 through June 10), summer (June 11 through September 7), autumn (September 8 through October 31), and winter (November 1 through March 31). The density of collar locations, as portrayed by the various utilization-distribution contours from the fixed-kernel analysis, was considered to approximate the density of range use by the herd: the high-density contour enclosed 50 percent of all collar locations, the moderate-density contour enclosed 75 percent of the locations, and the low-density contour enclosed 95 percent of all locations.

16.2.6.2 Aerial Transect Surveys

Strip-transect surveys targeted large terrestrial mammals (caribou, moose, brown bear, and black bear), but also incidentally detected other mammal species (mainly larger furbearers such as gray wolf, coyote, red fox, and wolverine).

A fixed-wing airplane (Cessna 206) equipped with a Global Positioning System (GPS) receiver was chosen as the platform for systematic aerial surveys of strip transects (Caughley, 1977). Strip transects were used instead of line transects because the objective of these surveys was to evaluate the relative abundance and distribution of large mammals over as much of the study area as possible on each survey, rather than to derive population-density estimates. Transect centerlines were spaced at 1.6-kilometer intervals on east-west-oriented U.S. Geological Survey (USGS) section lines (Figure 16.2-1). Two observers viewed 0.8-kilometer-wide transect strips, each on opposite sides of the airplane, to obtain complete coverage of the survey area. The airplane was flown at an altitude of 150 meters above ground level (occasionally higher or lower as dictated by terrain or weather conditions) and at an airspeed of approximately 140 kilometers per hour. The coordinates of mammal locations were recorded using GPS receivers, and the data collected for each sighting included species, number of animals, sex and age composition (when possible), activity, and direction of movement. An effort was made to map caribou trails (which persist over years) in summer 2005.

Five strip-transect surveys of the study area were flown in 2004 on the following dates: April 12, May 21, July 1, October 20, and November 29-30. Seven strip-transect surveys of the study area were flown in 2005: March 29, May 9, May 25, June 29, July 21, October 10, and December 12. Four strip-transect surveys were flown in 2006: May 24, June 28, July 14, and December 1-2. Two strip-transect surveys were flown in 2007: June 27 and July 16-17.

The seasonal timing was selected to correspond to the primary purpose of each survey window:

- Late March/early April: late-winter moose and caribou distribution.
- Early May: spring bears (after den emergence and before leaf-out).
- Late May: caribou and moose calving.
- Late June/early July: caribou postcalving.
- Mid-July: caribou postcalving and bears along salmon-spawning streams.
- Mid-October: caribou breeding season (rut).
- Late November/early December: early-winter moose and caribou distribution.

Sightability generally was high in tundra habitats in the study area but was substantially lower in thick shrub vegetation. To address this concern, simultaneous double counts were added to the study plan in 2007 to quantify sightability. During aerial transect surveys, two observers independently scanned for large mammals on the same side of the airplane, recording whether each animal was seen by the front observer, the back observer, or both observers. Modified Lincoln-Petersen estimates were applied to the results to estimate sightability (Graham and Bell, 1989).

16.2.6.3 Bear Population Survey

An aerial survey of the spring population density of brown and black bears in the area surrounding Iliamna Lake was conducted jointly during May 16-29, 2009, by ADF&G and ABR biologists, with major funding from PLP (Becker, 2010). The survey used an advanced line-transect method (Becker and Quang, 2009), combining aspects of both distance sampling and double-count methods to estimate the detectability of individual bears. Surveys of 1,004 randomly distributed, 20-kilometer-long transects were flown by five pilot-and-observer teams flying in Piper PA-18 “Super Cub” airplanes. For each bear observed along a transect, the observer recorded whether the bear was seen by the pilot, the observer, or by both. They also recorded the distance to the bear, the farthest distance searched, and other covariates affecting visibility, such as vegetation density. After removing nine transects from the analysis to adjust for distance and elevation effects, the area of bear habitat surveyed was calculated as 9,796.8 km^2 (Becker, 2010). This information was used to calculate detectability functions (Becker and Quang, 2009) for use in estimating the total density of bears in the survey area.

16.2.6.4 Moose Population Survey

An aerial survey of quadrat sampling units was conducted by an ABR biologist to estimate moose population density during April 6-10, 2010; a large snowfall on April 4 provided ideal survey conditions by substantially increasing moose sightability. The survey was conducted using the Geospatial Population Estimator (GSPE) method of Kellie and DeLong (2006), which was designed by ADF&G for regional surveys. The survey area was not stratified into high- and low-density areas because the information available before the survey was inadequate to predict the spatial pattern of moose density. Surveyed sample units were selected randomly from all available units to satisfy the requirements of the GSPE method (Kellie and DeLong, 2006).

The entire 2,398-km² survey area comprised 146 sample units in both the mine and transportation-corridor study areas. Thirty sample units were selected randomly within the entire survey area; 11 of the selected units were located in the mine study area, encompassing 191 km² (16.2 percent) of the 1,178-km² portion of the survey area located in that study area.

The 11 sample units were surveyed using a fixed-wing airplane (Piper Super Cub) carrying an experienced pilot and observer. In each sample unit, the plane flew closely spaced transects, followed elevation contours, or used an overlapping search pattern, depending on terrain, spending approximately 2.3–3.1 min/km² (6–8 min/mi²) examining suitable moose habitat. Less time was spent surveying open, high-elevation sample units in which sightability was high and moose habitat was limited. When moose tracks were observed, the plane searched the area to locate the moose. When moose were observed, the crew circled the plane to search for additional animals. The locations were recorded with a hand-held GPS and moose were classified, to the extent possible, according to characteristics of age and sex. Because the survey was conducted in early April, bull moose did not have hard antlers, but new antler growth often was visible, allowing identification of some males. Adult females were identifiable only if accompanied by calves. The sex of moose that did not have obvious antler growth and were not accompanied by a calf was recorded as unknown.

Sightability tests were conducted in six of the 30 sample units to estimate a sightability correction factor (SCF). For these tests, a high-intensity survey (~4 min/km²) of one-quarter of each of the six sample units was conducted to search for any moose that were missed during the initial survey. This information was used to calculate the SCF, following standard methods (Gasaway et al., 1986; Kellie and DeLong, 2006).

The observed density in each sample unit and the estimated SCF were used to calculate an overall density for the mine deposit area and the transportation corridor using the block-kriging GSPE method outlined by Kellie and DeLong (2006) to model the spatial pattern of moose density in the study area. Analysis was conducted using the ADF&G Winfonet website, which was developed to facilitate analysis of moose survey data (http://WinfoNet.alaska.gov; DeLong 2006).

16.2.6.5 Other Surveys

In addition to the aerial transect surveys, surveys were conducted with a helicopter to look for seasonal concentrations of bears along anadromous fish streams in and near the mine study area and to search for and examine bear dens. A bear survey along salmon-spawning streams was conducted on August 18 and 19, 2004, using a turbine helicopter (Hughes 500D or Aerospatiale AS350) and experienced pilot. Streams mapped by ADF&G as providing spawning habitat for salmon (ADF&G, 2004) were preselected for the survey, and other streams were added during the survey on the recommendation of local-knowledge observer Raymond Wassillie or if spawning salmon were observed. Two observers searched on the right side of the helicopter, and one observer and the pilot searched on the left side. Flight altitude varied depending on topography, but was usually 60 to 90 meters above ground level. Location coordinates of bears and other mammals were recorded using GPS receivers. The data collected for each sighting included species, number of animals, sex and age composition (when possible), activity, and direction of movement.

In summer 2005, surveys were not flown specifically for bears along salmon streams; instead, bears were recorded during piston-helicopter (Robinson R44) surveys for Harlequin Duck broods in late July and mid-August (Section 16.4), thereby reducing wildlife disturbance by combining species coverage.

Suspected dens of bears were recorded on GPS receivers during strip-transect surveys and by helicopter pilots ferrying various work crews around the mine study area. Ground visits to prospective bear den sites were conducted by helicopter on August 18 and 19, 2004; May 11 and 12 and August 29 and 30, 2005; and May 8 and 9, 2006.

A piston helicopter (Robinson R44) was used in the mine study area on October 9, 2005, to locate and map active beaver colonies, as indicated by fresh food caches near lodges (Hay, 1958; Payne, 1981). Survey altitude was generally about 60 meters above ground level, descending lower occasionally to check specific sites. The areas to be surveyed were selected based on mapping of beaver dams already done on high-resolution imagery by Eagle/Kodiak Mapping for the Pebble Project.

Aerial strip-transect surveys, den visits, and bear surveys along salmon streams are referred to collectively below as large mammal surveys. Incidental sightings of mammals (caribou, moose, brown bear, black bear, gray wolf, coyote, red fox, river otter, wolverine) also were recorded during aerial and ground surveys for beaver colonies, waterfowl, raptors, and breeding birds. Those sightings are referred to below as having been made during other wildlife surveys. In addition, incidental sightings were solicited from other project personnel at the Iliamna base of operations and were recorded on wildlife-sighting forms; those sightings are not depicted on map figures or included in tables of wildlife survey results, but are mentioned in text where relevant.

Harvest data acquired from the ADF&G statistics section in Anchorage (Schwartz, 2006) provided useful background information on the distribution and relative abundance of several species of furbearers, which are difficult to enumerate using aerial surveys.

16.2.7 Results and Discussion

16.2.7.1 Caribou

Several herds of caribou have been delineated in southwestern Alaska, based on their fidelity to calving grounds and long-term patterns of range use. The MCH is the principal herd distributed throughout the Bristol Bay region (Figure 16.2-2). The much smaller Kilbuck Herd formerly occurred in the western portion of the MCH range (Hinkes et al., 2005), but that herd was subsumed by the MCH in the early 1990s (Valkenburg et al., 2003; Hinkes et al., 2005). The range of the adjacent Northern Alaska Peninsula Herd is south of the MCH range and formerly extended as far north as the western end of Iliamna Lake, but that herd has never been reported farther north in the mine study area. The Northern Alaska Peninsula Herd declined from a high of approximately 20,000 caribou in the 1980s to less than half that size in the 1990s (Valkenburg et al., 2003). The most recent estimate of that herd was 2,500 caribou in 2005 (Butler, 2007b).

The MCH increased dramatically and rapidly in the 1980s, peaked in the mid-1990s, and has declined since then (Figure 16.2-3). The most recent size estimate for the MCH was a minimum of 30,000 animals in July 2008, continuing a steep decline from the previous estimates of 45,000 caribou in July 2006, 85,000 caribou in July 2004, and 147,000 caribou in 2002 (Woolington, 2010); herd size has fallen well below the management objective of 100,000 to 150,000 caribou.

Caribou are highly mobile and move across large areas of range during different seasons. The MCH has shown substantial and unpredictable variation in range use since the early 1990s (Hinkes et al., 2005;

Woolington, 2007a, 2010). Although surveys were not conducted specifically in the mine area between 1993 and 2004, telemetry data indicate that use of the mine area by the MCH occurred primarily during the postcalving aggregation period and, to a much lesser extent, during the rut (Woolington, 2003).

Spatial Analysis of Telemetry Data

Fixed-kernel analysis of MCH collar locations showed large variations in seasonal distribution among the three time periods (1981-1989, 1990-1999, and 2000-2010). During 1981-1989, the herd covered a much smaller area than in subsequent years. During the 1980s, the MCH was concentrated east of the Nushagak River, and the smaller Kilbuck Herd was distributed farther west (Hinkes et al., 2005). The range of the MCH during spring was centered largely on the area north of Lake Clark and Nikabuna Lakes, with low density use of the greater mine study area (Figure 16.2-4). Most calving occurred in the Bonanza Hills north of Lake Clark with low density use in the western part of the greater mine study area (Figure 16.2-5). The summer distribution was similar to the spring distribution; with medium- and low-density use in the greater mine study area (Figure 16.2-6). During autumn, the herd concentrated in the Nikabuna Lakes area and west of Iliamna Lake, with medium- to high-density use in the greater mine study area. (Figure 16.2-7). Winter concentrations also occurred near Nikabuna Lakes and west of Iliamna Lake, again with medium- to high-density use in the greater mine study area (Figure 16.2-8).

The decade of the 1990s was a period of transition for the MCH. The herd increased in size, expanded its range, and subsumed the smaller Kilbuck Herd (Hinkes et al., 2005). Beginning about 1994, the MCH distribution shifted as far west as the Kuskokwim River. Spring distribution was spread out between the Bonanza Hills on the east and the Kilbuck Mountains on the west, with an area of high concentration extending to Nikabuna Lakes, northwest of the greater mine study area. The greater mine study area experienced medium-density use in spring during the 1990s (Figure 16.2-4). High-density calving also shifted west to the area around the Shotgun Hills and Nushagak Mountains (Figure 16.2-5). Summer distribution was spread out between Lake Clark and the western Kilbuck Mountains, with concentrated, high-density use extending throughout most of the greater mine study area (Figure 16.2-6). Autumn distribution split between two different concentration areas on either side of the Kilbuck Mountains (Figure 16.2-7). That separation was even more distinct during winter, with part of the herd remaining on the western side of the Kilbuck Mountains and lower concentrations stretching from Naknek on Bristol Bay through the greater mine study area and farther north (Figure 16.2-8).

During 2000-2010, the seasonal distribution of the MCH generally was similar to that seen in the latter 1990s, even though the herd was declining in size. During spring, the herd concentrated mostly west of Iliamna Lake and the greater mine study area, with areas of lower concentration in the Kilbuck Mountains (Figure 16.2-4). The concentrated calving area shifted west from the area used in the 1980s into two concentration areas east of the Kilbuck Mountains between Dillingham and the Nushagak Mountains (Figure 16.2-5), west of the greater mine study area. During summer, the herd was distributed throughout a broad zone from the Shotgun Hills north of Lake Clark, south to Dillingham, and west into the Kilbuck Mountains, with the high-density contour overlapping the western portion of the greater mine study area (Figure 16.2-6). During autumn, the herd again split into two groups with high densities, one centered around Koliganek and the other in the western Kilbuck Mountains, with low-density use in the greater mine study area (Figure 16.2-7). During winter, the herd was concentrated in two distinct areas, one centered between the Kilbuck Mountains and the Kuskokwim River and the other between the Kvichak River and Koliganek, with low-density use of the greater mine study area (Figure 16.2-8). During 2000-

2010, the greater mine study area experienced high-density use only during the summer (postcalving) season.

Over all 29 years of data, the greater mine study area has experienced moderate- to high-density use by collared caribou during spring, low-density use during calving, high-density use during summer and winter, and moderate-density use during autumn (Figures 16.2-4 through 16.2-8). During the period covered by the telemetry data set, the MCH increased rapidly, peaked, and then declined sharply. If the population continues to decrease, it is unclear whether the herd will constrict toward the areas used during the 1980s or will continue to use parts of the range into which it expanded in the 1990s. Thus far, the herd continues to use a large area of annual range despite the recent population decline (Woolington, 2010). Based on past use, it is reasonable to expect large aggregations of caribou to occur occasionally, although perhaps not annually, in the greater mine study area during the summer (postcalving) period.

Spatial analysis of telemetry data is valuable for delineating herd ranges and seasonal patterns of range use, but it reflects the distribution of only a small percentage of all caribou. The degree to which collared caribou reflect the overall herd distribution is not known for certain. Collaring caribou at times of year when they occur in large groups can help distribute collars randomly, but it is still possible that the collared sample may not accurately represent the true distribution of caribou in the greater mine study area. In addition, because tracking of VHF collars tends to be done infrequently, large movements into some areas may be missed, and the observed distribution of collared caribou depends on the timing of survey flights.

A small herd of caribou was thought to reside year-round in the upper Stuyahok and Koktuli drainages (including the greater mine study area) during the early 1990s (Van Daele and Boudreau, 1992; Van Daele, 1994). Telemetry data collected since then and the aerial transect surveys conducted in 2004-2007 indicate that caribou no longer reside in the area year-round (Woolington, 2007a, 2010) and that the greater mine study area is used primarily in summer, when large groups occasionally move through the study area.

Caribou Locations in the Greater Mine Study Area

A total of 198 locations of collared caribou from the MCH (1.6 percent of the total of 12,198 locations) occurred within the greater mine study area from March 1981 to March 2010. The proportion of collared caribou that occurred in the area varied among years between 0 and 11.6 percent (Figure 16.2-9). Despite those low annual percentages, more than a quarter (117 of 488, or 24.0 percent) of all collared caribou in the data set were located in the greater mine study area at least once during the time their collars were active. Of all collared caribou with at least 10 locations, 32.9 percent (103 of 313) were located in the greater mine study area at least once during the time their collars were active. The telemetry data indicate that many different caribou moved through the area briefly during the summer postcalving season, when the greatest use of the greater mine study area occurred (Figure 16.2-10). High-density use occurred during summer in the 1990s and 2000s (Figure 16.2-6).

The cumulative observations made by agency biologists on telemetry surveys during 1981-2010 consistently demonstrated a greater degree of use of the area west and northwest of the deposit area than of areas south or east of the deposit area (Figure 16.2-11). The largest numbers of caribou recorded in the greater mine study area during telemetry surveys occurred in late June 1996 and early July 1997 (Figure 16.2-11). On June 29-30, 1996, aggregations of approximately 100,000 caribou (about half of the MCH at that time) were recorded north of the general deposit area in the Nikabuna Lakes area and west of the general deposit area in the drainage of the North Fork Koktuli River. On July 2, 1997, an estimated 180,000 caribou (about 90 percent of the previous year's estimated herd size) were observed in two aggregations near the northern and the northwestern edges of the greater mine study area. Other large postcalving aggregations were noted in or adjacent to the northwestern part of the greater mine study area on August 3, 1995; July 2, 2001; June 26 and 30, 2002; June 28, 2004; and June 27, 2005 (Figure 16.2-11). Two large winter aggregations were recorded nearby on March 31, 1997, and October 7, 1997; those aggregations were unusual in the area because they occurred in seasons other than the summer postcalving period (between the end of June and the beginning of August).

Three satellite-collared caribou were observed in the northwestern portion of the greater mine study area with 15 VHF-collared caribou during a telemetry survey by ADF&G on June 27, 2005, within a loose aggregation estimated at 18,650 caribou (including the group of 16,650 caribou depicted in Figure 16.2-11, plus smaller groups to the southwest). An aerial transect survey of the mine study area two days later found no caribou in the mine survey area (Table 16.2-1), although that survey could not be completed because of low clouds and fog. The observations of uncollared caribou that were included in the telemetry data set were not collected systematically, so they may not accurately reflect actual herd distribution, but they provide additional documentation of the locations of groups in the greater mine study area. Of the 6,557 locations of groups of uncollared caribou in the MCHTWG data set, 15 (0.2 percent) were in the greater mine study area: four groups of 25 to 1,500 caribou in 1993; three groups of 20 to 250 caribou in 1994; one group of 300 in 1995; six groups of 10 to 100,000 in 1996, including a group of 10 on May 9; and one group of three in 2006.

Aerial Transect Surveys

Aerial transect surveys of the mine study area for caribou were conducted in April, May, July, October, and November 2004; March, May, June, July, October, and December 2005; May, June, July, and December 2006; and June and July 2007 (Table 16.2-1). Most surveys were completed as planned, except when low clouds and fog prevented some transects from being surveyed (one transect in November 2004, eleven transects in June 2005, nine transects in July 2006).

Sightability was evaluated to provide an indication of the proportion of animals present that were detected during the surveys. An evaluation of sightability in 2007 suggested that up to half of the large mammals present in summer may have been missed during the transect surveys in 2004 through 2006; sightability was much higher in winter because of snow cover and the lack of leaves on shrubs. Pebble researchers recorded a total of 11 groups of large mammals during simultaneous double counts of transects in the mine study area on the two surveys conducted in June and July 2007 (Table 16.2-2). Those sightings included six groups of brown bears (three single adults, two sows with two cubs each, and one sow with three cubs) and five groups of caribou (1, 2, 4, 45, and 2,100 animals). The group of 2,100 caribou was omitted from the sightability analysis because the probability of not detecting a group that large is assumed to be zero. The detectability of the remaining 10 groups of large mammals was estimated as 76.9 percent (95 percent confidence interval = 53.5-100 percent) with two observers on the same side of the aircraft, for an SCF of 1.30. With one observer (as was used on each side of the aircraft during transect surveys in 2004 through 2006), the estimated detectability was 50 percent (95 percent confidence interval = 34.8-88.8 percent), resulting in an SCF of 2.0.

This application of double counts to estimate sightability on strip-transect surveys had several limitations. The method assumed that all groups had equal sightability; this assumption is unlikely to be true, however, because sightability varied by habitat, time of year (because of snow cover and presence of leaves on deciduous shrubs), species, and group size. The sample sizes of mammals observed in this study were not adequate to calculate different sightability estimates for each of these factors. Graham and Bell (1989) noted that sightability was higher for larger groups, especially from survey aircraft flying at higher altitudes. In addition, in habitats with heavy vegetative cover (such as brown bears in dense patches of shrubs), sightability could approach zero. Animals with very low sightability in such habitats likely would not be seen by either observer and thus would not be factored into the sightability estimate. Therefore, the resulting estimate of sightability would be too high and any densities derived from it for the study area would underestimate the true density. Thus, the unadjusted data presented below represent minimal counts of the numbers of mammals present during the transect surveys. Nevertheless, because of the repeated nature of the surveys, the complete set of transect survey data represents a reasonable sampling of the distribution and relative abundance of large mammals among seasons.

Two cow/yearling groups of caribou totaling 30 animals were seen during the calving survey on May 21, 2004 (Table 16.2-1, Figure 16.2-12); several of the females appeared to be pregnant, but no calves were seen in either group. Only a single caribou was seen on the calving survey in 2005. No caribou were observed in the transect survey area on the late-winter surveys (March 29, 2005; April 12, 2004). None were seen on early-winter surveys in 2004 (November 29-30), 2005 (October 10), or 2006 (December 1-2), but 146 caribou were found on the December 12, 2005, survey, the largest number seen on any transect survey that year (Table 16.2-1). In the early 1990s, the mine study area was thought to be part of the range used by a small number of resident caribou and to provide locally important calving habitat and, occasionally, winter range (Van Daele and Boudreau, 1992; Van Daele, 1994), but that local use ceased after the MCH ranged through the area and those caribou moved away with the larger herd (Woolington, 2007a).

Transect surveys in 2004, 2006, and 2007 corroborated the results of the MCH telemetry analysis, in that the greatest numbers of caribou used the mine study area during the summer period of postcalving aggregation. Incidental observations during breeding-bird surveys in June 2004 and 2005 revealed small groups of caribou (each containing fewer than 25 animals) scattered throughout the mine study area (Figure 16.2-12), some of which were observed standing and lying on remnant snow patches in upland areas, presumably for relief from warm temperatures and insect harassment. During the postcalving transect survey on July 1, 2004, observers recorded 9,963 caribou in the mine study area (Table 16.2-1, Figure 16.2-12), moving steadily southwest. At the time of the MCH photocensus on July 7, 2004, as many as 70,000 to 80,000 caribou were located 70 to 80 kilometers southwest of the mine study area near the Stuyahok River (Woolington, 2004). A northeasterly movement through the mine study area by moderate to high numbers of caribou was noted later in July 2004 (Kneen, 2004); although those animals were not counted, they were estimated to number in the high hundreds to low thousands. As mentioned above, the transect survey on June 29, 2005, did not find any caribou, even though several large groups had been seen near the northwestern corner of the survey area two days earlier during a postcalving survey by ADF&G (Figure 16.2-11). Only 16 caribou were found in the survey area during the postcalving survey on July 21, 2005. Similar to 2004, large groups of caribou were seen in or near the mine study area during postcalving surveys in the two subsequent years: 5,039 caribou were recorded on transect surveys on June 28, 2006, and 2,132 caribou were found on June 27, 2007 (Table 16.2-1, Figure 16.2-13).

16.2.7.2 Bears

Brown bears are relatively common inhabitants of the tundra habitats in the mine study area, but black bears are much less common there than in forested habitats at lower elevations farther east and north. The mine study area is located in an area of transition between substantially higher coastal densities and lower inland densities of brown bears (Becker, 2007). By assuming a mean density of approximately 50 bears/1,000 km^2, a population-density extrapolation by ADF&G in 1989 estimated that 879 brown bears inhabited state lands in GMU 9B (that part of the subunit encompassing the Kvichak River drainage, including streams entering Iliamna Lake but excluding lands in Lake Clark and Katmai national parks and preserves; Butler, 2005). A rigorous population survey in 1999-2000 estimated a lower density of 38.6 brown bears/1,000 km^2 in GMU 9B North (Becker, 2001, 2003; Butler, 2007a), including the lands north of Iliamna Lake (just east of the mine study area) and Lake Clark National Park and Preserve. The 1999-2000 survey detected 272 brown bears in 167 groups; of those bears, 155 (57 percent) were in family groups and 117 (43 percent) were independent bears, including 60 (22 percent) large males (Butler, 2007a). The mean litter size over both years was 1.7 for cubs of the year and yearlings and 2.0 for 2-year-olds or older; the litters in 2000 were larger than those in 1999 (Butler, 2005).

The line-transect survey in May 2009 produced sightings of 152 brown bear groups throughout the regional survey area (Figure 16.2-14), 144 of which were within the 510-meter effective survey width and 914-meter maximum-elevation limit used for the density calculation (Becker, 2010). Preliminary estimates of population density were derived using two similar analytical methods, one employing a double-count method to calculate individual detection functions for the pilot and the observer (following Becker and Quang, 2009) and the other combining observations for both the pilot and the observer and calculating a single detectability function for the airplane crew (plane model; Becker, 2010). The resulting estimates of population density were 47.7 brown bears/1,000 km^2 (standard error = 7.66) using the double-count method, indicating a minimum population of 412 brown bears in the area surveyed, and 58.3 brown bears/1,000 km^2 using the plane model.

No black bears were observed in the mine study area during Pebble Project wildlife surveys in 2004-2007, but other Pebble Project personnel reported one black bear on a southern slope of Koktuli Mountain on May 23, 2005. The density of black bears estimated by ADF&G from the 1999-2000 survey in GMU 9B North (76.6 bears/1000 km^2) was twice that of brown bears (Becker, 2003), but the vast majority of those bears were in the northernmost portion of the subunit (Lake Clark National Park and Preserve), north and east of the mine study area. Black bears were sparse (two incidental sightings) on line transects between Groundhog Mountain and the boundary of Lake Clark National Park and Preserve (Becker, 2007). A female with a cub was seen near Sharp Mountain in the mine study area on the May 2009 population survey (Figure 16.2-14; Becker, 2010). During that survey, 25 black bears were observed in 18 groups in the entire regional survey area, but the sample size was inadequate to estimate the population density (Becker, 2010). Most of the black bear groups were observed in the eastern portion of the regional survey area, especially near the Iliamna River (Figure 16.2-14).

In contrast to black bears, brown bears were recorded often during wildlife surveys and other work by Pebble Project personnel. Sightings of 15 brown bears were recorded in the mine study area during aerial transect surveys in 2004: five in May, six in July, and four in October (Table 16.2-1, Figure 16.2-15). Incidental observations of 39 brown bears were recorded off-transect and during other wildlife surveys in 2004, including 21 bears seen during waterfowl surveys in September 2004 along Lower Talarik Creek, 24 to 32 kilometers southwest of the general deposit area. Sightings of 19 brown bears were recorded in the mine study area during seven aerial transect surveys in 2005: four bears in early May, six in late May, two each in June and July, and five in October (Table 16.2-1, Figure 16.2-15). In addition, 74 brown bears were recorded incidentally during other wildlife surveys (including the beaver colony survey) in the mine study area in 2005; the increased number of bears observed incidentally in 2005 reflected increased survey effort that year, mainly for waterbirds. The greatest number of brown bears observed during a single survey of the mine study area occurred on June 28, 2006, when eight sightings totaling 18 bears (including four sows with 10 dependent young) were recorded on a strip-transect survey (Table 16.2-1, Figure 16.2-16).

The helicopter survey of salmon-spawning streams in and near the mine study area on August 18 and 19, 2004, recorded 16 brown bears, most of which were located along streams 15 to 30 kilometers south and southeast of the Pebble Deposit (Figure 16.2-15). The dense vegetation in shrub stands along the streams in August greatly reduced the sightability of bears, so the number reported was a substantial undercount of the actual number present. Unfortunately, there was no practical way to quantify the proportion of bears detected on that survey. Even when bears were not observed directly, however, the survey was useful for locating areas of current and recent bear activity along the streams by noting trails, beds, and feeding areas. The occurrence of spawned-out carcasses of salmon farther upstream in the mine area showed that a spawning run had been completed by the time of the mid-August survey. Incidental observations during bird surveys revealed brown bears feeding on salmon in streams in the mine study area during the second half of July 2004. Additional observations of bears along streams were recorded during surveys for Harlequin Duck broods in July and August 2005 (Figure 16.2-15).

The helicopter survey in August 2004 also searched for and examined prospective bear dens in and near the mine study area. Of seven prospective sites reported west of the Newhalen River during strip-transect surveys and incidental observations, three proved to be brown bear dens. Two other brown bear dens were found during the den survey in 2004. Brown bear dens ranged from a high-elevation site on a rocky slope of Groundhog Mountain (occupied by a hoary marmot) to a low-elevation site in mixed forest. None of the bear dens examined in 2004 appeared to have been used in the preceding winter. Two of the seven prospective bear dens turned out to be wolf dens, neither of which was used in 2004; one was located east of Upper Talarik Creek and the other was south of the mine study area near Pete Andrews Creek. A red fox den also was located near the latter wolf den. Numerous other sites that appeared at first to be bear dens turned out to be burrows of arctic ground squirrels that had been partially excavated by bears.

Helicopter surveys on May 11-12 and August 29-30, 2005, and May 8-9, 2006, located or confirmed more dens, most of which were located during other work as biologists and helicopter pilots recorded GPS coordinates of suspected den sites. Eleven brown bear dens were confirmed in the mine study area during 2004 through 2006; in addition, two other dens were confirmed south of the mine study area between Upper Talarik and Lower Talarik creeks and four other dens were confirmed just east of the mine study area boundary (Figure 16.2-17). A single brown bear was observed near the entrance to a den approximately 5 kilometers east of Sharp Mountain during the moose survey in early April 2010 (Figure 16.2-17). Several other dens possibly were present in the mine study area, according to reports by other observers, but were not confirmed. These den numbers are minimal because a comprehensive search of the entire mine study area was not attempted; instead, the sample of confirmed bear dens was accumulated over time as prospective sites were noted during wildlife surveys and as reports were received from other Pebble personnel.

Suitable denning habitat for brown bears is common in the mine study area, and dens were found in a variety of habitats, ranging from low-elevation wooded sites to high-elevation scree slopes. The mean elevation of bear dens (determined using a digital elevation model [DEM] and GPS coordinates of dens) was 300 meters above sea level; the elevation range in the mine study area was 14 to 935 meters above sea level. Den searches in summer tended to locate dens on more exposed sites, whereas searches in spring (before leaf emergence) provided a better sampling of brushy habitats, such as alder thickets, where dens were overlooked later in the season. Some of the best information on dens came from incidental observations collected over time by helicopter pilots working in the mine study area during the period when most bears emerged from dens (mid-April to mid-May). A den survey by fixed-wing airplane on May 4, 1992 (a date by which it was estimated that 70 percent of bears would likely have emerged from their dens), found two dens in a 250-km^2 search area that encompassed the mine study area: one approximately 500 meters east of the outlet of Frying Pan Lake and the other 6 kilometers south-southeast of the general deposit location (Boudreau et al., 1992).

Since 1975, the hunting season for brown bears on the Alaska Peninsula has been open only in the fall of odd-numbered years and in the spring of even-numbered years (Butler, 2007a). The reported harvest of brown bears in four reporting units in and bordering the mine study area fluctuated from 1991 through 2005, with a high of 30 in 2001 and a low of four in 1994 (Schwartz, 2006). Black bear harvests in those reporting units were reported in only about half the years examined, with no more than two taken in any single year.

16.2.7.3 Moose

Moose occur in low numbers in the tundra habitats of the mine study area, consistent with the observation (Woolington, 2006) that moose are located predominantly in riparian habitats in the region in which the study area is located. Three moose were observed during the October 2004 strip-transect survey, four moose were observed during strip-transect surveys in 2005 (two in early May, one in late May, and one in December), and three were observed during a beaver survey in October 2005 (Table 16.2-1, Figure 16.2-19). Five moose were recorded in the mine study area on transect surveys in 2006 (one in late May, two in mid-July, and two in early December), but none were seen on the two surveys in 2007. Strip-transect surveys in late winter (April 12, 2004, and March 29-30, 2005) found no moose in the mine study area (Table 16.2-1) despite excellent survey conditions, but several sets of fairly recent tracks were seen near riparian shrub thickets. It is likely that moose move out of the transect-survey area to lower elevations as snow depth increases during winter.

Twenty-five moose were recorded incidentally in the mine study area during other wildlife surveys in 2004 and 2005; 19 of those moose were observed in May 2005 (Table 16.2-1). Most of the incidental sightings occurred during waterfowl surveys flown at low altitudes over waterbodies in productive wetlands that constituted some of the best moose habitat in the mine study area, maximizing the opportunity to see moose (and probably repeating some of the same individuals among surveys). Incidental sightings of moose were reported in the vicinity of the Pebble Deposit by other Pebble Project personnel in early May 2004 and late May 2005; the latter observation was of a cow with twin calves.

During the 2010 aerial survey, 11 of 68 (16.2 percent) sample units in the general deposit area were surveyed during April 6-10 (Figure 16.2-18). Three moose were seen in the surveyed sample units and another four moose were seen outside of them (Table 16.2-3). Most of the moose observed in the mine study area were at lower elevations on the periphery of the area.

Approximately a foot of snow fell in the survey area on April 4 (two days before the survey began) and weather conditions remained cool and calm during the surveys, so little snow melted and survey conditions were classified as good or excellent for 29 of the 30 units sampled. Moose tracks were readily visible in the fresh snow and nearly every set of moose tracks seen could be followed until the animals were found. By the final day of the survey, the network of moose trails was extensive enough to make locating moose more challenging than earlier in the survey.

In six sample units (five in the transportation-corridor study area and one in the mine study area), an intensive survey was conducted in one quarter of each sample unit to calculate an SCF. Moose were observed in four of these sample units during the initial survey. No more moose were observed during the intensive survey, resulting in an estimated SCF of 1.0. Combined with the favorable snow conditions, this result indicated that sightability was high during the survey. Therefore, the estimates were not adjusted to account for moose missed during the surveys.

The estimated population for the entire 2,398-km^2 survey area (mine and transportation corridor study areas combined) was 96.2 moose (0.04 moose/km^2). Because moose density was highly variable among sampling units, with all moose observations occurring in just six of the 30 units sampled, the variance associated with the estimates was large (Table 16.2-4). The 95 percent confidence interval around the estimated population for the entire survey area was 38 to 176 moose. The estimated density in the mine study area was 0.03 moose/km^2, producing an estimated population of 33 moose and a 95 percent confidence interval of 7 to 81 moose.

Because the survey was conducted long after bulls had shed their antlers, it was not possible to reliably classify the sex of all of the moose observed. Of the total of 38 moose seen in the entire survey area, 9 were classified as adult males, 6 were adult females, 7 were calves, and 16 were adults of unknown sex. If it is assumed that all adults of unknown sex were females, then the minimum population ratios were 31.8 calves:100 cows and 40.9 bulls:100 cows.

Local winter concentrations of moose have been reported previously in the Upper Talarik Creek drainage in the eastern portion of the mine study area (ADF&G, 1985). A low density (0.08 moose/km^2) was noted on December 19, 1991 in a 780-km^2 survey that included the mine study area; sightability was estimated at about 75 percent in that survey, so the true density probably was close to 0.1 moose/km^2 (Boudreau et al., 1992). The few moose seen on that survey were found along Upper Talarik Creek and the Koktuli River and were thought to have been forced to lower elevations by increasing snow cover; none were seen within 8 kilometers of the general deposit location.

The moose population throughout GMU 17 increased in the last two decades (Woolington, 2008). The population in the Mulchatna River drainage in eastern GMU 17B (of which the mine study area is a small part) was estimated at 1,953 animals (90 percent confidence interval = 1,699-2,207 moose) in March 2002, based on a stratification model using spatial statistics (Woolington, 2008); however, no density estimate was presented. In adjoining GMU 9B (which includes the eastern portion of the mine study area), the moose population was estimated at 2,000 animals in the 1980s and appears to have been stable at low densities (fewer than 0.2 moose/km^2) since the late 1980s (Butler, 2004). The moose in GMU 9B were considered important for high levels of human consumption under the state legislative mandate for intensive management (Butler, 2008); however, the moose population is thought to be limited primarily by predation by brown bears, making large-scale reduction of predation unlikely because of the management priority given to brown bears in GMU 9 (Butler, 2008).

Despite the reportedly stable moose population in GMU 9B (Butler, 2008), the reported harvests of moose in four reporting units in and bordering the mine study area declined consistently from 45 in 1991 to 10 in 2005, with the largest drop occurring since 2000. Butler (2008) noted a similar trend for declining harvest throughout GMU 9 since 2000, attributing it to reduced hunter effort rather than a decrease in hunter success or in the overall moose population. In contrast, the harvest of moose in GMU 17B has been fairly high in recent years, although the population there is less than the population management objective (Woolington, 2008).

16.2.7.4 Other Mammals

Gray Wolf

One wolf was observed just northeast of the general deposit location on an aerial transect survey in October 2004 (Table 16.2-1, Figure 16.2-19). In addition, four incidental observations of wolves were recorded in the mine study area during other wildlife surveys in 2004: three lone wolves (one southeast of the general deposit location in April, one near Frying Pan Lake in June, and one [not mapped] that killed a caribou in July near Big Wiggly Lake in the northern portion of the mine study area) and a pack of six wolves near Sharp Mountain in September. One wolf was observed incidentally in the mine study area near Sharp Mountain during a waterfowl survey in August 2005 (Table 16.2-1). Other Pebble Project personnel reported incidental sightings of wolves in the mine study area in April and May 2004 and May and July 2005. No wolves were seen during wildlife surveys in 2006 or 2007, but the survey effort was less in those years than in the preceding two years. A single wolf was seen west of Groundhog Mountain during the bear survey in May 2009.

Three dens of wolves (plus several unmapped dens of coyotes and red foxes) were found incidentally in and near the mine study area during searches for and ground visits at prospective bear dens (Figure 16.2-17).

The reported harvests of wolves in four reporting units in and bordering the mine study area varied substantially during 1991 through 2005, ranging from highs of 78 in 1994 and 60 in 1999 to lows of three in 1996, zero in 2002, and two in 2004 (Schwartz, 2006).

Beaver

The beaver is a keystone species exerting profound effects on hydrology, geomorphology, the productivity of aquatic habitats, and the distribution of fish and other aquatic organisms (Butler, 1995; Collen and Gibson, 2001; Rosell et al., 2005). The mine study area and nearby drainages host a healthy population of this species. The helicopter survey of active beaver colonies on October 9, 2005, recorded 113 active colonies in the mine study area (Figure 16.2-20), including one active lodge without a visible cache and two caches without visible lodges; all others were a combination of a fresh food cache near a lodge. Active colonies were found in and near the major drainages of Upper Talarik Creek and both forks of the Koktuli River, but also on more isolated tundra ponds, especially those perched on slopes and terraces west of the general deposit area. Averaging the number of colonies mapped over the 425-kilometer-long flight-line of the survey produced an estimate of 0.27 lodges per linear kilometer.

Other Species

No wolverines were seen in the mine study area during aerial strip-transect surveys in 2004-2007; all sightings came from incidental observations. Two wolverines were observed in the mine study area during bird surveys: one west of the general deposit location in June 2004 and one west of Groundhog Mountain in July 2005 (Table 16.2-1, Figure 16.2-19). Incidental sightings of wolverines in the mine study area by other Pebble Project personnel were reported in April 2004 and April-May 2005, but no map coordinates were available.

Two groups of river otters were observed incidentally in the mine study area during wildlife surveys in July 2005: a group of five southwest of Groundhog Mountain and a group of two south of the general deposit location (Figure 16.2-19). An incidental sighting of a river otter in the South Fork of the Koktuli River on April 10, 2004, was reported by other Pebble Project personnel, but no map coordinates were available.

Only two coyotes were observed in the mine study area. A lone coyote was observed beside Lower Talarik Creek during a waterfowl survey in August 2005, and another was seen near the general deposit area on the bear survey in May 2009 (no GPS coordinates were obtained for the latter sighting). Red foxes were observed on numerous occasions by Pebble Project personnel.

Other than wolves and beavers, the reported harvests of furbearers in four reporting units in and bordering the mine study area were generally low during 1991-2005. Annual harvests included one to four lynx through 1998, with only one reported after that year (in 2000); fluctuating numbers of river otters, up to a high of 18 in 2003; and 15 wolverines in 1991, but nine or fewer afterward, with no more than five annually since 1995 (Schwartz, 2006).

Although snowshoe hares occur at lower elevations in shrub and forest habitats in the mine study area, an incidental observation of a tundra hare during a raptor survey in 2005 (Figure 16.2-19) provided the only reported observation of that species during wildlife surveys. An incidental sighting of two hares atop Koktuli Mountain on May 1, 2006, may have been the latter species (based on location and habitat), but species identity could not be confirmed. The mine study area is at the southeastern edge of the range of this endemic Alaska species, which occurs farther southwest on the Alaska Peninsula and in coastal western Alaska (Anderson, 1978; Cook and MacDonald, 2004b) and was expected to occur in the region north of Iliamna Lake (Jacobsen, 2004).

16.2.8 Summary

Pebble researchers evaluated the distribution and abundance of large mammals in the mine study area using aerial strip-transect surveys conducted five times in 2004 (April, May, July, October, and November), seven times in 2005 (March, early May, late May, June, July, October, and December), four times in 2006 (May, June, July, and December), and two times in 2007 (June and July). In addition, researchers surveyed bear use of salmon-spawning streams in August 2004; examined bear dens in August 2004, May and August 2005, and May 2006; and recorded incidental observations of large mammals during other wildlife surveys.

Radio-telemetry data from collared members of the Mulchatna Caribou Herd were analyzed to examine range use over time in relation to the Pebble Project location. Analysis of 29 years of telemetry data for the MCH documented seasonal patterns and changes in range use as the herd grew and expanded its range during the 1980s and 1990s. Over all years, based on telemetry data locations, the greater mine study area has experienced moderate- to high-density use during spring, low-density use during calving, high-density use during summer and winter, and moderate-density use during autumn. About a quarter (117 of 488, or 24.0 percent) of all collared caribou in the telemetry data set were located in the greater mine study area at least once during the time their collars were active, indicating that many different caribou used the area for at least a short time period. Very large aggregations have been recorded in or near the greater mine study area in the past, most notably 100,000 caribou in late June 1996 and 180,000 caribou in early July 1997. Pebble researchers observed a total of 9,997 caribou on strip-transect surveys in 2004, 163 in 2005, 5,040 in 2006, and 2,177 in 2007. A small resident herd of caribou was thought to be present in the greater mine study area during the early 1990s. Radio telemetry and aerial transect surveys of the area since then suggest that resident caribou no longer occur there and indicate that the mine study area is primarily used in summer, when large groups occasionally move through the study area.

Brown bears were common in the mine study area, whereas black bears were reported only rarely. The number of brown bears totaled 15 on five strip-transect surveys in 2004, 19 on seven strip-transect surveys in 2005, 20 on four strip-transect surveys in 2006 (18 of which occurred on a single survey), 16 on two strip-transect surveys in 2007, 16 on the mid-August 2004 stream survey, 11 during den visits in May and August 2005 and May 2006, and five during the October 2005 beaver survey. Incidental sightings during other wildlife surveys in and near the mine study area totaled 39 brown bears in 2004 and 69 in 2005. A bear population survey conducted in May 2009 in the region surrounding Iliamna Lake produced density estimates of 47.7 and 58.3 brown bears/1,000 km², depending on the analytical method used (Becker, 2010).

A moose population survey in April 2010 estimated 33 moose in the 1,178-km² portion of the survey area in the mine study area, an estimated density of 0.03 moose/km². The population density of moose may be higher in the fall and early winter when moose use habitats at higher elevations than they do later in the winter.

In addition to caribou, brown bears, and moose, wolves and wolverines were sighted in the mine study area during aerial surveys and as incidental observations during surveys for other species. The mine site appeared to have low densities of brown bears, moose, wolves, and wolverines throughout the year.

Because most of these species are highly mobile and cover relatively large home ranges, the numbers of animals using the mine study area vary seasonally and even daily; in addition, the detectability of animals in shrub and forest cover is low. Therefore, the numbers observed and densities calculated from these surveys are low estimates of the use of the mine study area by large mammals throughout the year.

16.2.9 References

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16.2.10 Acknowledgments

Local residents Raymond Wassillie and James Lamont of Newhalen and Carl Jensen of Pedro Bay participated as observers on several mammal surveys and provided the benefit of their local and traditional knowledge. Pete Suskuk and Tamara Hedlund were bear guards and Anuska Ishnook was a local observer on bear-den surveys. The members of the MCHTWG (ADF&G, USFWS, NPS, and BLM) graciously agreed to provide their extensive 29-year telemetry data set on the distribution and movements of the Mulchatna Caribou Herd for analysis in this report. Jim Woolington, Bruce Dale, Earl Becker, Lem Butler, and Steve Schwartz of ADF&G; Andy Aderman of USFWS; Judy Putera of NPS; and Steve MacDonald and Brandy Jacobsen of the University of Alaska Museum provided valuable information on caribou, moose, bears, and other mammal species in the study area. We thank Rob DeLong of ADF&G for his help in using the ADF&G WinfoNet moose survey software. We thank Earl Becker of ADF&G for designing and managing the spring 2009 bear survey and making the results available for this report. Bruce Bartley and Rebecca Strauch of ADF&G served as an observer and the data manager/GIS analyst, respectively, for the bear survey. Sincere thanks go to fixed-wing airplane pilots Mark Lang, Mike Meekin, Harley McMahan, David Filkill, Mike Litzen, and Andy Greenblatt, and to helicopter pilots Brent Fedirchuk, Jeremy Zall, Bruce Andrews, Pascal Fischer, Tim Varnadoe, and Mark Stanton, for safe and efficient survey flights. ABR biologists Jennifer Boisvert, John Rose, Tim Obritschkewitsch, Matthew Evans, Ann Wildman, Spencer Rearden, and Harry Reynolds provided cheerful and diligent assistance in field surveys, and excellent office support was provided by Allison Zusi-Cobb, Matt Macander, Will Lentz, Chris Swingley, Tom DeLong, Helen Behan, Amy Turner, Pam Odom, Doris Armijo, and Tony LaCortiglia.

16.2.11 Glossary

Autocorrelation — A mathematical representation of the degree of similarity between successive data points. Many statistical analyses assume each data point is an independent random sample from the population. If data points are strongly related spatially or temporally to other data points, then the assumption of independence is not met and test statistics will not be accurate.

Fixed-kernel distribution — A statistical method using spatial data to estimate the relative density of use of an area by an animal or population of animals.

Line transect — Sampling technique in which the probability of detecting an animal is assumed to vary as a defined function of distance from the survey line. A detection probability function is estimated and used to derive a population estimate by adjusting observed counts using the detection function. Line-transect surveys require either the assumption of complete detection at the survey line or else additional information that can be used to estimate detectability at the survey line.

Sightability — The proportion of animals present within a survey area that is observed and counted during a survey. A sightability correction factor (SCF) is a numerical correction developed for population estimates to account for animals that may have been missed during a survey when sightability is less than complete.

Strip transect — Sampling technique in which observers define a strip of a certain width on one or both sides of a survey line and count all individuals detected within the strip. To generate a population estimate, the estimated densities are used to extrapolate to adjacent unsurveyed areas. All animals are assumed to be detected within the strip or the probability of detection is assumed to be constant at all distances from the center of the strip.

Telemetry — The use of various types of radio-transmitters (VHF, satellite, or GPS) attached to collars that are placed on animals to track their movements.

TABLES

TABLE 16.2-1
Species and Numbers of Mammals Recorded during Wildlife Surveys, Mine Study Area, 2004-2007

Survey Type	Year	Date	Brown Bear	Caribou	Moose	Wolf	Wolverine
Transect Surveys	2004	April 12	0	0	0	0	0
		May 21	5	30	0	0	0
		July 1	6	9,963	0	0	0
		Oct. 20	4	4	3	1	0
		Nov. 29-30	0	0	0	0	0
		TOTAL	**15**	**9,997**	**3**	**1**	**0**
	2005	March 29	0	0	0	0	0
		May 9	4	0	2	0	0
		May 25	6	1	1	0	0
		June 29	2	0	0	0	0
		July 21	2	16	0	0	0
		Oct. 10	5	0	0	0	0
		Dec 12	0	146	1	0	0
		TOTAL	**19**	**163**	**4**	**0**	**0**
	2006	May 24	1	0	1	0	0
		June 28	18	5,039	0	0	0
		July 14	1	1	2	0	0
		Dec. 1-2	0	0	2	0	0
		TOTAL	**20**	**5,040**	**5**	**0**	**0**
	2007	June 27	10	2,132	0	0	0
		July 16-17	6	45	0	0	0
		TOTAL	**16**	**2,177**	**0**	**0**	**0**
Stream/Den Survey	2004	Aug. 18-19	16	6	0	0	0
Den Checks	2005	May 11-12	3	0	0	0	0
		Aug. 29-30	4	10	0	0	0
	2006	May 8-9	4	0	0	0	0
		TOTAL	**11**	**10**	**0**	**0**	**0**
Beaver Survey	2005	October 9	5	0	3	0	0
Incidental Observations (during other wildlife surveys)	2004	April	0	3	0	1	0
		May	0	5	0	0	0
		June	5	65	0	1	1
		July	3	0	0	1	0
		September	21	0	0	6	0
		October	10	0	0	0	0
		TOTAL	**39**	**73**	**0**	**9**	**1**

Survey Type	Year	Date	Brown Bear	Caribou	Moose	Wolf	Wolverine
Incidental Observations (during other wildlife surveys)	2005	May	4	6	19	0	0
		June	14	15	2	0	0
		July	21	0	0	0	1
		August	19	22	1	1	0
		September	5	0	0	0	0
		October	6	100	3	0	0
		TOTAL	**69**	**143**	**25**	**1**	**1**

TABLE 16.2-2
Number of Large-mammal Groups Seen by Front Observer Only, Rear Observer Only, and Both Observers during Double-count Aerial Transect Surveys, Mine Study Area, June-July 2007

Observer	Caribou [a]	Brown Bear	Total
Front only	1	2	**3**
Rear only	2	2	**4**
Both	1	2	**3**
TOTAL	**4**	**6**	**10**

Note:

a. One large group of caribou was omitted because of its high probability of detection.

TABLE 16.2-3
Number of Moose Observed Inside and Outside of Surveyed Sampled Units, by Sex and Age Category, during Moose Population Survey, Bristol Bay Drainages, April 6-10, 2010

		Sex and Age Category				
On/Off Survey	**Study Area**	**Adult Male**	**Cow with 1 Calf**	**Cow with 2 Calves**	**Unknown Sex**	**Total**
Inside sample units	Mine Area	0	0	0	3	3
	Transportation Corridor	3	3	1	6	18
	TOTAL	**3**	**3**	**1**	**9**	**21**
Outside sample units	Mine Area	4	0	0	0	4
	Transportation Corridor	2	2	0	7	13
	TOTAL	**6**	**2**	**0**	**7**	**17**

TABLE 16.2-4
Estimated Number and Density of Moose, by Study Area, in Population Survey Area, Bristol Bay Drainages, April 6-10, 2010

		Estimated Population Size		Population Density (moose/km²)	
Study Area	**Area (km²)**	**Number**	**95% Confidence Interval [a]**	**Density**	**95% Confidence Interval**
Mine Area	1,178.4	33.1	7-80.9	0.03	0.01-0.07
Transportation Corridor	1,219.3	63.1	31-109.2	0.05	0.03-0.09
TOTAL	**2,397.7**	**96.2**	**38-175.6**	**0.04**	**0.02-0.07**

Note:

a. Lower confidence limit was set to the actual number of moose observed during the survey if it was greater than the calculated value.

FIGURES

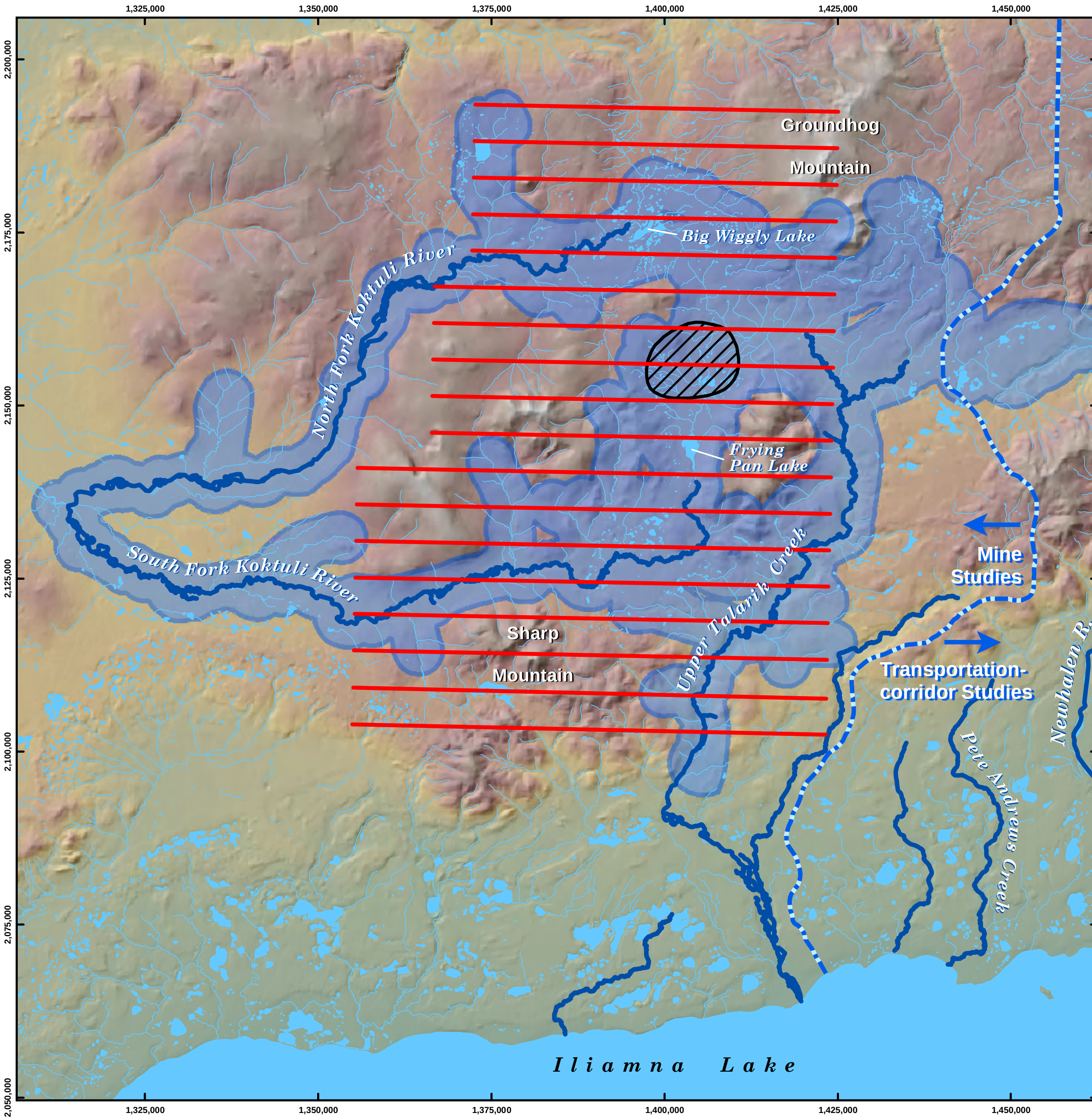

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Figure 16.2-1A
Survey Areas for Large Mammals and Beaver, Mine Study Area, 2004–2007

Legend

- 2004–2007 Aerial-survey Transect
- August 2004 Stream Survey
- October 2005 Beaver Survey Area
- General Deposit Location

Miles: 0 1 2 3 4 5

Kilometers: 0 2 4 6 8

N

Scale 1:275,000

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

File: 16-2-1A_MammalBeaverSAs_Mine_PLP_EBD_v02.mxd	Date: March 4, 2011
Version: 2	Author: ABR-AZC

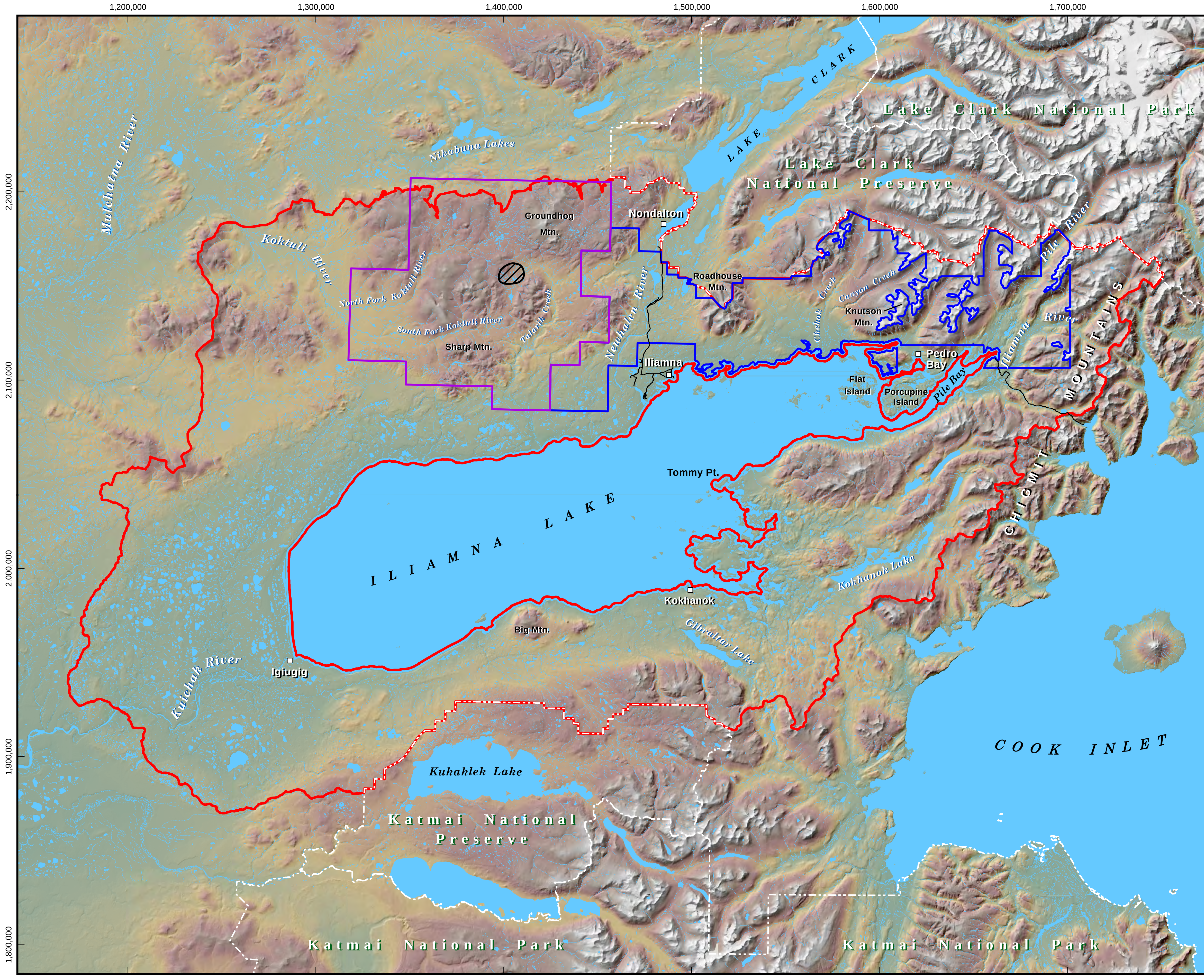

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Figure 16.2-1B
Bear and Moose Population Survey Study Areas, Bristol Bay Drainages, May 2009 and April 2010

Legend

May 2009 Bear Density Survey Area

April 2010 Moose Density Survey Area

Mine Study Area

Transportation-Corridor Study Area

Data source: Bear survey data used with permission of E. Becker, ADF&G.

General Deposit Location

Existing Road

Miles: 0 5 10 15 20

Kilometers: 0 5 10 15 20 25 30

N

Scale 1:630,000

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

File: 16-2-1B_BearMoosePopSAs_PLP_EBD_v02.mxd	Date: March 8, 2011
Version: 2	Author: ABR-AZC

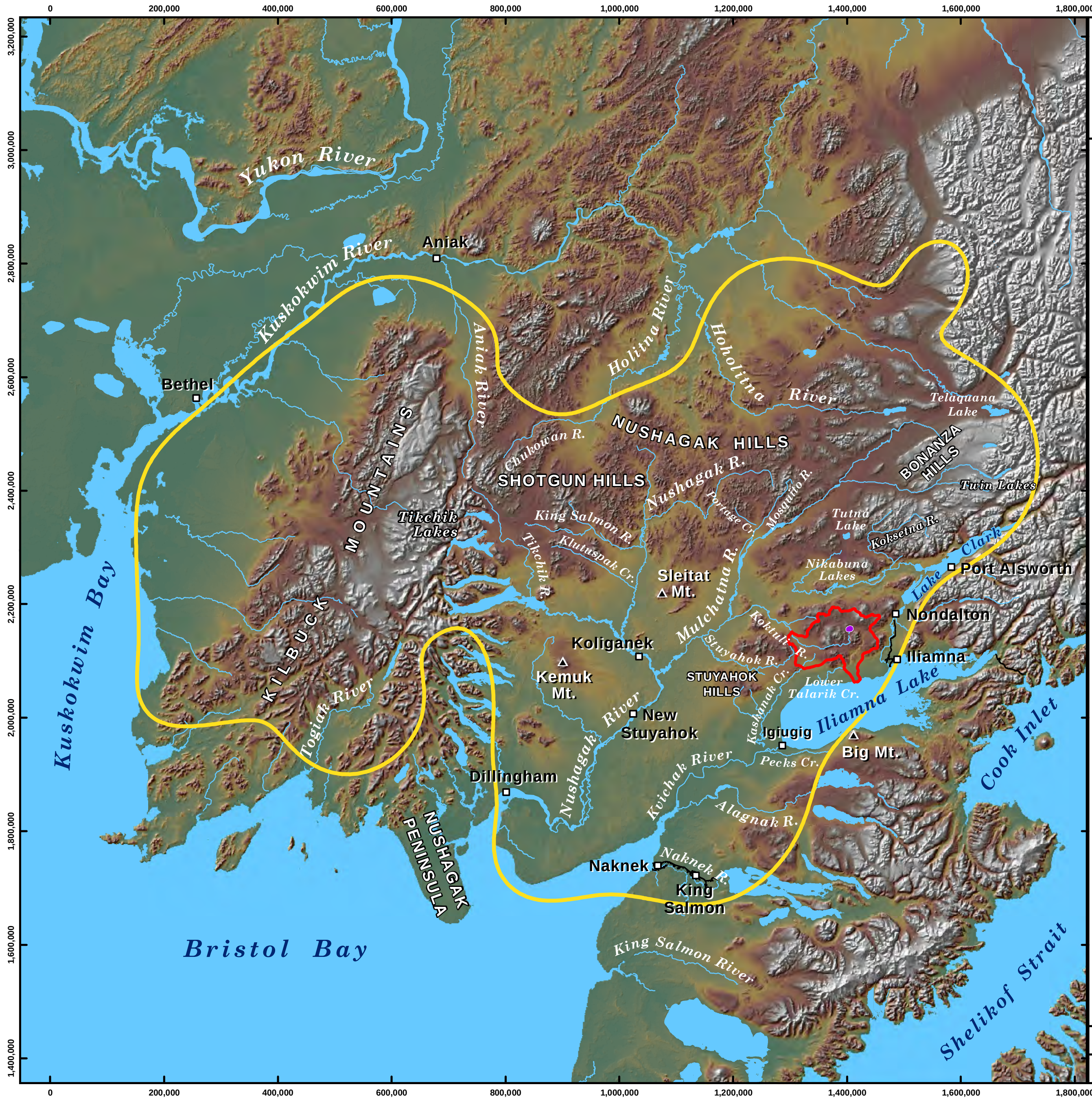
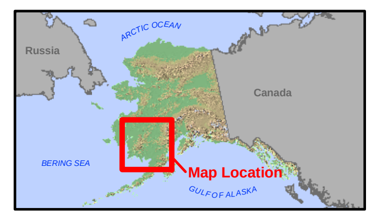


Figure 16.2-2.
Mulchatna Caribou Herd Range, Southwestern Alaska, 1981–2010

Legend

- Mulchatna Caribou Herd Range
- Greater Mine Study Area
- General Deposit Location
- Existing Road
- Town or Village
- Summit

Data source: MCHTWG telemetry data set (from ADF&G and Togiak and Yukon Delta National Wildlife Refuges), March 1981–March 2010.



Miles: 0 25 50 75
Kilometers: 0 25 50 75 100 125
N

Scale 1:3,300,000

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

File: 16-2-2_MHerdSA_PLP_EBD_v02.mxd	Date: March 7, 2011
Version: 2	Author: ABR-AZC

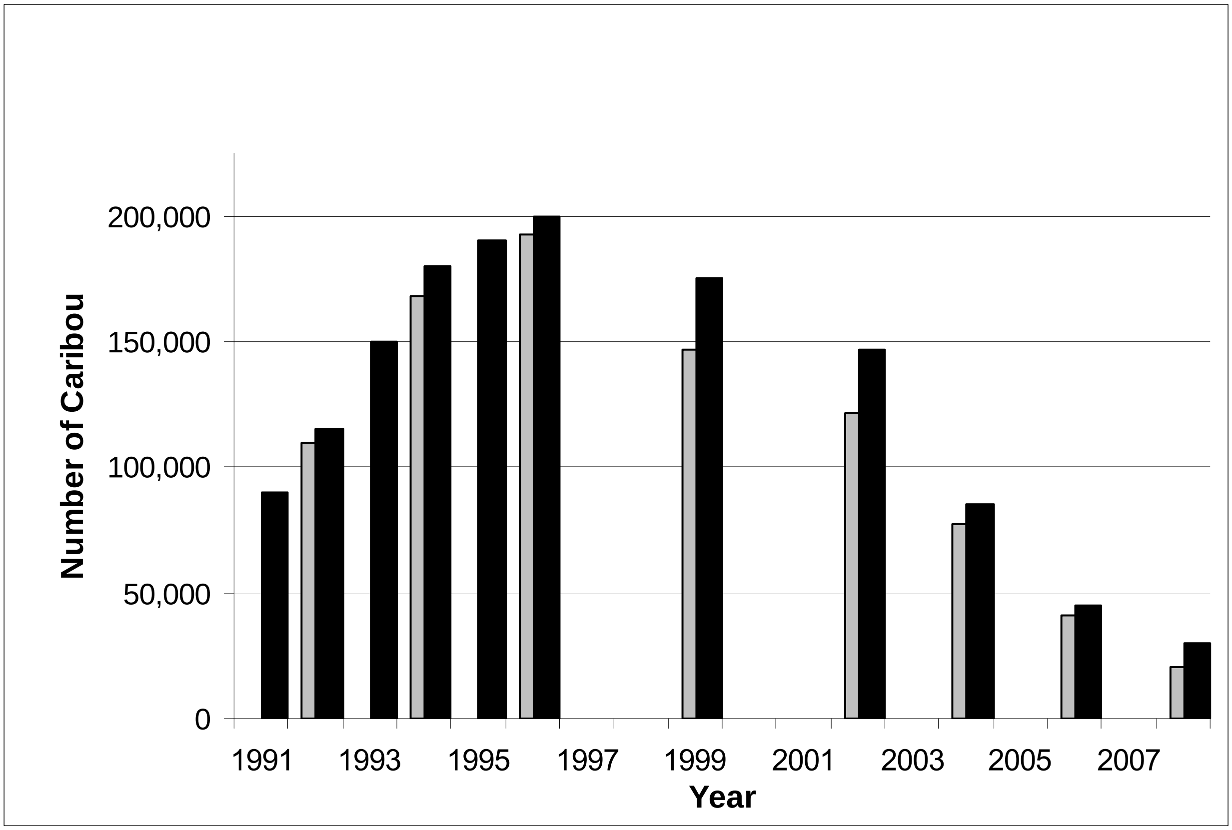


FIGURE 16.2-3
Population Estimates of the Mulchatna Caribou Herd, Southwestern Alaska, 1991-2008

Note:

gray bars = photocensus counts plus field counts during censuses; black bars = extrapolated estimates incorporating additional data (no photocensus counts available)

Source: Woolington, 2010

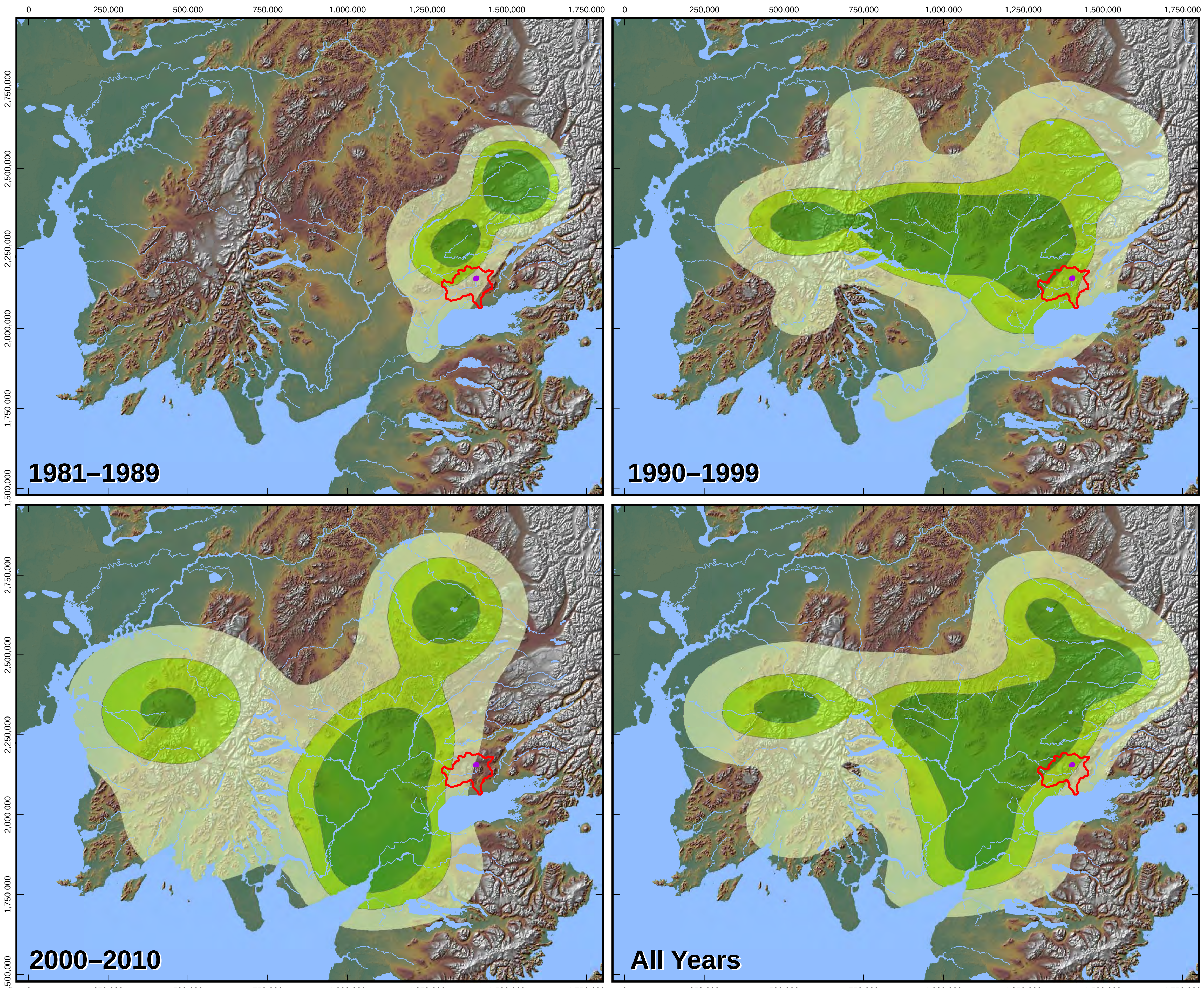


Figure 16.2-4
Mulchatna Caribou Herd, Seasonal Range Use, Southwestern Alaska, Spring 1981–2010

Spring (April 1–May 14)
Areas of Concentrated Use

- High Density
- Medium Density
- Low Density

- Greater Mine Study Area
- General Deposit Location

Data source: Utilization distribution contours from fixed-kernel analysis of locations of radio-collared caribou (telemetry database from ADF&G, Togiak and Yukon Delta National Wildlife Refuges). Contours enclose stated percentages of all collar locations. High-, medium-, and low-density areas are the 50%, 75%, and 95% utilization distribution contours, respectively.

Miles: 0 25 50 75 100 125
Kilometers: 0 50 100 150 200
N
Scale 1:3,750,000
Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: 16-2-4_MHerdSpringUse_PLP_EBD_v02.mxd	Date: March 7, 2011
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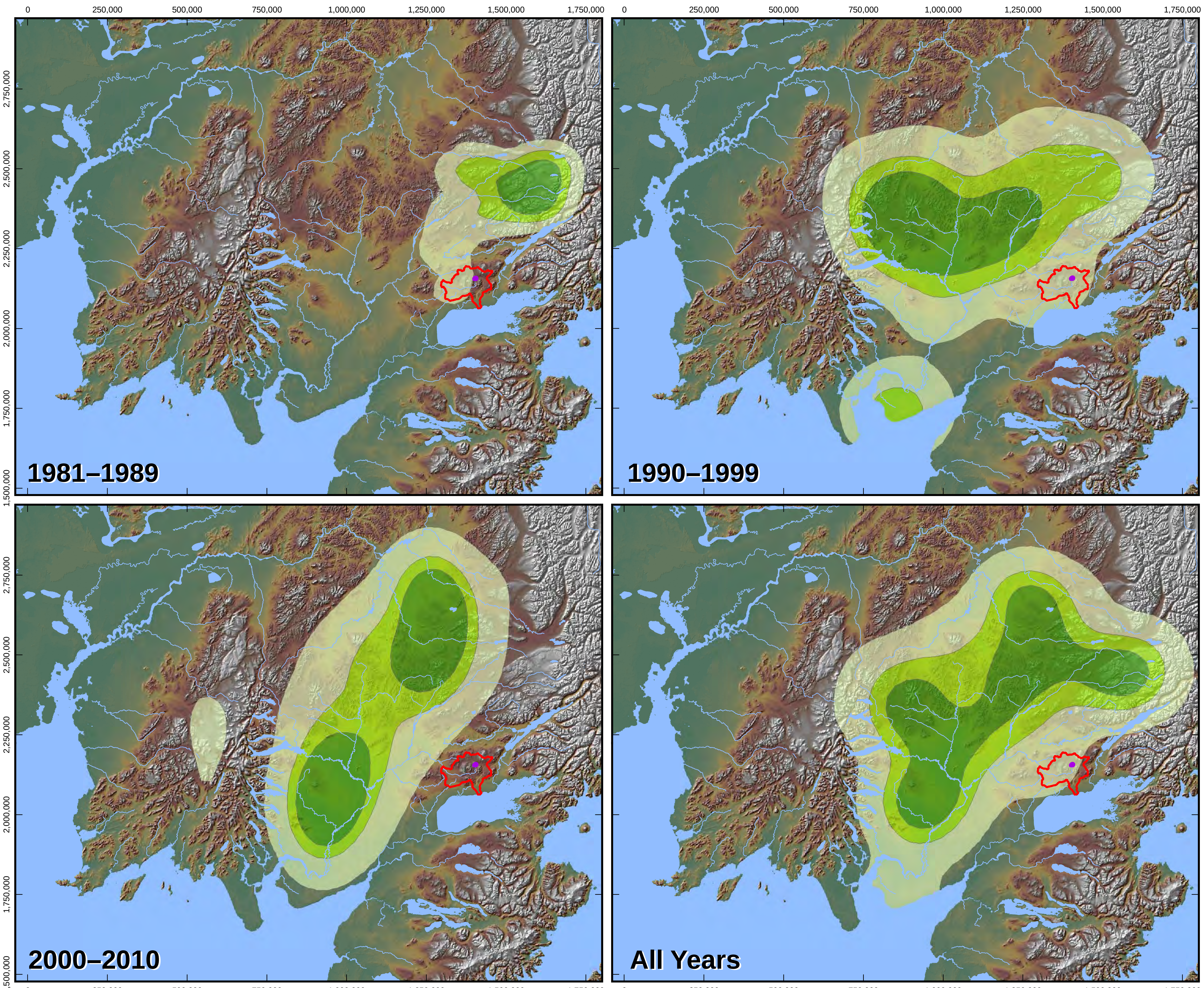

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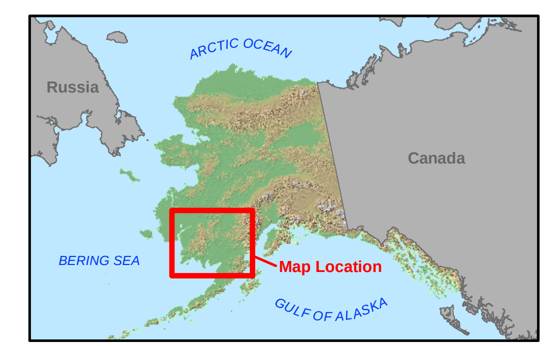
Figure 16.2-5
Mulchatna Caribou Herd, Seasonal Range Use, Southwestern Alaska, Calving 1981–2010

Calving (May 15–June 10)
Areas of Concentrated Use

- High Density
- Medium Density
- Low Density

- Greater Mine Study Area
- General Deposit Location

Data source: Utilization distribution contours from fixed-kernel analysis of locations of radio-collared female caribou (telemetry database from ADF&G, Togiak and Yukon Delta National Wildlife Refuges). Contours enclose stated percentages of all collar locations. High-, medium-, and low-density areas are the 50%, 75%, and 95% utilization distribution contours, respectively.



Miles: 0 25 50 75 100 125
Kilometers: 0 50 100 150 200
N

Scale 1:3,750,000

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

File: 16-2-5_MHerdCalvingUse_PLP_EBD_v02.mxd	Date: March 7, 2011
Version: 2	Author: ABR-AZC

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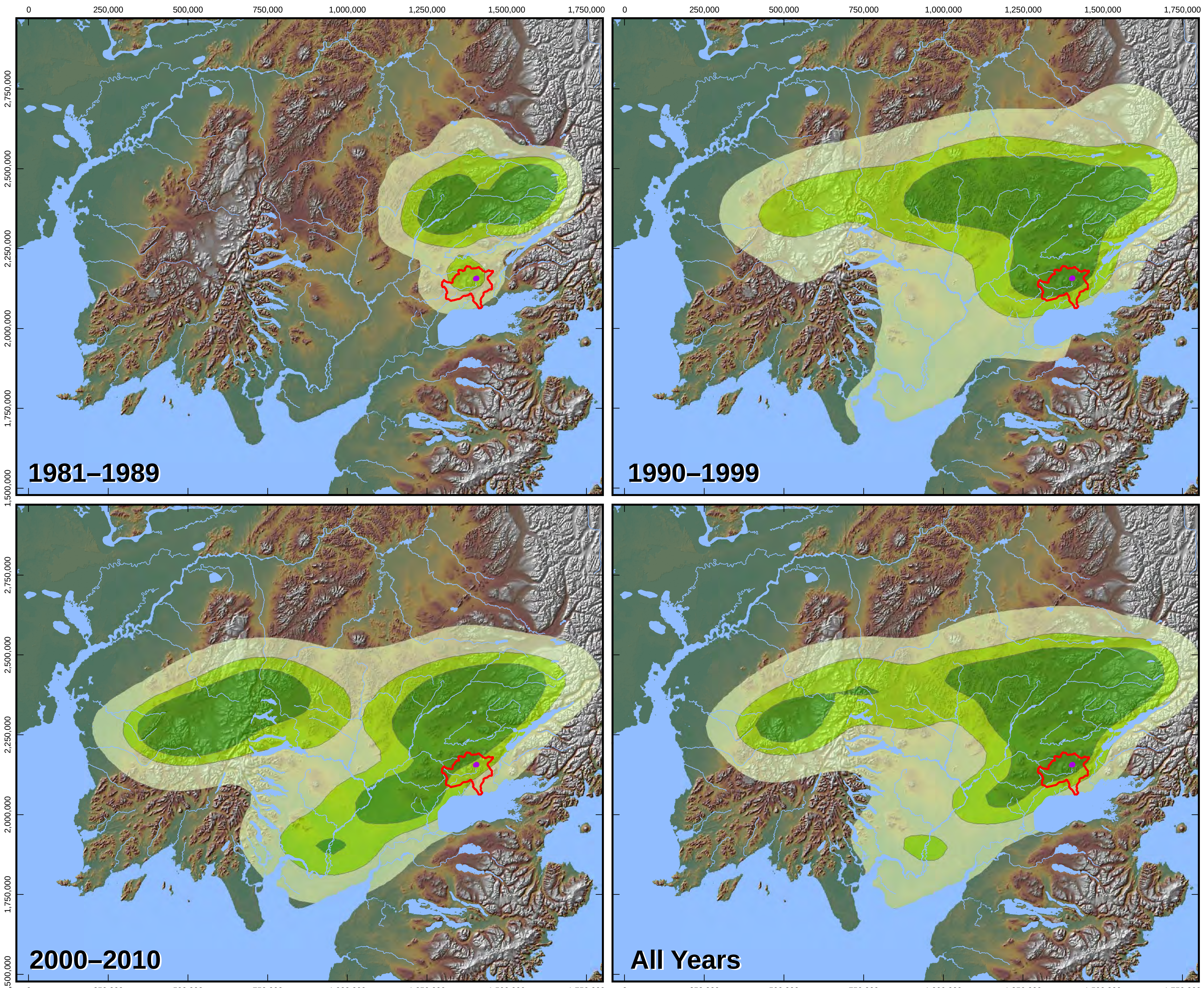
Figure 16.2-6
Mulchatna Caribou Herd, Seasonal Range Use, Southwestern Alaska, Summer 1981–2010

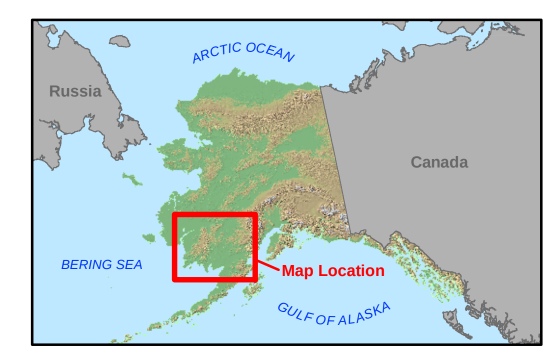


Summer (June 11–September 7)
Areas of Concentrated Use

- High Density
- Medium Density
- Low Density

- Greater Mine Study Area
- General Deposit Location

Data source: Utilization distribution contours from fixed-kernel analysis of locations of radio-collared caribou (telemetry database from ADF&G, Togiak and Yukon Delta National Wildlife Refuges). Contours enclose stated percentages of all collar locations. High-, medium-, and low-density areas are the 50%, 75%, and 95% utilization distribution contours, respectively.



Miles: 0, 25, 50, 75, 100, 125
Kilometers: 0, 50, 100, 150, 200
N

Scale 1:3,750,000

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

File: 16-2-6_MHerdSummerUse_PLP_EBD_v02.mxd	Date: March 7, 2011
Version: 2	Author: ABR-AZC

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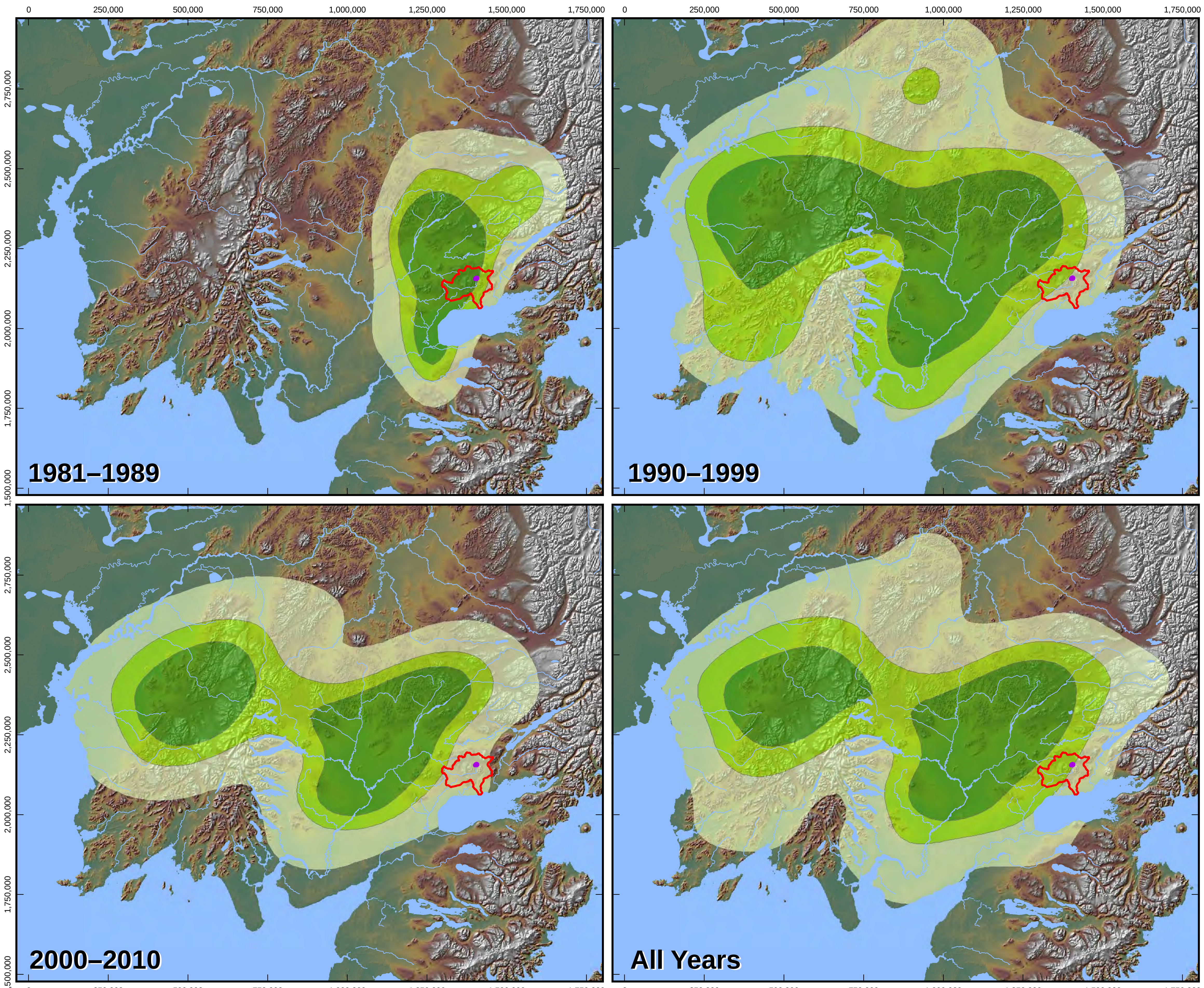
Figure 16.2-7 Mulchatna Caribou Herd, Seasonal Range Use, Southwestern Alaska, Autumn 1981–2010



Autumn (September 8–October 31)
Areas of Concentrated Use

- High Density
- Medium Density
- Low Density

- Greater Mine Study Area
- General Deposit Location

Data source: Utilization distribution contours from fixed-kernel analysis of locations of radio-collared caribou (telemetry database from ADF&G, Togiak and Yukon Delta National Wildlife Refuges). Contours enclose stated percentages of all collar locations. High-, medium-, and low-density areas are the 50%, 75%, and 95% utilization distribution contours, respectively.

Miles: 0, 25, 50, 75, 100, 125

Kilometers: 0, 50, 100, 150, 200

N

Scale 1:3,750,000

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

File: 16-2-7_MHerdAutumnUse_PLP_EBD_v02.mxd	Date: March 8, 2011
Version: 2	Author: ABR-AZC

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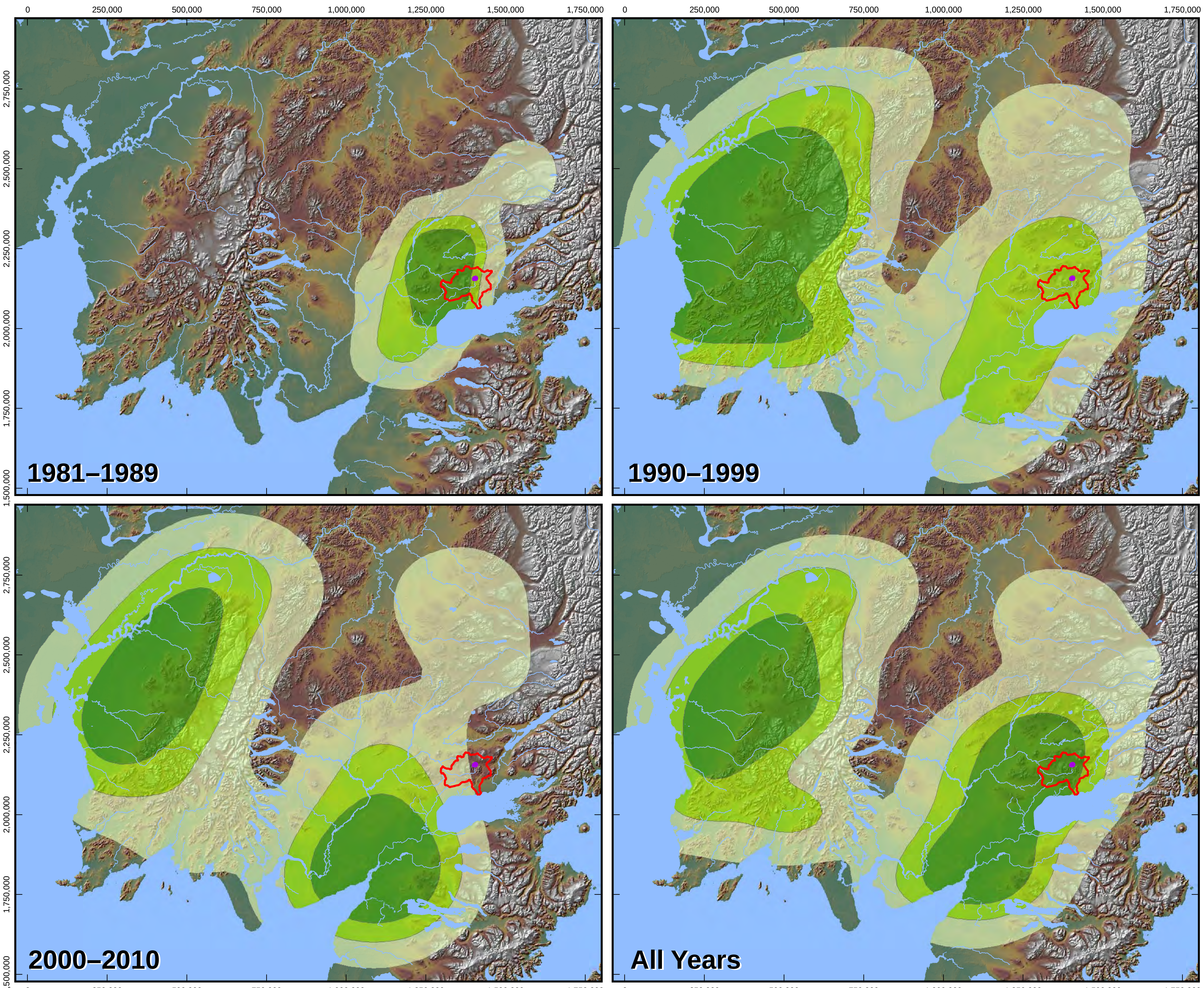


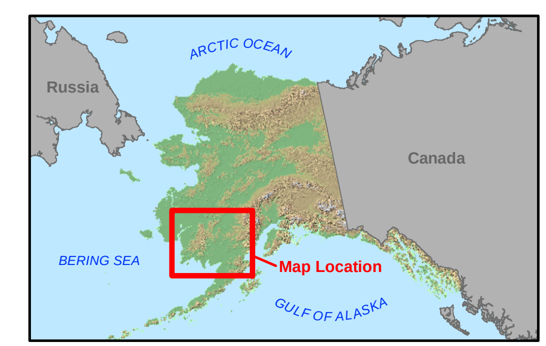
Figure 16.2-8
Mulchatna Caribou Herd, Seasonal Range Use, Southwestern Alaska, Winter 1981–2010

Winter (November 1–March 31)
Areas of Concentrated Use

- High Density
- Medium Density
- Low Density

- Greater Mine Study Area
- General Deposit Location

Data source: Utilization distribution contours from fixed-kernel analysis of locations of radio-collared caribou (telemetry database from ADF&G, Togiak and Yukon Delta National Wildlife Refuges). Contours enclose stated percentages of all collar locations. High-, medium-, and low-density areas are the 50%, 75%, and 95% utilization distribution contours, respectively.



Miles: 0, 25, 50, 75, 100, 125

Kilometers: 0, 50, 100, 150, 200

N

Scale 1:3,750,000

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

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Version: 2	Author: ABR-AZC

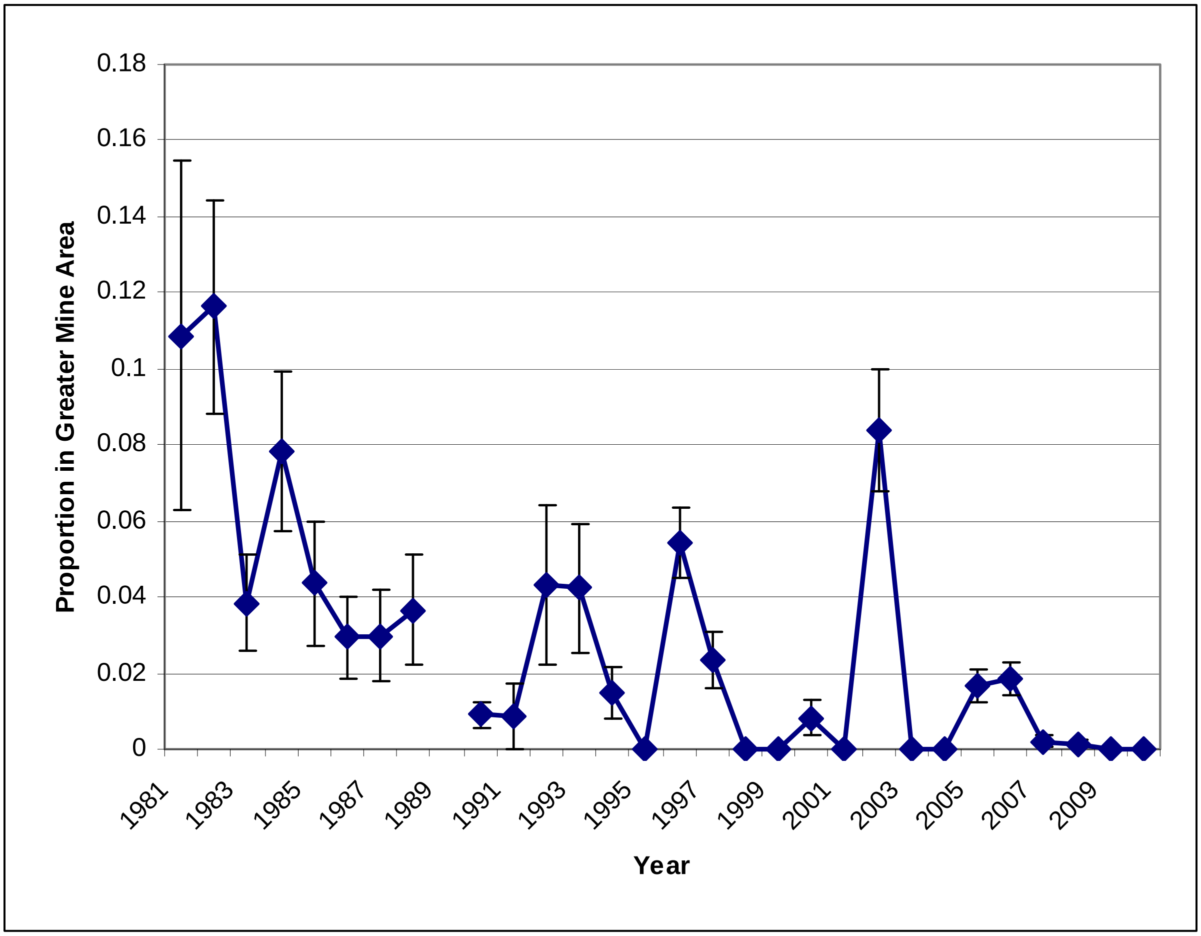

FIGURE 16.2-9
Proportion of Radio-collared Caribou Locations in the Greater Mine Study Area, by Year, Mulchatna Caribou Herd, 1981-2010

Note:

Vertical error bars indicate standard error.

Source: MCHTWG telemetry data set, as described in Section 16.2.6.1.

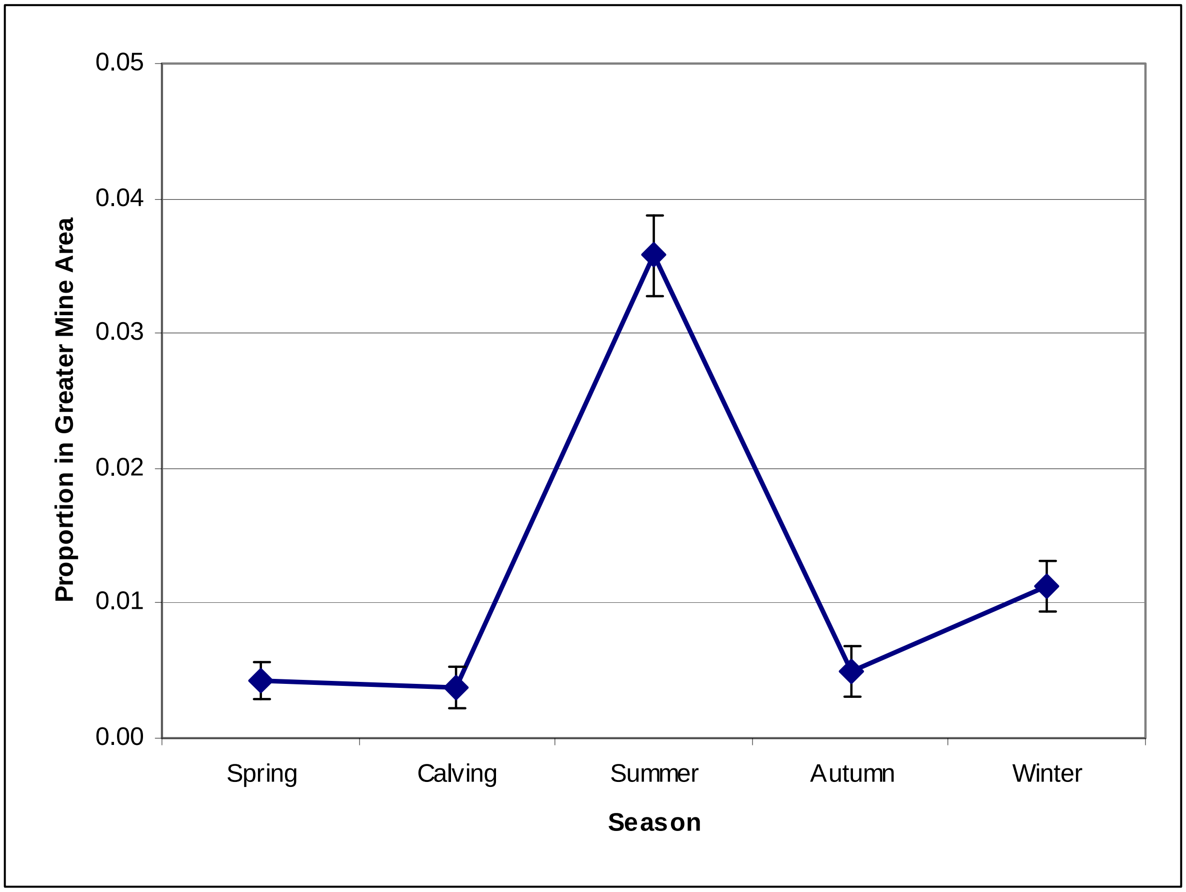

FIGURE 16.2-10
Proportion of Radio-collared Caribou Locations in the Greater Mine Study Area, by Season, Mulchatna Caribou Herd, 1981-2010

Note:

Vertical error bars indicate standard error.

Source: MCHTWG telemetry data set, as described in Section 16.2.6.1.

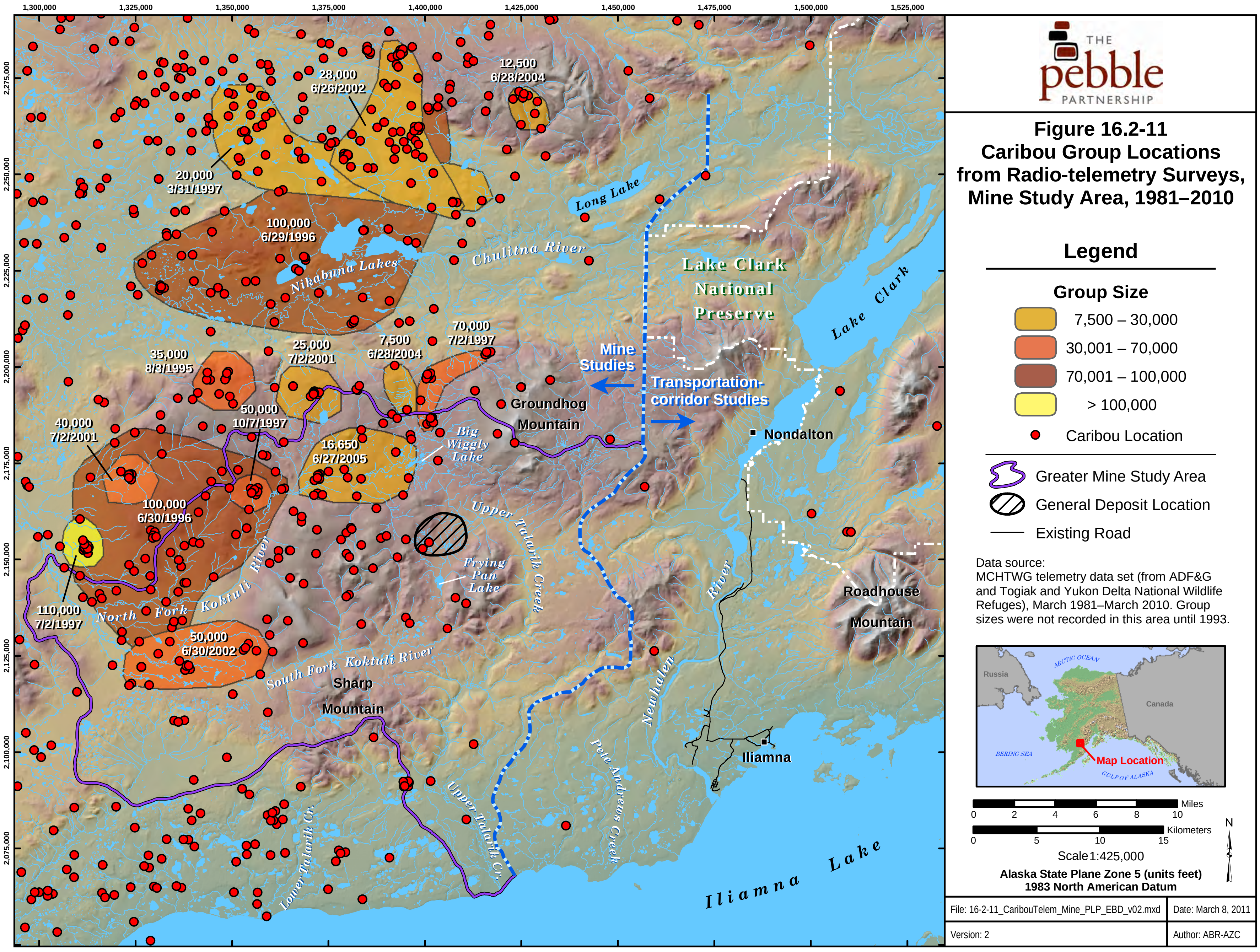

Figure 16.2-11
Caribou Group Locations from Radio-telemetry Surveys, Mine Study Area, 1981–2010

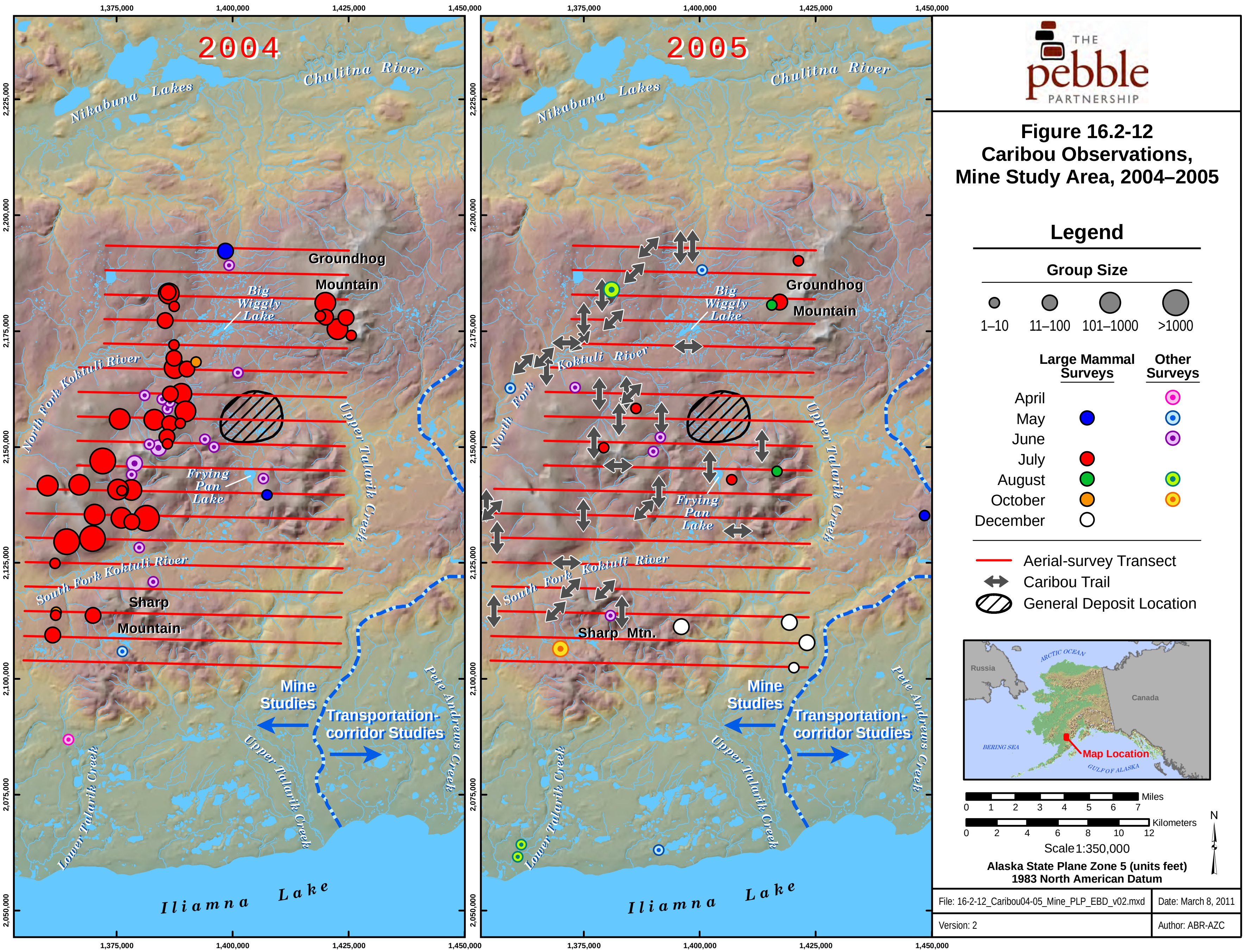

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Figure 16.2-12
Caribou Observations,
Mine Study Area, 2004–2005
2004
2005
Chulitna River
Nikabuna Lakes
Groundhog Mountain
Big Wiggly Lake
North Fork Koktuli River
Upper Talarik Creek
Frying Pan Lake
South Fork Koktuli River
Sharp Mountain
Sharp Mtn.
Mine Studies
Transportation-corridor Studies
Lower Talarik Creek
Pete Andrews Creek
Iliamna Lake
1,375,000
1,400,000
1,425,000
1,450,000
2,225,000
2,200,000
2,175,000
2,150,000
2,125,000
2,100,000
2,075,000
2,050,000
Legend
Group Size
1–10
11–100
101–1000
>1000
Large Mammal Surveys
Other Surveys
April
May
June
July
August
October
December
Aerial-survey Transect
Caribou Trail
General Deposit Location
Russia
ARCTIC OCEAN
Canada
BERING SEA
GULF OF ALASKA
Map Location
Miles
0 1 2 3 4 5 6 7
Kilometers
0 2 4 6 8 10 12
Scale 1:350,000
N
Alaska State Plane Zone 5 (units feet)
1983 North American Datum
File: 16-2-12_Caribou04-05_Mine_PLP_EBD_v02.mxd
Date: March 8, 2011
Version: 2
Author: ABR-AZC

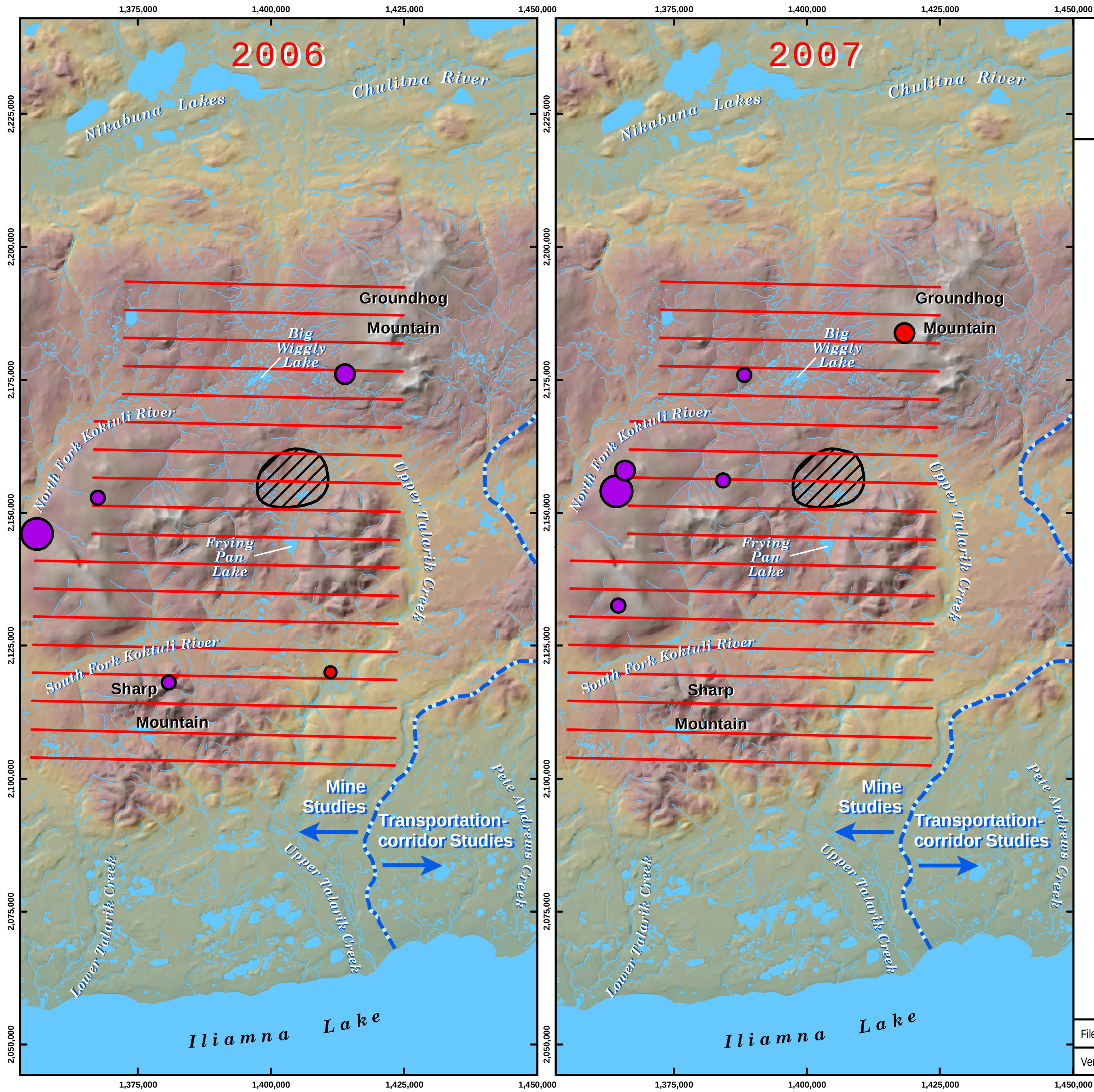

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Figure 16.2-13
Caribou Observations, Mine Study Area, 2006–2007

Legend

Group Size
- 1–10
- 11–100
- ≥2000

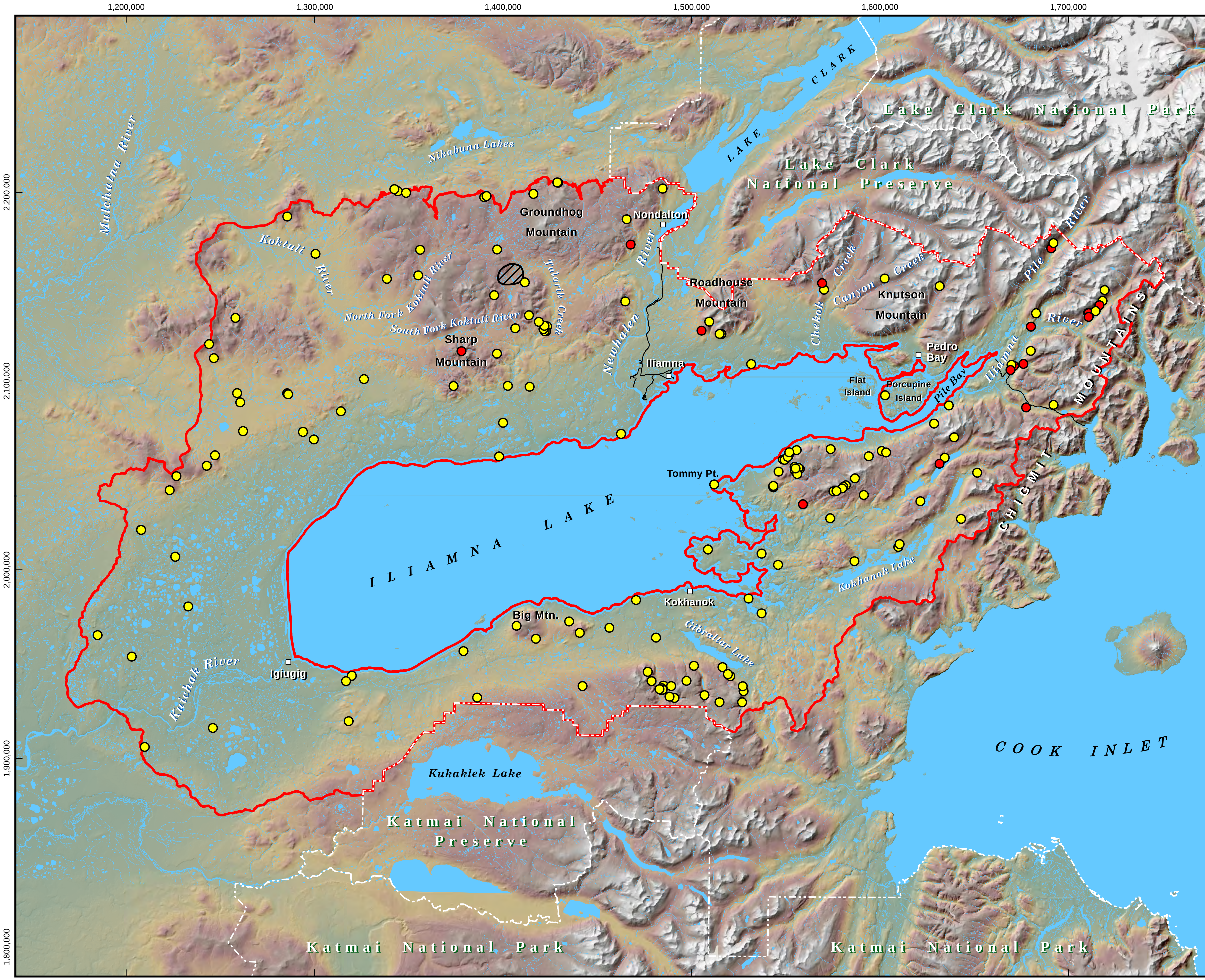
Month
- June
- July

Aerial-survey Transect
General Deposit Location

Miles 0 1 2 3 4 5 6 7
Kilometers 0 2 4 6 8 10 12
N
Scale 1:350,000

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

File: 16-2-13_Caribou06-07_Mine_PLP_EBD_v02.mxd	Date: March 8, 2011
Version: 2	Author: ABR-AZC



![The Pebble Partnership logo]

Figure 16.2-14
Brown and Black Bear Observations during Bear Population Survey, Bristol Bay Drainages, May 2009

Legend

Bear Observation

- Black Bear
- Brown Bear

Bear Density Survey Area

Data source: Data used with permission of E. Becker, ADF&G.

General Deposit Location

Existing Road

Russia
ARCTIC OCEAN
Canada
BERING SEA
Map Location
GULF OF ALASKA

Miles: 0 5 10 15 20

Kilometers: 0 5 10 15 20 25 30

Scale 1:630,000

N

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

File: 16-2-14_BearPopSurv09_PLP_EBD_v02.mxd	Date: March 8, 2011
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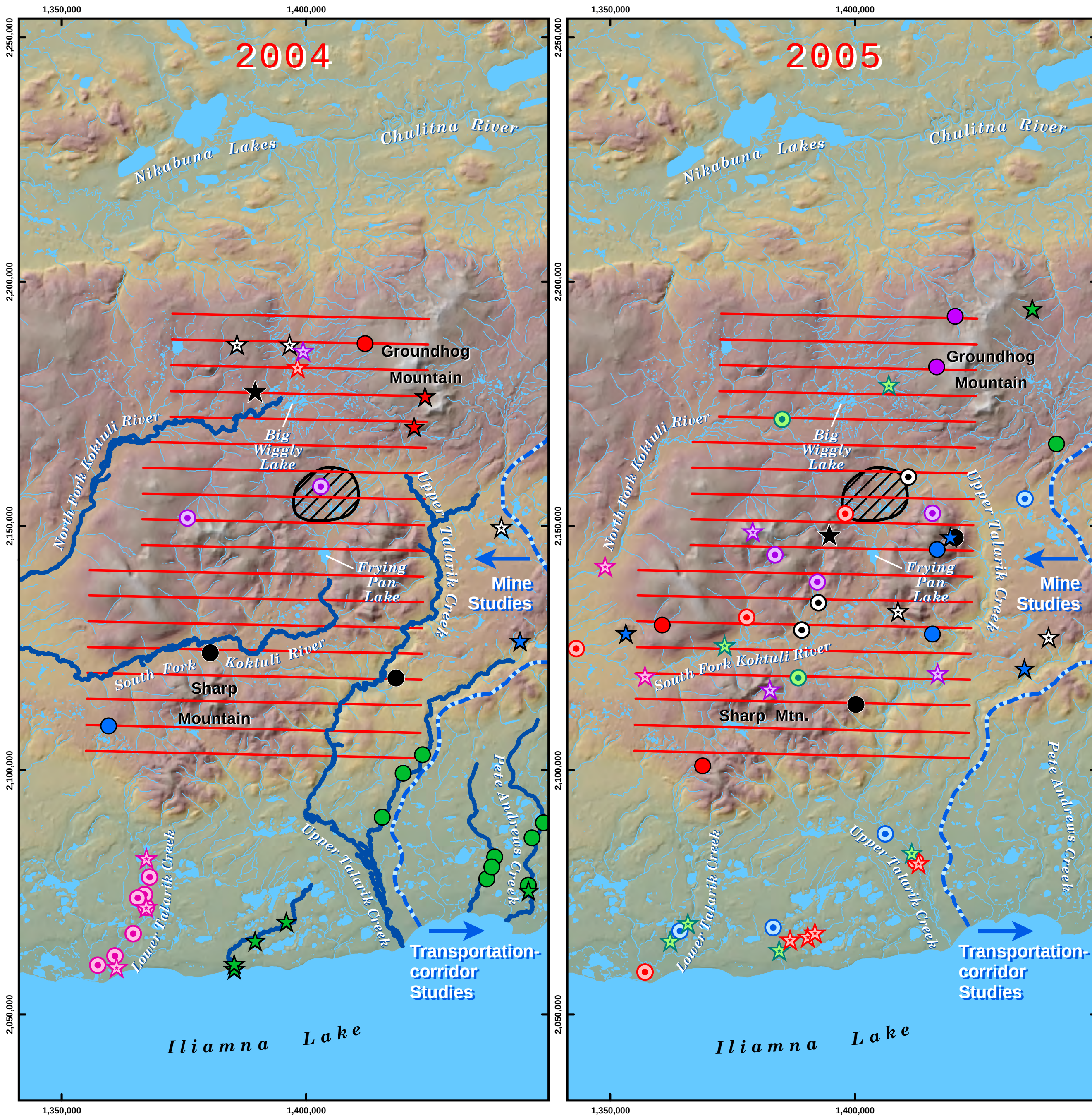

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Figure 16.2-15
Brown Bear Observations, Mine Study Area, 2004–2005

Legend

	Large Mammal Surveys		Other Surveys	
	w/ cubs		w/o cubs	
May				
June				
July				
August				
September				
October				

Aerial-survey Transect
August 2004 Stream Survey
General Deposit Location

Miles 0 1 2 3 4 5 6 7 8
Kilometers 0 2 4 6 8 10 12 14
Scale 1:390,000
N

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

File: 16-2-15_Bears04-05_Mine_PLP_EBD_v02.mxd	Date: March 8, 2011
Version: 2	Author: ABR-AZC

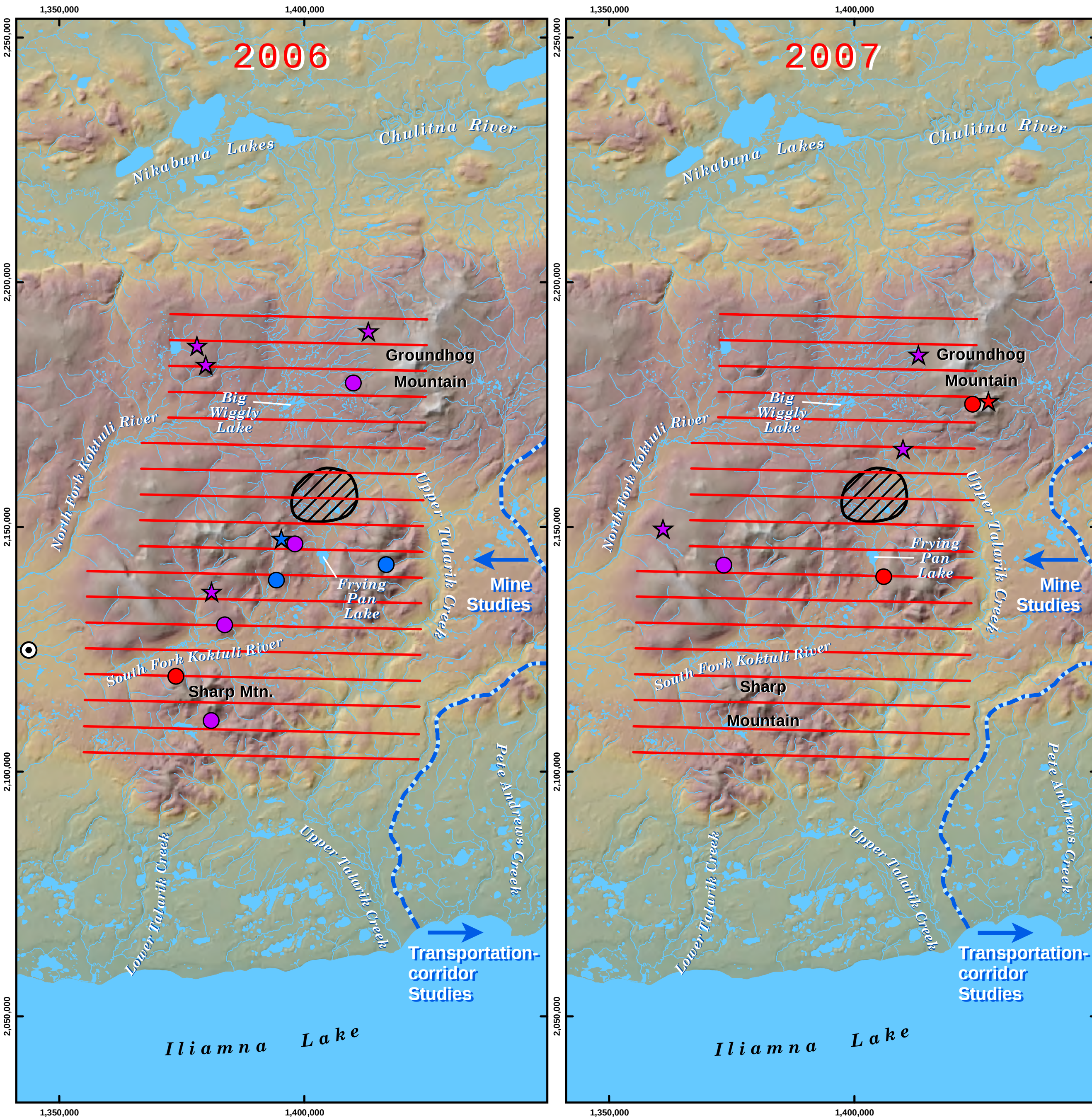

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Figure 16.2-16
Brown Bear Observations, Mine Study Area, 2006–2007

Legend

Large Mammal Surveys	Other Surveys
☆ ○	⊙

	w/ cubs	w/o cubs
May	★	●
June	★	●
July	★	●
October		⊙

Aerial-survey Transect

General Deposit Location

Miles 0 1 2 3 4 5 6 7 8

Kilometers 0 2 4 6 8 10 12 14

N

Scale 1:390,000

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

File: 16-2-16_Bears06-07_Mine_PLP_EBD_v02.mxd	Date: March 8, 2011
Version: 2	Author: ABR-AZC

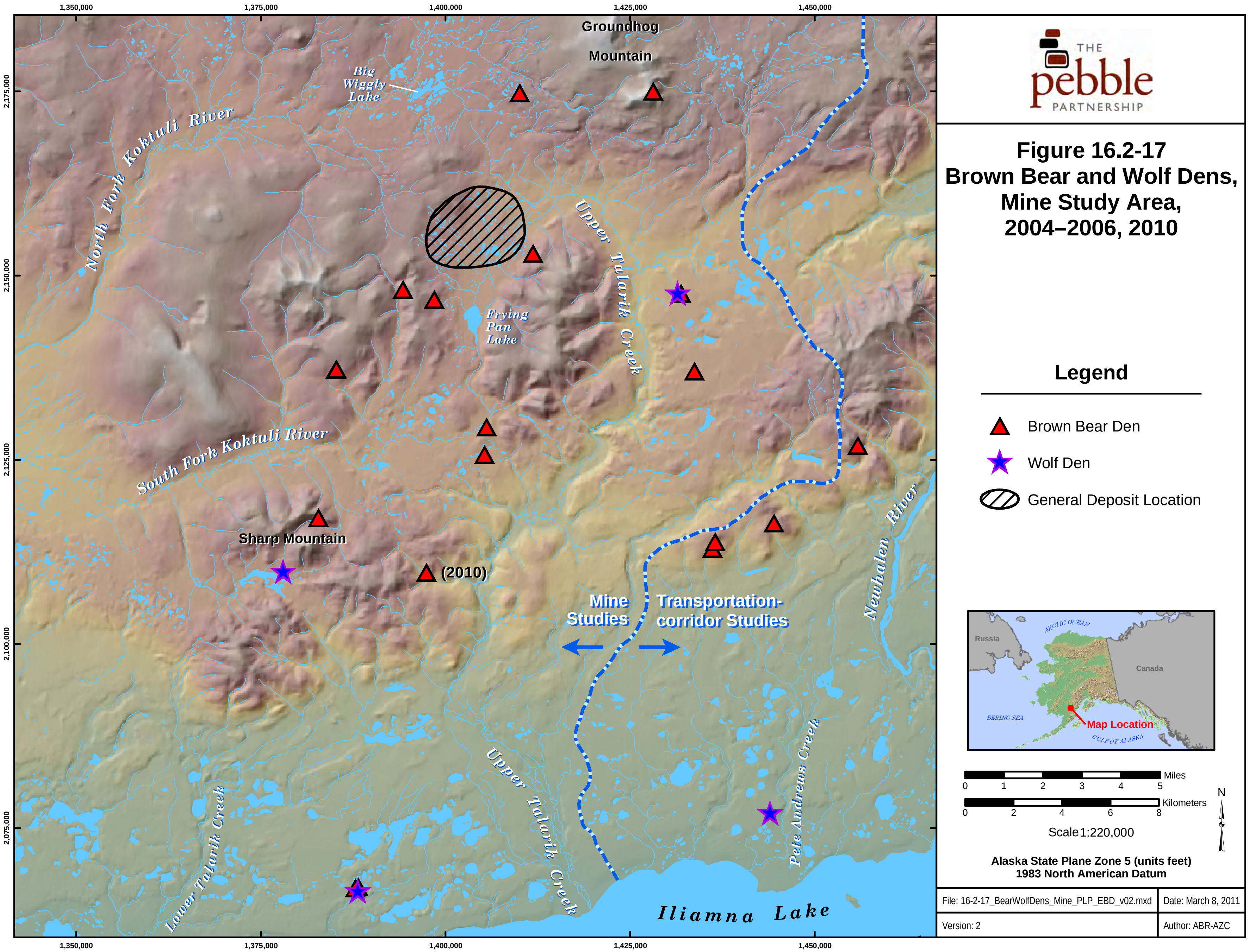


Figure 16.2-17
Brown Bear and Wolf Dens, Mine Study Area, 2004–2006, 2010

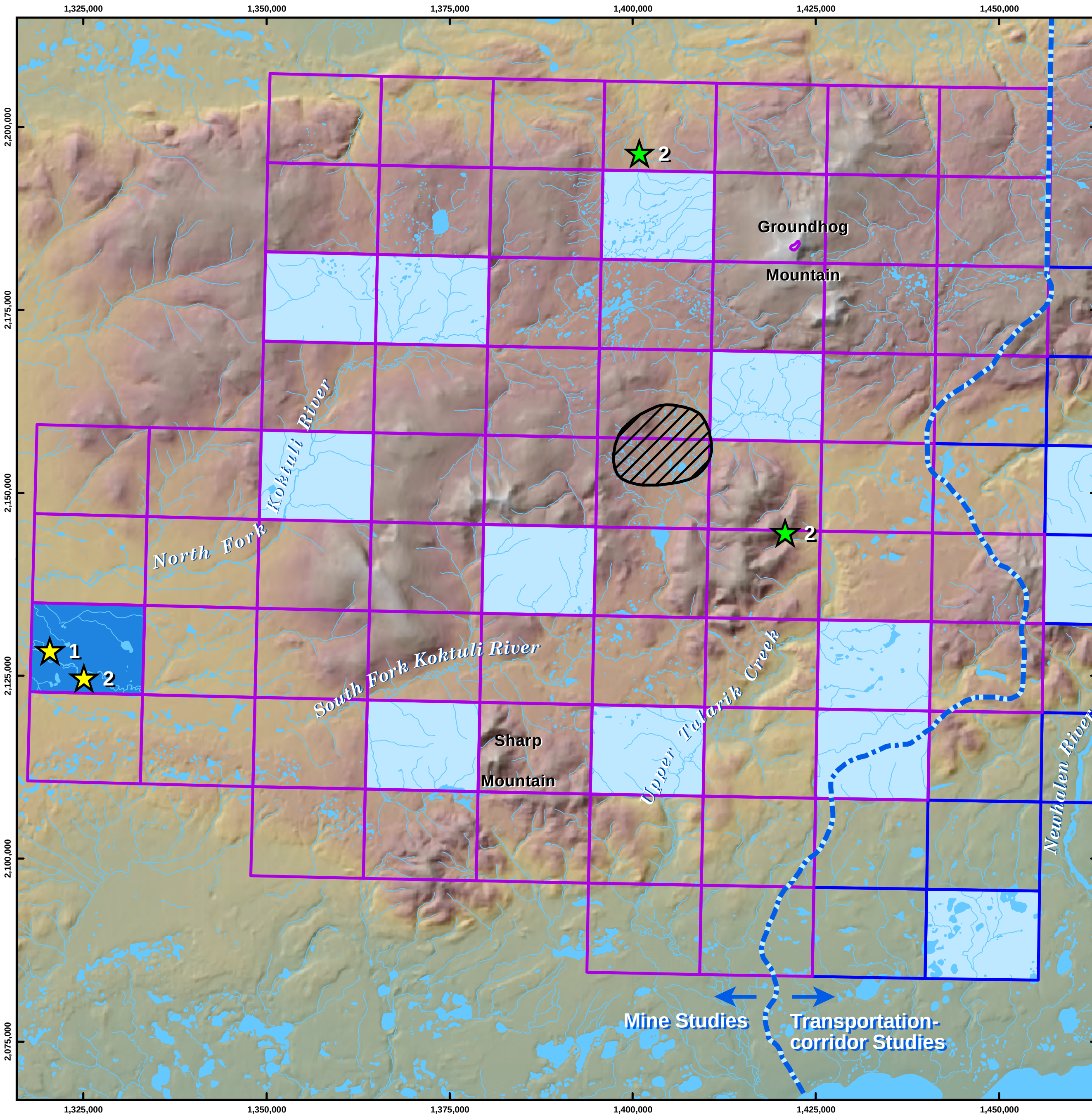


Figure 16.2-18
Moose Population Survey Results, Mine Study Area, April 2010

Legend

Number of Moose

- Out of Surveyed Area (#)
- In Surveyed Area (#)

Number of Moose in Surveyed Sample Units

- 0
- 1
- 2 – 3

Sample Units not Surveyed

- Mine
- Transportation-Corridor

General Deposit Location

Miles 0 1 2 3 4 5

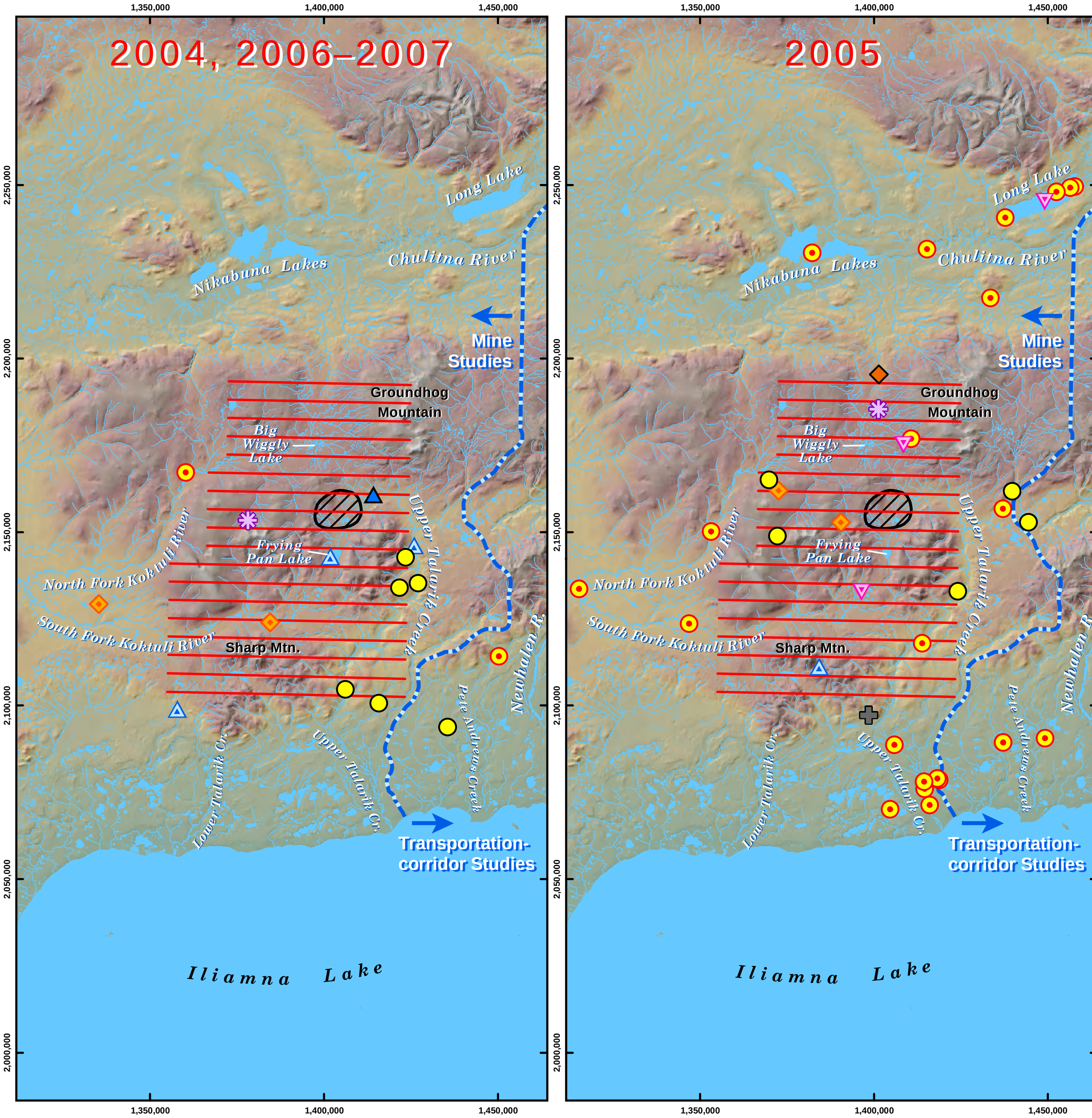
Kilometers 0 2 4 6 8

N

Scale 1:260,000

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

File: 16-2-18_MoosePop_Mine_PLP_EBD_v02.mxd	Date: March 9, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.2-19 Observations of Other Mammals, Mine Study Area, 2004–2007

Legend

	Large Mammal Surveys	Other Surveys
Moose		
Red Fox		
River Otter		
Tundra Hare		
Wolf		
Wolverine		

Aerial-survey Transect

General Deposit Location

Miles
0 2 4 6 8 10 12

Kilometers
0 5 10 15 20

N

Scale 1:550,000

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

File: 16-2-19_OtherMam_Mine_PLP_EBD_v02.mxd	Date: March 9, 2011
Version: 2	Author: ABR-AZC

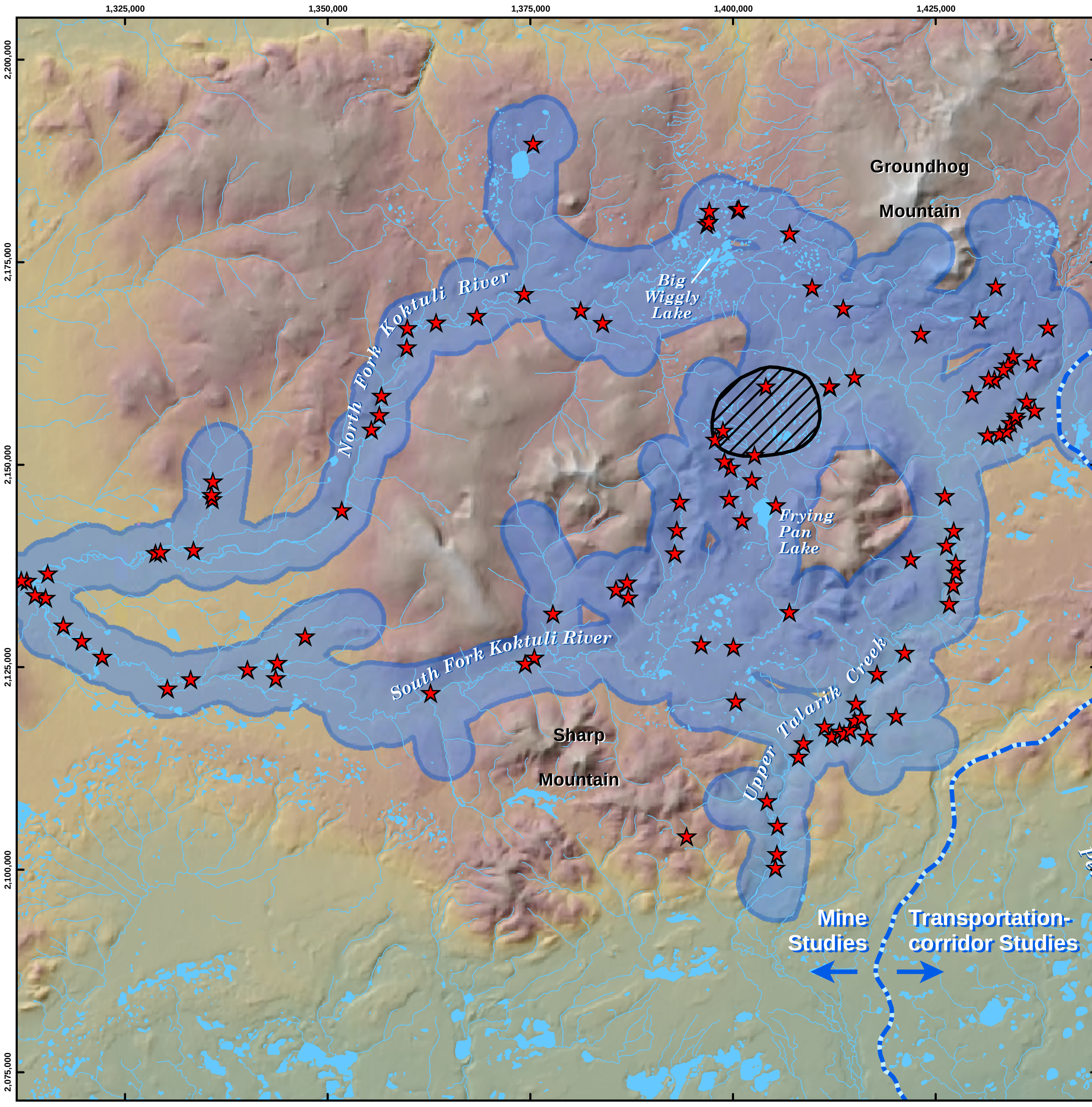


Figure 16.2-20
Active Beaver Colonies, Mine Study Area, October 2005

Legend

- Beaver Colony
- Survey Area
- General Deposit Location

Miles: 0 1 2 3 4 5

Kilometers: 0 2 4 6 8

N

Scale 1:235,000

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

File: 16-2-20_BeaverCol_Mine_PLP_EBD_v02.mxd	Date: March 24, 2011
Version: 2	Author: ABR-AZC

APPENDICES

APPENDIX 16.2A

REGIONAL LIST OF MAMMAL SPECIES
BRISTOL BAY DRAINAGES

APPENDIX 16.2A
Regional List of Mammal Species, Bristol Bay Drainages

Order	Family	Genus	Species	Common Name
INSECTIVORA	Soricidae	*Sorex*	*cinereus*	Cinereus shrew
			hoyi	Pygmy shrew
			monticolus	Dusky shrew, montane shrew
			palustris	Water shrew
			tundrensis	Tundra shrew
			yukonicus	Alaska tiny shrew
CHIROPTERA	Vespertilionidae	*Myotis*	*lucifugus*	Little brown bat
CARNIVORA	Canidae	*Canis*	*latrans*	Coyote
			lupus	Wolf
		Vulpes	*vulpes*	Red fox
	Felidae	*Lynx*	*canadensis*	Lynx
	Mustelidae	*Lontra*	*canadensis*	River otter
		Gulo	*gulo*	Wolverine
		Martes	*americana*	Marten
		Mustela	*erminea*	Ermine, short-tailed weasel
			nivalis	Least weasel
		Neovison	*vison*	Mink
	Phocidae	*Phoca*	*vitulina*	Harbor seal
	Ursidae	*Ursus*	*americanus*	Black bear
			arctos	Brown bear
ARTIODACTYLA	Cervidae	*Alces*	*americanus*	Moose
		Rangifer	*tarandus*	Caribou
	Bovidae	*Ovis*	*dalli*	Dall's sheep
RODENTIA	Sciuridae	*Marmota*	*caligata*	Hoary marmot
		Spermophilus	*parryii*	Arctic ground squirrel
		Tamiasciurus	*hudsonicus*	Red squirrel
	Castoridae	*Castor*	*canadensis*	Beaver
	Dipodidae	*Zapus*	*hudsonius*	Meadow jumping mouse
	Cricetidae	*Myodes*	*rutilus*	Northern red-backed vole
		Dicrostonyx	*groenlandicus*	Collared lemming
		Lemmus	*trimucronatus*	Brown lemming
		Microtus	*miurus*	Singing vole
			oeconomus	Tundra vole, root vole
			pennsylvanicus	Meadow vole
		Ondatra	*zibethicus*	Muskrat
		Synaptomys	*borealis*	Northern bog lemming
	Erethizontidae	*Erethizon*	*dorsatum*	Porcupine

Order	Family	Genus	Species	Common Name
LAGOMORPHA	Ochotonidae	*Ochotona*	*collaris*	Collared pika
	Leporidae	*Lepus*	*americanus*	Snowshoe hare
			othus	Tundra hare, Alaska hare

Sources: Osgood (1904), Cahalane (1959), Cook and MacDonald (2004a, 2004b), Jacobsen (2004), MacDonald and Cook (2009).

16.3 Raptors—Mine Study Area

16.3.1 Introduction

This section presents results from the 2004-2005 raptor study, which focused on the large tree- and cliff-nesting birds of prey (raptors) occurring in the mine study area. These pre-development studies included raptor species with legal or conservation status, traditional use of nesting territories, or potential sensitivity to disturbance. Bald and Golden eagles are included because they are afforded special protection under the Bald and Golden Eagle Protection Act (16 USC, Section 668). The American Peregrine Falcon (*Falco peregrinus anatum)*, whose range probably includes the Lake Clark/Iliamna region (White, 1968), was delisted as an endangered species in 1999 (64 FR 46542). This subspecies was included in our studies, along with other cliff-nesting raptors (including Golden Eagle, the coastal subspecies of Peregrine Falcon [*F. p. pealei*], Gyrfalcon, and Rough-legged Hawk), because of continued agency interest in their populations (USFWS, 2002; Audubon 2002). In addition, raptors are highly traditional in their use of nesting habitats and because some of these raptors are sensitive to disturbance, particularly near their nests during the breeding season, knowledge of nest locations is very valuable in reducing potential disturbances. The Northern Goshawk is a tree-nesting raptor, and the coastal race in southeast Alaska is a species of concern (ADFG, 1998; Audubon, 2002). Identifying goshawk nest sites is regularly a component of baseline surveys throughout interior and coastal Alaska, and specific surveys for this species were conducted in 2004. Other tree-nesting species (Osprey and Great Horned Owl) were identified during pre-leaf-out surveys for Bald Eagles and Northern Goshawks. Finally, the study includes records of Common Raven nests because of the birds' close association with raptors (i.e., ravens build many nests subsequently used by raptors) and humans (e.g., attraction to camps).

16.3.2 Study Objectives

The goal of raptor surveys in the mine study area in 2004-2005 was to determine the distribution, abundance, and nesting status of raptors in the region of the Pebble Deposit. Researchers recorded all raptor species and raptor nests observed in the field, and placed special emphasis on locating individuals or nests of protected or sensitive species, such as Bald and Golden eagles, Peregrine Falcon, and the Northern Goshawk. Researchers did not make concerted efforts to determine the nesting status or abundance, or to locate nests of, small raptors, including Merlin and small woodland owls. In addition, , surveys were conducted in the winters of 2005 and 2006 to gather information on wintering Bald Eagles. The specific study objectives in the mine study area in 2004 and 2005 were as follows:

- Locate, identify, and map primary cliff- and tree-nesting raptor nest sites.
- Delineate important cliff-nesting raptor habitats.
- Compile a comprehensive list of raptor species nesting in and using the area.
- Develop strategies to avoid and minimize effects on raptors.

In 2005, expanded study objectives were to include the following:

- Locate and enumerate Bald Eagles wintering in the area (2005 and 2006).
- Determine the rates of success and productivity of nesting raptors.

- Develop aircraft guidelines to avoid disturbance of wildlife, including nesting raptors.

16.3.3 Study Area

The study area for nesting raptors included all suitable cliff habitats and woodland tracts that could provide nesting platforms for large cliff- and tree-nesting raptors in the mine study area (Figure 16.3-1). This mine study area included core uplands around the deposit area, and around drainages originating in the deposit area (e.g., North Fork Koktuli River; Figure 16.3-1), as well as important drainages in the greater region (e.g., Lower Talarik Creek). The mine study area lies in an ecological transition zone between the Bristol Bay/Nushagak Lowlands and Interior Forested Lowlands and Uplands (Gallant et al., 1995), where interior mixed spruce/hardwood forests grade into alpine and coastal tundra habitats.

Suitable habitats for cliff-nesting raptors in the mine study area range from low riparian bluffs (less than 10 meters of vertical relief) to large cliff faces and rock outcroppings (greater than 50 meters) scattered in uplands in the area. Many areas of substantial relief (e.g., Sharp Mountain), however, are dominated by talus slopes that provide less stable sites, are more accessible to ground predators, and are less often used by most nesting raptor species. Suitable habitats for tree-nesting raptors are limited to a few stands of cottonwood in the upper reaches of drainages in the mine study area, increasing south of 59°45’ north latitude between the Newhalen River and Lower Talarik Creek, and west of 155°37’ west longitude along the Koktuli River. In these areas more distant from the deposit area, riparian poplar and upland spruce are the primary species of trees that are suitable for tree-nesting raptors.

16.3.4 Previous Studies

Information on raptors, specifically their nesting status and nest sites, is limited for the mine study area. Exceptions include some nest locations identified in regional avifaunal investigations (e.g., Williamson and Peyton, 1962) and a cliff-nesting raptor survey in areas adjacent to Iliamna Lake (Haugh and Potter, 1975). Finally, a few raptor nest sites were identified from an inventory of raptor nest records summarized from U.S. Geological Service (USGS) 1:250,000-scale quadrangle maps (unpublished map files housed at ABR Inc., Fairbanks, AK). Most records from the Iliamna Quadrangle, and specifically from the Talarik drainages, were provided by a fisheries research biologist with numerous years of field experience in the region (Russell, pers. comm., 2004).

General information on the relative abundance and distribution of all raptor species was summarized from a search of published literature and unpublished agency reports for the greater Lake Clark/Iliamna region. Primary accounts from this region include biological reconnaissance at the turn of the century (Osgood, 1904) and natural resource inventories on national interest lands (Cahalane, 1959; Racine and Young, 1978). A major source of reports and references was *An Annotated Bibliography of Alaskan Raptor Literature* (Ritchie et al., 1982).

16.3.5 Scope of Work

The research and field work for this study were primarily conducted during April and May 2004, and May through August in 2005. Winter surveys occurred in February and November 2005, and in November 2006. Robert J. Ritchie and John E. Shook, of ABR, Inc., Fairbanks, Alaska, conducted the study according to the approach described in Chapter 9 of the *Draft Environmental Baseline Studies, Proposed*

2004 Study Plan (NDM, 2004) and the *Draft Environmental Baseline Studies, 2005 Study Plans* (NDM, 2005). Minor modifications in study protocols are described in the methods section below. Specific project tasks were as follows:

- Compile a list of possible raptors and synthesize literature to help determine the probable breeding status of raptors in the region (2004-2005).
- Conduct aerial surveys to locate cliff- and tree-nesting raptors in the mine study area (2004-2005).
- Identify habitats for nesting raptors in the mine study area (2004-2005).
- Conduct aerial surveys to locate wintering Bald Eagles in the mine study area (2005, 2006).
- Revisit known nest sites during the nestling period to assess nesting success and productivity (2005).
- Develop aircraft guidelines to avoid disturbance of wildlife, including nesting raptors (2005).

16.3.6 Methods

16.3.6.1 Occupancy Surveys

Field personnel conducted two aerial surveys by helicopter in the mine study area (Table 16.3-1) to identify potential habitats, and to locate and document the status (occupancy) of raptor nests in 2004 and 2005. The first survey each year was conducted before deciduous-tree leaf-out and was timed to identify the nests of tree-nesting species, particularly Northern Goshawk, but also Bald Eagle and other woodland species. (In 2005, surveys specifically for Northern Goshawks were not flown, and surveys for other tree-nesting raptors were flown later in the season.)

The second survey each year was timed and conducted to coincide with peak occupancy by cliff-nesting raptors, particularly Golden Eagle, Gyrfalcon, Peregrine Falcon, and Rough-legged Hawk. Common Raven nests also were recorded in both surveys. In 2004, some efforts were made to increase the coverage of suitable Bald Eagle habitats during this second survey because pre-leaf-out surveys had been conducted during Bald Eagle arrival, and less conspicuous inactive nests (e.g., nests in spruce trees) may have been missed.

The helicopter followed a slow (60 to 90 kilometers per hour), low-level (less than 50 meters above ground level) flight pattern during both aerial surveys. Two observers were seated on the same side of the aircraft. During the pre-leaf-out survey, researchers scrutinized all suitable forest stands (e.g., large timber)for raptor nests and signs of occupancy (e.g., perched birds or birds showing territorial behaviors [aggressive flight]). Standard operating procedures for woodland species included searching suitable forest stands in riparian areas, on hillsides, and along coastlines and lakeshores (including island shorelines).

During cliff-nesting surveys (some cliff areas were searched during the pre-leaf-out survey), observers searched all cliffs, rock outcrops, and soil bluffs for raptor nests and signs of occupancy (e.g., white-wash, adults). Standard operating procedures for helicopter searches of cliff habitats included using an angled approach toward the prospective cliff or bank area from at least 0.8 kilometers away from the site and slowly approaching potential nesting areas. This technique is employed to reduce the chance of startling incubating birds (Fyfe and Olendorff, 1976). Multiple passes of some cliff habitats were necessary.

When a nest or suggestions of nesting (e.g., an aggressive pair) occurred, observers recorded the location on a USGS map and with the onboard or hand-held global positioning system (GPS). The following additional data were recorded on field data forms:

- Species (if determined, otherwise "unidentified").
- Number of adults and their behavior (particularly if defensive and suggesting occupancy).
- Nest status (inactive or unoccupied, active or occupied, or undetermined).
- Tree species or substrate type (cliff, bluff top).
- Habitat type (riparian, lacustrine, montane, coastal).
- Nest condition and approximate location on substrate.
- Height and exposure (for cliff nests).

All nest locations later were entered into a geographic information system (GIS) database (using *ArcGIS 9* software). (To reduce additional disturbance of incubating birds at active nests, GPS locations were often taken at distances greater than 50 meters; therefore, map locations may not be exact.)

A nest was determined to be *occupied* if an adult was observed to be incubating, or if eggs and/or young were observed, or if a pair of adults was closely associated with a nest (either exhibiting defensive behaviors near the nest or perched in or adjacent to the nest). A nest was determined to be *unoccupied* (inactive) if the nest was found but no adults or signs of nesting activity were obvious (Steenhof, 1987). Occasionally, adult birds were observed near suitable habitat but no nests were obvious. If exhaustive searching of that terrain did not identify a nest platform and the pair did not show defensive behaviors, these observations were not recorded as nest sites. These locations can be retrieved from the data set. Many of these areas, where only adult pairs were observed in 2004, were revisited in 2005 to better establish nesting status.

16.3.6.2 Productivity Surveys

In 2005, a second set of aerial surveys was conducted during the nestling period to determine the success and productivity of nests located during the first surveys in the mine study area (Table 16.3-1). We conducted one survey in late June through early July that primarily served to determine the success of early nesting species (e.g., Gyrfalcon, Golden Eagle). A second survey was conducted in early August to more clearly determine nesting success and productivity at some late-hatching sites (e.g., Rough-legged Hawk) where brooding adults did not allow a good view of the nest in early July.

A nest was considered *successful* if at least one live nestling at approximately 80 percent of the average age of first flight (preferably more than three weeks old for medium-sized raptors and more than five weeks for large raptors) was observed during productivity surveys (Steenhof, 1987). Productivity was calculated as number of young per occupied nest or total number of pairs, and number of young per successful nest or successful pair.

16.3.6.3 Wintering Bald Eagle Surveys

Aerial surveys were conducted in February and November 2005, and in November 2006 (Table 16.3-1) to determine if Bald Eagles used the mine study area in winter and whether or not suitable open-water habitats (e.g., substantial areas of slow-moving water) were available for feeding by eagles. In February 2005, surveys were conducted from a Cessna 206 fixed-wing plane. A helicopter was used for the surveys in November 2005 and 2006. In all surveys, two observers were seated on opposite sides of the aircraft, which was flown at approximately 150 kilometers per hour, and 50 to 70 meters above ground level. Flights were oriented along the centerline of drainages, often within 50 meters of one shoreline, allowing for unimpeded views of both shorelines.

If Bald Eagles were observed, the following data were collected: location (GPS and/or location marked on USGS 1:250,000 map), number and ages of Bald Eagles (adult or subadult), perch substrate (cliff, tree [species], ground), behavior (remained perched, flew, in flight), primary aquatic habitat (creek, lake, pond, other), open water (present or absent) and ice conditions, and sign of prey resources (salmon carcasses, over-wintering waterfowl, carrion). Records of other birds associated with open water (e.g., wintering waterfowl) and locations of these observations also were collected.

16.3.6.4 Aircraft Guidelines to Minimize Disturbance to Raptors

Literature and unpublished reports that included recommendations for minimizing human disturbance near raptor nests were gathered in 2005. Best practices were synthesized and included in a brief flyer, *Aircraft Guidelines to Avoid Disturbance to Wildlife* (Appendix 16.3A), which was distributed to pilots and camp managers working on the Pebble Project in the Iliamna area. Maps of nest locations and other sensitive wildlife habitats also were distributed to pilots and camp managers to identify areas where activities should be limited and/or conducted with care.

16.3.7 Results and Discussion

At least 19 species of raptors (12 diurnal raptors and seven owl species) may occur in the greater Iliamna Lake/Lake Clark Region, including the mine study area (Appendix 16.3B). (This list was developed from the literature and unpublished reports, our aerial surveys, and incidental observations from other wildlife surveys (e.g., land bird and waterbird studies.) Aerial surveys recorded ten raptor species and Common Ravens in the mine area (Table 16.3-2). Nests of seven of these raptors (Bald and Golden eagles, Osprey, Gyrfalcon, Merlin, Rough-legged Hawk, and Great Horned Owl) and the Common Raven were recorded in the mine study area. Additional species, including other woodland raptors (e.g., Northern Goshawk), may also nest in this area (Squires and Reynolds, 1997), but were not recorded during aerial surveys. In particular, the presence of suitable habitat and the general breeding range of Northern Harriers and Short-eared Owls (MacWhirter and Bildstein, 1996; Holt and Leasure, 1993) suggested the probability of nesting for these species in this area (Table 16.3-3).

16.3.7.1 Nest Distribution, Abundance, and Occupancy

Researchers identified 73 different raptor nests in the mine study area during the 2004-2005 study; 41 raptor nests were found in the mine study area during 2004 and 71 were found in 2005 (Table 16.3-3). As indicated by the totals, some nests identified in 2004 were also used in 2005, but the greater number of nests found in 2005 was because a larger area was searched that year (Figure 16.3-1). The greatest densities of nest sites in woodlands were located along Upper Talarik Creek (Figure 16.3-2).The greatest densities of nest sites on cliffs were found on small canyons along Upper Talarik Creek and uplands between and including Ground Hog Mountain and mountains east of Frying Pan Lake (Figure 16.3-3). (Readers should note that some nests located in the transportation-corridor study area to the east [Section 16.9] may appear on figures in this section on the mine study area.)

Rough-legged Hawk

Ten nests of Rough-legged Hawks were located at eight locations in 2004 and 2005 (Table 16.3-3, Figure 16.3-3). Most Rough-legged Hawk nests (nine of ten nests, 90 percent) were found on cliffs or steep banks, while the remaining nest was in a cottonwood tree. In addition, all but one nest were associated with cliffs along shorelines of creeks or lakes. Occupancy ranged from 40 percent in 2004 to 60 percent in 2005 (Table 16.3-3).

The Rough-legged Hawk is a pan-boreal species typically associated with tundra areas during the breeding season (Bechard and Swem, 2002). Rough-legged Hawks nest throughout southwestern Alaska, including on the Alaska Peninsula and the Aleutian Islands (Osgood, 1904; Cahalane, 1959; Gill et al., 1981; Bechard and Swem, 2002). Rough-legged Hawks regularly nest on cliffs and more rarely in trees in Alaska (Bechard and Swem, 2002), but they also occasionally nest on the ground or on structures (Ritchie, 1991). Rough-legged Hawks have been reported as breeding at Lake Clark (Osgood, 1904) and along the Upper Talarik Creek (Russell, pers. comm., 2004), but have been described as uncommon breeders near Iliamna (Williamson and Peyton, 1962).

The number of breeding pairs and the breeding success of Rough-legged Hawks fluctuate with prey abundance among years (Bechard and Swem, 2002), and occupancy rates determined during these surveys may reflect the relative abundance of prey. Tundra habitats in the mine study area are probably more suitable for this species than those habitats to the east (e.g., Pebble Project transportation corridor).

Golden Eagle

Researchers located Golden Eagle nests at 14 distinct cliff or river bluff formations in the mine study area (Figure 16.3-3). A few of these locations (21 percent) had multiple (or supernumerary) nest sites at the cliff and some of the more widely spaced nests may also represent supernumerary nests within territories (supernumerary nests can be separated by a few kilometers [Kochert et al., 2002]). Therefore, occupancy rates of 21 and 44 percent in 2005 and 2004, respectively (Table 16.3-3), may overestimate the number of territories that occur.

Golden Eagles nest throughout Alaska including the Lake Clark/Iliamna region in southwestern Alaska. Golden Eagles show strong breeding territory fidelity (Kochert et al., 2002). Golden Eagles have been reported as relatively common in Lake Clark National Park and likely breed there (Racine and Young, 1978). They also have been found breeding in mountains around Iliamna Lake (Haugh and Potter, 1975;

this study, Sections 16.3 and 16.9). Golden Eagles are probably less common along the Alaska Peninsula and were absent from species accounts for some areas to the south (Katmai National Monument [Cahalane, 1959], Alaska Peninsula [Osgood, 1904]).

Bald Eagle

Bald Eagles were the most common nesting raptor in the mine study area with at least 21 nests recorded in 2005 (Table 16.3-3; Figure 16.3-2). However, none of these nests were located in upland areas surrounding the deposit area. Instead, most nests (71 percent) were located in cottonwood stands along the Upper and Lower Talarik Creek drainages; occasionally, spruce trees were used for nest substrates. The remaining nests were found on the north and south forks of the Koktuli River and on lakes between Upper and Lower Talarik creeks.

Nest-site occupancy ranged from 33 percent in 2005 to 50 percent in 2004. (The lower occupancy rate in 2004 may have been an artifact of our survey timing because only some areas were surveyed in late April prior to maximum nest initiation by Bald Eagles.) Nest-site occupancy was 38 percent and 47 percent for Bald Eagle nests on the coastline of Lake Clark National Park in 1994 and 1996, respectively (Bennett, 1996). Rates described during this Pebble Project study were lower than the mean long-term rates of territory occupancy by Bald Eagles recorded on the Kodiak National Wildlife Refuge (60 percent; Zwiefelhofer, 1997) and for seven continental North America populations (mean = 71 percent, range 53.7 to 91.0 percent; Stalmaster, 1987).

Field crews and helicopter pilots regularly reported seeing Bald Eagles on the ground on small bluffs overlooking lakes in the Upper Talarik Creek drainage. These sightings may have suggested ground-nesting, but closer scrutiny of these locations did not reveal any nest structures. Instead, these sites were probably good perches or vantage points for foraging eagles. Bald Eagles have been recorded nesting on the ground primarily in coastal Alaska, but there are only two records for interior regions of Alaska (Ritchie and Ambrose, 1996).

Although some older accounts of Bald Eagles in the region (e.g., Osgood, 1904) described them as occurring sparingly throughout the area, the Bald Eagle more often has been described as common and often breeding in the Iliamna and Lake Clark region (Gabrielson and Lincoln, 1959; Haugh and Potter, 1975; Racine and Young, 1978; Bennett, 1996). Bald Eagle populations have increased in interior regions of Alaska in the past decades following over a half century of persecution (Ritchie and Ambrose, 1996). Increasing numbers of nesting pairs on Kodiak Island suggest the possibility of population increases in southwestern Alaska as well (Zwiefelhofer, 2005, pers. comm.).

Osprey

Researchers identified a single nest during aerial surveys in the mine study area in 2005 that may have been constructed by Ospreys (Figure 16.3-2). This nest was located adjacent to two other Osprey nests (in the transportation-corridor study area) in a large wetland complex just east of lower Upper Talarik Creek. A few sightings of Osprey in the lake areas in Upper Talarik Creek (Wildman, 2004, pers. comm.) suggest occasional use of the mine area by foraging Ospreys. Typically, Ospreys build stick nests on top of dead snags or live trees with broken tops; suitable woodland habitat is not present near the deposit area. Ospreys have been known to nest on the ground, however, if the area is free of ground predators (Poole et al., 2002). Suitable nesting habitat occurs primarily in the region of large lakes and wetlands east of the mine study area between the north shore of Iliamna Lake and the mountains.

Within Alaska, Ospreys nest along rivers and coastlines south of the Brooks Range, including southwestern Alaska (Poole et al., 2002) where they are locally common to uncommon along rivers and coastal areas of the Alaska Peninsula east of the Chignik River. A small number of Ospreys have been reported at Lake Clark National Park (Racine and Young, 1978,) and near Iliamna Lake (Osgood, 1904; Williamson and Peyton, 1962; this study, Section 16.9). Ospreys occasionally nest close to other nesting Ospreys, suggesting limited territoriality (Poole et al., 2002).

Gyrfalcon

Researchers found seven and nine Gyrfalcon sites (10 total) in the mine study area in 2004 and 2005, respectively (Table 16.3-3). All but one of the sites discovered in 2004 (86 percent) were occupied, while conservatively only five (56 percent) were occupied in 2005. Nest sites were distributed on cliffs throughout tundra areas north of the main canyon along the Upper Talarik Creek and its associated uplands (Figure 16.3-3). Nests were found on riparian cliffs (33 percent), upland cliffs (44 percent), and overlooking lakes (22 percent).

In southwest Alaska, the Gyrfalcon could be described as an uncommon summer visitor with scattered resident breeders. Although much of southwest Alaska has not been surveyed, numerous nest sites have been recorded between the Alaska Peninsula and the Aleutians (Swem et al., 1994). Gyrfalcons were not recorded during avifaunal investigations in Lake Clark National Park (Racine and Young, 1978; Ruthrauff et al., 2005) and are listed as a rare breeder there (NPS, 2000). Although they were not reported in some ornithological accounts near Iliamna Lake (Williamson and Peyton, 1962), two Gyrfalcon nests have been identified in the Iliamna Lake area (Haugh and Potter, 1975; Russell, 2004, pers. comm.).

It is noteworthy that ptarmigan (*Lagopus* spp.), a primary prey item of Gyrfalcons (Cade, 1960), also were regularly observed in the mine study area during the Pebble Project surveys in 2004 and 2005. Size and overall productivity of Gyrfalcon populations may be correlated with ptarmigan numbers, as they are the falcon’s chief prey species (Cade, 1960; Clum and Cade, 1994).

Great Horned Owl

Single stick nests of Great Horned Owls were located in cottonwood trees along Upper Talarik Creek in 2004 and 2005 (Figure 16.3-2 and Table 16.3-3). Suitable nesting habitats for this species occur along Upper Talarik Creek and in scattered conifer woodlands between the Upper and Lower Talarik creeks and near the junction of the north and south forks of the Koktuli River. Great Horned Owls most commonly use stick nests made by other birds (i.e., Bald Eagles, hawks, ravens), but will nest in tree cavities, on cliffs, on artificial platforms, and occasionally on the ground (Houston et al., 1998). Although no cliff nests were identified in the mine study area, Great Horned Owls have been recorded using cliffs in the Iliamna Lake region (Haugh and Potter, 1975; this study, Section 16.9).

Within the greater Iliamna Lake/Lake Clark region, Great Horned Owls are probably uncommon, but regular, breeding and resident raptors. Williamson and Peyton (1962) thought that they were well distributed in woodlands near Iliamna Lake. Racine and Young (1978) considered them probable regular breeders in Lake Clark National Park.

Northern Goshawk

No Northern Goshawks were observed, nor were nests of this species found, in the mine study area. However, two unidentified raptor stick nests located in cottonwood stands southeast of Groundhog Mountain may have been built by Goshawks (Figure 16.3-2). A few forested areas, primarily along and east of the lower sections of Upper Talarik Creek, appeared to have the physical features found in woodland habitats typically used by this species elsewhere in their range (i.e., large trees in closed and open canopy forest). Most of the mine study area is shrub or tundra-covered, and while this is not the preferred habitat for Northern Goshawks, they have been reported to nest in tundra areas with similar limited woodlands (Swem and Adams, 1992).

The Iliamna Lake area is within the range of the Northern Goshawk in southwestern Alaska (Squires and Reynolds, 1997), but no records have been recorded for the mine study area. Williamson and Peyton (1962) regarded this “hawk as rare in the Iliamna area” and thought that they probably occurred in small numbers. The goshawk has been described as an uncommon breeder in the Lake Clark National Park (NPS, 2000) and is probably more abundant in woodland regions north and east of the mine study area. Nests have been recorded in the Iliamna region near the village of Iliamna (Russell, pers. comm., 2004) and near Bristol Bay (Petersen et al., 1991). Generally resident, irruptive migratory movements (i.e., not seasonally or geographically predictable) of Northern Goshawks often coincide with population lows of primary prey species (snowshoe hare and grouse; Squires and Reynolds, 1997). Observations of a few goshawks at Katmai National Monument in late August/September 1954 were described in this context (Cahalane, 1959).

Other Raptors and Common Ravens

A single Sharp-shinned Hawk was recorded in a small stand of cottonwoods in Upper Talarik Creek during aerial surveys in 2004. Because Sharp-shinned Hawks generally prefer taiga forest (Bildstein and Meyer, 2000) they are probably rare visitors to the mine study area. They have been recorded in the greater region (Katmai National Monument [Cahalane, 1959] and the Lake Clark National Park [Ruthrauff et al., 2005; Racine and Young, 1978], but are undoubtedly more common in taiga forests to the north.

Short-eared Owls and Northern Harriers were recorded in the mine study area during aerial surveys and by field crews conducting ground surveys for landbirds and waterfowl. Although no nests were recorded for either species, both species nest on the ground and should breed in tundra habitats in this region (Northern Harrier: Macwhirter and Bildstein, 1996, Short-eared Owl: Gabrielson and Lincoln, 1959, Holt and Leasure, 1993). Both species have been recorded in the Lake Clark/Iliamna region (Williamson and Peyton, 1962; Racine and Young, 1978; University of Alaska Museum, 2003).

Merlins were recorded at a cliff during aerial surveys in 2004 and 2005. An adult male reacted defensively to Golden Eagles nesting in the area in 2004, suggesting nesting by this small raptor species on the same cliff. Records of a subadult and adult at the same cliff in August 2005 also support the existence of an occupied territory. Two pairs of Merlin were found nesting in wooded areas (Figures 16.3-3 and 16.3-4). One pair was found by a ground crew performing point-counts for passerines; the nest was in an old Black-billed Magpie nest in a cottonwood tree on the Upper Talarik River. The distributional range of Merlins includes the Iliamna Lake area (Sodhi et al., 1993), and they have been reported as nesting in the area (Williamson and Peyton, 1962).

Peregrine Falcons were not recorded in the mine study area during aerial surveys in 2004 and 2005.They are probably rare to uncommon breeders in the region although they have been recorded in the Iliamna/Lake Clark region (Williamson and Peyton, 1962; Racine and Young, 1978; this study, Section 16.9). Suitable habitats, similar to cliffs used by nesting peregrines on the Newhalen River and Canyon Creek east of the mine study area, occur along middle sections of Upper Talarik Creek in the mine study area. As Peregrine Falcons have recovered throughout their range from population declines in the 1960s and 1970s (White et al., 2002), many areas without a clear history of use have been found to be occupied. Peregrines have not been previously recorded in the mine or transportation corridor study areas. With our discovery of nests in the Iliamna region, east of the mine study area, this phenomenon of expansion or increased occupation may be occurring and suggests greater possibilities for peregrine occupancy of suitable habitat in the mine study area.

Common Ravens were observed regularly and were found nesting at five locations in the mine study area in 2004 and 2005 (Figure 16.3-3). Ravens nested in trees (three nests) along the Upper and Lower Talarik creeks and on cliffs (two nests). Common Ravens regularly use both cliff and tree substrates, as well as man-made structures, for nesting platforms (Boarman and Heinrich, 1999). Ravens have been described as uncommon (Williamson and Peyton, 1962) to common in the region (Kakhtul [Koktuli]: Osgood, 1904). The locations of raven nests are important because Ravens often associate with humans and identifying nests before development may be useful in assessing increases in their population. They also “improve” habitats for some cliff-nesting species that do not build their own nests (e.g. Gyrfalcon, Peregrine Falcon; Cade, 1960).

16.3.7.2 Nesting Success and Productivity

Researchers located 19 successful nests representing six raptor species and Common Ravens in the mine study area in 2005. Accurate counts of young were made at 16 of these nests representing five species (Table 16.3-4). Nest productivity at Merlin (one) and Common Raven (two) nests was not calculated because researchers may have missed fledged young at these nest sites (i.e., surveys occurred after some birds may have fledged), thus possibly underestimating production.

Rough-legged Hawk

Sixty-seven percent of Rough-legged Hawk nests recorded as occupied during initial aerial surveys were determined to be successful in 2005 (Figure 16.3-4, Table 16.3-4). On the Colville River in northern Alaska, success ranged from 35 to 84 percent (Swem, 1996). Many studies report considerable variation in annual populations, nest occupancy, and productivity, which may be due at least in part to fluctuations in small mammal populations, which are their major prey (Bechard and Swem, 2002).

Mean productivity was calculated to be 2.3 young per successful nest and 1.5 young per occupied nest at Rough-legged Hawk nests in the mine study area in 2005 (Table 16.3-4). Productivity has ranged from 0.6 to 3.0 young per occupied nest for a long-studied population of Rough-legged Hawks in northern Alaska (Swem, 1996).

Golden Eagle

Only two of three occupied Golden Eagle nests (67 percent) were determined to be successful in the mine study area in 2005 (Figure 16.3-4, Table 16.3-4). Single young were produced at both successful nests (1.0 young per successful nest, 0.7 young per occupied nest; Table 16.3-4). This small sample size does not allow much comparison, but mean numbers of young per successful nest have ranged from 1.1 to 1.5 in northern Alaska (Ritchie and Curatolo, 1982; Young et al., 1995).

Bald Eagle

Seventy-one percent of seven occupied Bald Eagle nests were successful in the mine study area in 2005 (Figure 16.3-5, Table 16.3-4). One nest had fallen from the nest tree, but a large (seven-week-old) nestling was successfully being provisioned by its parents. Nesting success was 62 percent for nests on the Alaska Peninsula in 1970 (n = 38; Hehnke and White, 1978) and ranged from 65 to 88 percent for Katmai National Monument in the 1970s (n = 20; Troyer, 1979). Nesting success was lower (53 percent) for Bald Eagles nesting along the Lake Clark National Park/Cook Inlet coastline (Bennett, 1996). Nesting success was determined to be 54 percent for 518 occupied nests on Kodiak National Wildlife Refuge in 1997 (Zwiefelhofer, 1997).

Five successful nests found in this study produced a total of eight young eagles, or 1.6 young per successful nest and 1.1 per occupied nest (Table 16.3-4). Ages of nestlings ranged from two weeks to six weeks during surveys in mid-July, suggesting a relatively protracted range of laying dates for Bald Eagles in the region. Overall, production was similar to other populations in adjacent areas: 1.6 young per successful nest and 1.0 per occupied nest along the southern Alaska Peninsula (Hehnke and White, 1978); and 1.5 young per successful nest and 0.8 per occupied nest along the Lake Clark National Park coastline (Bennett, 1996). Productivity was higher in Katmai National Monument; young per successful nest ranged from 1.7 to 2.3 between 1974 and 1979 (Troyer, 1979). The mean productivity for a number of Bald Eagle populations in North America in1970 through 1982 was 1.6 young per successful nest and 0.9 per occupied nest (Stalmaster, 1987).

Gyrfalcon

Eighty percent of five occupied Gyrfalcon nest sites were successful in the mine study area in 2005 (Figure 16.3-4, Table 16.3-4). Four successful sites produced 10 young for means of 2.5 young per successful nest and 2.0 young per occupied nest (Table 16.3-4). A fifth occupied nest appeared to be abandoned (eggs were left in the nest) and substantial brown bear sign (e.g., abundant scat and worn beds above the nest site) suggest failure resulting from disturbance by bears.

Mean productivity found in other studies has ranged from 1.0 to 3.0 young per successful nest in northern Alaska (Cade, 1960; Swem et al., 1994) and brood size averaged 2.5 young per successful nest for a 10-year period in Canada’s Northwest Territory (Shank and Poole, 1994). The breeding population of Gyrfalcons is regulated in part by the availability of suitable nest sites and of sufficient prey (Shank and Poole, 1994). The number of breeding Gyrfalcons and their overall productivity may be correlated with ptarmigan numbers, a chief prey species (Cade, 1960; Clum and Cade, 1994).

Great Horned Owl

The single Great Horned Owl nest located on Upper Talarik Creek in 2005 was successful (Figure 16.3-5 and Table 16.3-4) and produced two young. Success and productivity vary at northern latitudes relative to cyclic prey conditions (Houston et al., 1998).

16.3.7.3 Wintering Bald Eagles

No Bald Eagles were recorded on the aerial surveys designed to record wintering eagles in the mine study area in 2005 and 2006. Lower Talarik Creek, Frying Pan Lake, and a portion of Upper Talarik Creek (east of Sharp Mountain) were included in the winter survey for Bald Eagles in February 2005. Besides a small stretch of the South Fork Koktuli River directly north of Sharp Mountain, very little slow-moving open water suitable for foraging habitat was encountered. In November 2005 and 2006, the north and south forks of the Koktuli River, the Big Wiggly Lake area, and Upper Talarik Creek were surveyed. Suitable open water was present in small sections of both forks of the Koktuli River and Upper Talarik Creek in 2005 and 2006. No carrion or spawned-out fish were recorded at these open-water areas, but a small group of Harlequin Ducks, potential prey for Bald Eagles, was present in the North Fork Koktuli River approximately 4 kilometers west of the Big Wiggly Lake area in 2005. Bald Eagles were recorded adjacent to the mine study area along the Newhalen River during winter surveys in both years and near the junction of the north and south forks of the Koktuli River in November 2005.

Wintering Bald Eagles have been recorded in the region (this study, Section 16.9), but probably occur uncommonly, particularly by mid-winter (December through February). Substantial concentrations of Bald Eagles have been reported during fall near the mouth of Chekok Bay (Russell, 2004, pers. comm.). Bald Eagles are probably more common along the coast during winter and have been recorded along the Lake Clark National Park coastline (Bennett, 1996).

16.3.7.4 Habitat Suitability for Breeding Raptors

Woodland Habitats

Habitat for most tree-nesting raptors is limited in the mine study area to a few stands of poplar trees along Upper Talarik Creek and its tributaries, and the lower reaches of the Koktuli River. More extensive spruce-dominated woodlands occur in the area between Iliamna Lake and the foothills between Upper and Lower Talarik creeks.

Cliff Habitats

Habitats for cliff-nesting species are scattered in the region, but include high-value habitats such as isolated cliffs, and cliffs and bluffs along riparian areas. The best cliff-nesting raptor habitats within the mine study area—based on nests recorded, physical attributes of the cliffs, suitable ledges, and raptor sign (white-wash, perches)—occur in the following areas:

- In the hills between the North Fork Koktuli River and the upper South Fork Koktuli River (i.e., centered at VABM [vertical angle benchmark] Kaskanak).
- On the east side of Koktuli Mountain between Frying Pan Lake and the Upper Talarik Creek drainage.
- On the eastern and southern slopes of Groundhog Mountain northeast of the deposit area, including small cliffs associated with lakes and drainages on the south side of the mountain.
- Along Upper Talarik Creek, as isolated riparian bluffs and in well-defined, but small, canyons.

16.3.7.5 Survey Efficacy

Suitable cliff and woodland areas within the mine study area were thoroughly searched in both years (2004, 2005) of the raptor study. In particular, the inventory of cliff-nesting sites for Golden Eagle, Gyrfalcon, Peregrine Falcon, and Rough-legged Hawk was very thorough at discrete cliff faces and riparian areas in the study area. Areas used traditionally by these species (e.g., heavily white-washed Gyrfalcon ledges, stick nests) generally were obvious in these habitats.

Researchers were most effective at locating nests of tree-nesting species during surveys of woodlands along shorelines of lakes and rivers, where the primary tree-nesting species of interest in this study usually select nest sites. Exceptions might include woodland raptors, such as the Northern Goshawk or Great Horned Owl, which often locate their nests in more dense and complex woodlands. In 2004, surveys were conducted before all species of tree-nesting species had occupied nest sites (late April), to increase the chance of recording early nesting residents, especially woodland raptors such as Northern Goshawks. This early survey probably underestimated occupancy of nests by other tree-nesting species, such as the nonresident Bald Eagle and Osprey. This possible cause for underestimation of nest occupancy for other species, however, was “corrected” in 2005, as spring surveys were conducted at dates coinciding more with nesting chronologies of Bald Eagles and other large raptor species (mid-May).

Researchers did not record Northern Goshawks or nests definitively constructed by this species during any of the surveys in the mine study area, which is at the southern extent of the goshawk breeding range in southwestern Alaska (Squires and Reynolds, 1997). Woodland habitat in the mine study area may not be regularly occupied by breeding goshawks. Unfortunately, little information on the density of Northern Goshawks or other woodland species in this region is available to improve an assessment.

16.3.8 Summary

Researchers conducted aerial surveys to gather information on the abundance, distribution, and breeding status of large cliff- and tree-nesting raptors in the mine study area in 2004 and 2005, and wintering distribution of Bald Eagles in 2005 and 2006. Surveys included several raptor species because of their legal or conservation status, sensitivity to disturbance, and traditional use of nesting territories. Large raptors, such as Bald and Golden eagles, Peregrine Falcon, Gyrfalcon, Osprey, and Northern Goshawk, were the primary focus of the surveys.

Surveyors successfully mapped the general nest distribution, relative abundance, and breeding status of large raptors in the mine study area. At least 73 nests, representing seven species of raptors and the Common Raven were located in a broad study area associated with the deposit area and surrounding cliff and woodland habitats. Bald Eagle was the most abundant nesting species (30 percent of 2005 nests), followed by Golden Eagle (20 percent), Rough-legged Hawk (14 percent), and Gyrfalcon (13 percent). At least two nests of Merlin and single nests of Osprey and Great Horned Owl were recorded during aerial surveys. No Peregrine Falcons or Northern Goshawks were recorded in the mine study area. No Bald Eagles were recorded wintering in the study area.

Bald Eagle nests were found along the lower north and south forks of the Koktuli River, Upper Talarik Creek, and Lower Talarik Creek. Golden Eagle, Gyrfalcon, and Rough-legged Hawk were the primary cliff-nesting raptors, and their nesting habitats were found in the Upper Talarik Creek and Koktuli River drainages. Although no Northern Goshawk or Peregrine Falcon nests were found, habitat for both species is available, although limited in extent.

Nesting success and productivity information was determined for five species of raptors, including Bald and Golden eagles, Gyrfalcon, and Rough-legged Hawk. Nesting success ranged from 67 percent for Rough-legged Hawk and Golden Eagle to 71 and 80 percent for Bald Eagle and Gyrfalcon, respectively. Productivity (young per successful nest) for each of these species generally fell within the ranges of productivity determined for studies elsewhere in Alaska and/or North America.

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TABLES

TABLE 16.3-1
Dates of Aerial Surveys for Raptors in the Mine Study Area, 2004 and 2005

Survey Type	Species of Interest	2004	2005	2006
Occupancy Survey	Tree-nesting species	April 22	May 6-7	
Occupancy Survey	Cliff-nesting species	May 24-26	May 21-25	
Productivity Survey	Early nesting species	—	July 1	
Productivity Surveys	Later nesting species	—	Mid-July, Mid-August	
Late Winter Survey	Bald Eagle	—	February 22	
Early Winter Survey	Bald Eagle	—	November 10	November 13

TABLE 16.3-2
Status of Raptor Species Observed during Aerial Surveys in the Mine Study Area, April-May 2004, May-August 2005

Common Name	Scientific Name	Status	References [a]
Northern Harrier	*Circus cyaneus*	Probably Breeding	This study, 1, 2, 3
Sharp-shinned Hawk	*Accipiter striatus*	Rare visitor	This study, 1, 3
Rough-legged Hawk	*Buteo lagopus*	Breeding	This study, 4
Golden Eagle	*Aquila chrysaetos*	Breeding	This study
Bald Eagle	*Haliaeetus leucocephalus*	Breeding	This study, 4
Osprey	*Pandion haliaetus*	Probable Breeding	This study
Merlin	*Falco columbarius*	Breeding	This study
Gyrfalcon	*Falco rusticolus*	Breeding	This study
Short-eared Owl	*Asio flammeus*	Probably Breeding	This study
Great Horned Owl	*Bubo virginianus*	Breeding	This study, 3
Common Raven	*Corvus corax*	Breeding	This study, 3

References:

a. 1) Cahalane, 1959; 2) Williamson and Peyton, 1962; 3) Racine and Young, 1978; 4) R. Russell, pers. comm.

TABLE 16.3-3
Numbers and Status of Raptor Nests in the Mine Study Area, 2004 and 2005

	2004			2005		
Species	**Unoccupied**	**Occupied (%)**	**Total**	**Unoccupied**	**Occupied (%)**	**Total**
Rough-legged Hawk	3	2 (40)	5	4	6 (60)	10
Golden Eagle	5	4 (44)	9	11	3 (21)	14
Bald Eagle	5	5 (50)	10	14	7 (33)	21
Osprey	0	0	0	1	0 (0)	1
Merlin	0	0	0	0	2 (100)	2
Gyrfalcon	1	6 (86)	7	4	5 (56)	9
Great Horned Owl	0	1 (100)	1	0	1 (100)	1
Common Raven	0	2 (100)	2	2	4 (67)	6
Unidentified raptor [a]	7	0 (0)	7	7	0 (0)	7
Total nests	**21**	**20 (49)**	**41**	**43**	**28 (39)**	**71**

Notes:

a. “Unidentified raptor” includes remnant stick nests on cliffs and some smaller stick nests in trees used by woodland species such as Northern Goshawks and Great Horned Owls.

TABLE 16.3-4
Nesting Success and Productivity of Raptor Nests in the Mine Study Area, 2005

Species	**No. Occupied Nests**	**No. Successful Nests**	**% Successful Nests**	**No. Young**	**Young/ Occupied Nest**	**Young/ Success. Nest**
Rough-legged Hawk	6	4	67	9	1.5	2.3
Golden Eagle	3	2	67	2	0.7	1.0
Bald Eagle	7	5	71	8	1.1	1.6
Gyrfalcon	5	4	80	10	2.0	2.5
Great Horned Owl	1	1	100	2	2	2

FIGURES

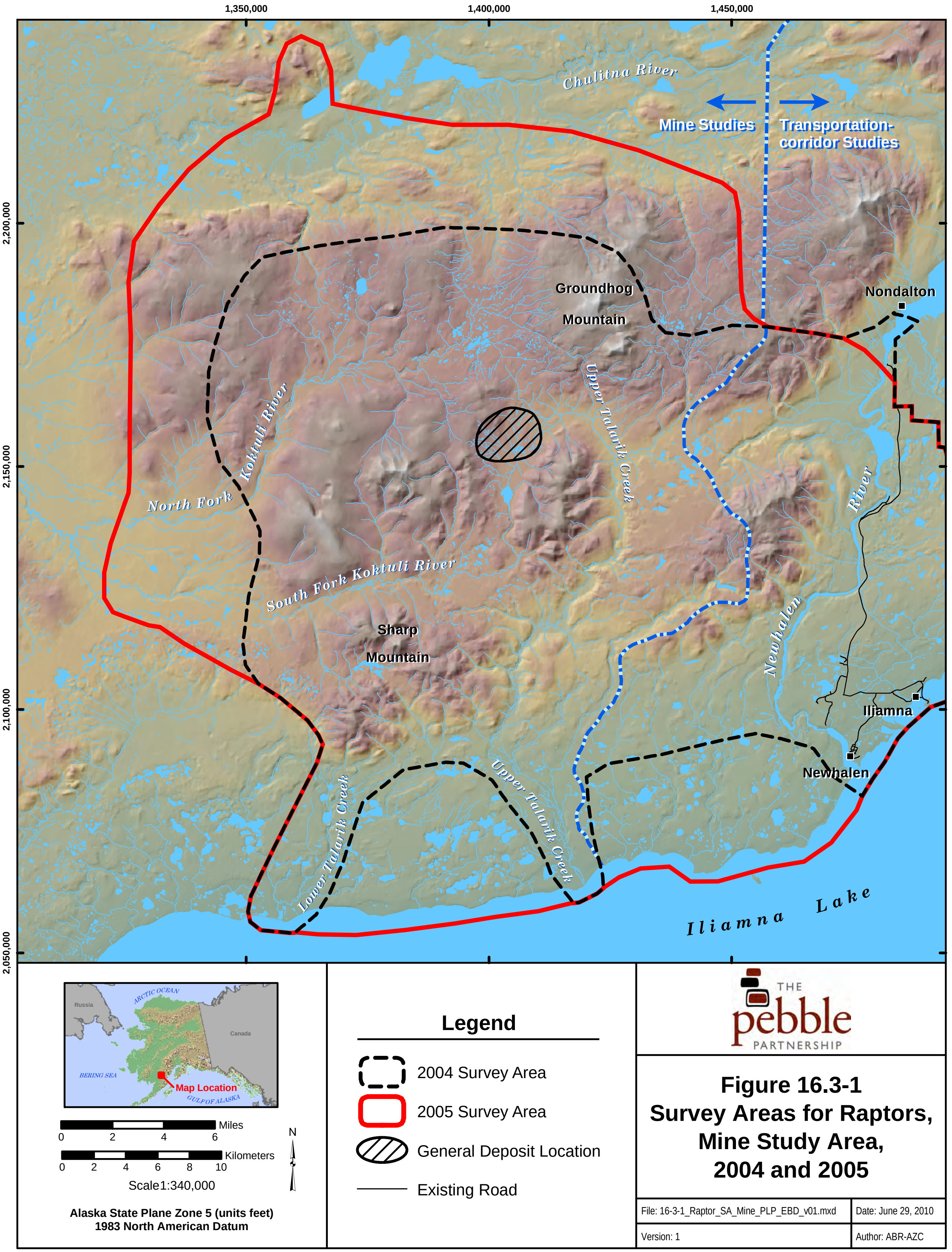


Figure 16.3-1
Survey Areas for Raptors, Mine Study Area, 2004 and 2005

File: 16-3-1_Raptor_SA_Mine_PLP_EBD_v01.mxd	Date: June 29, 2010
Version: 1	Author: ABR-AZC

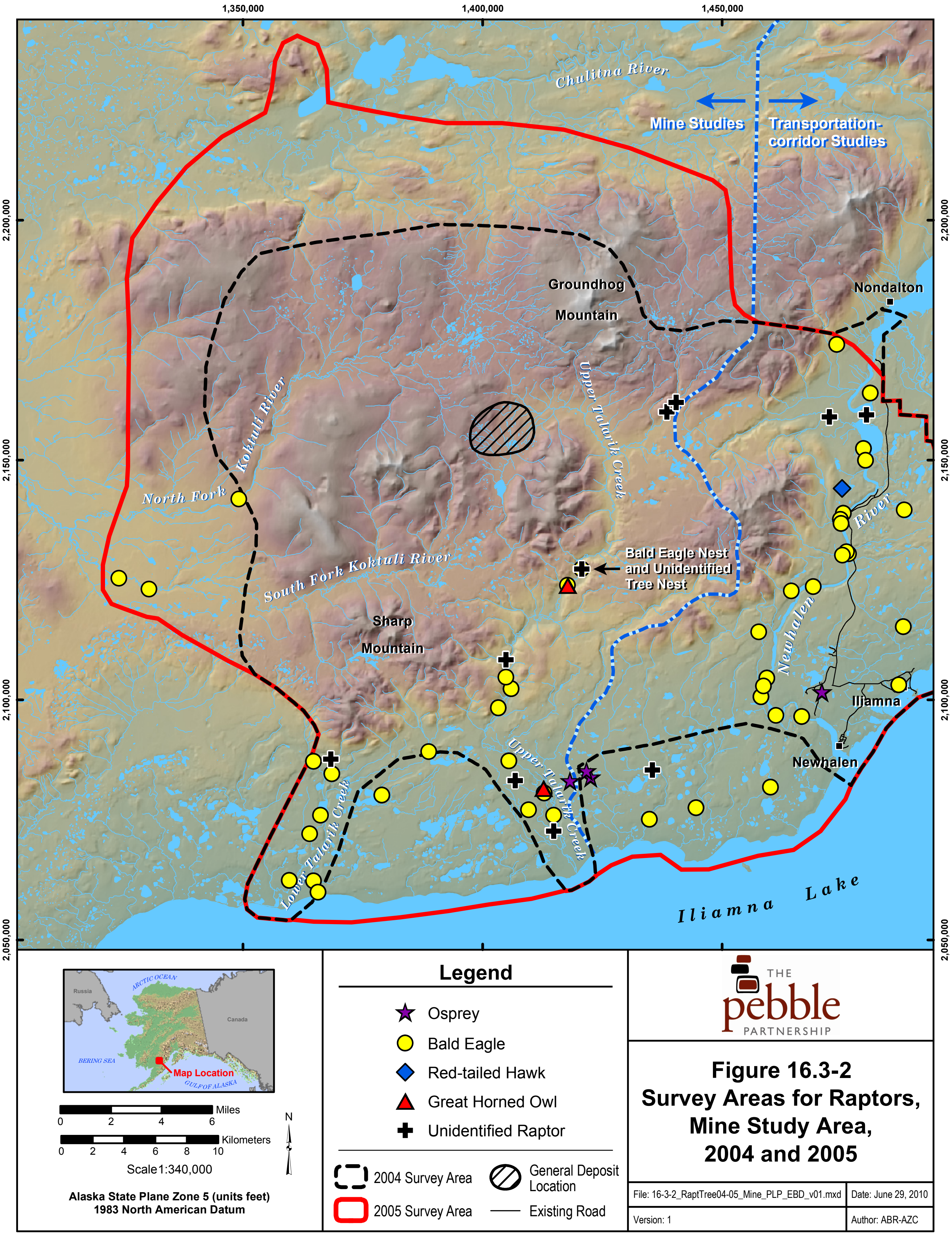
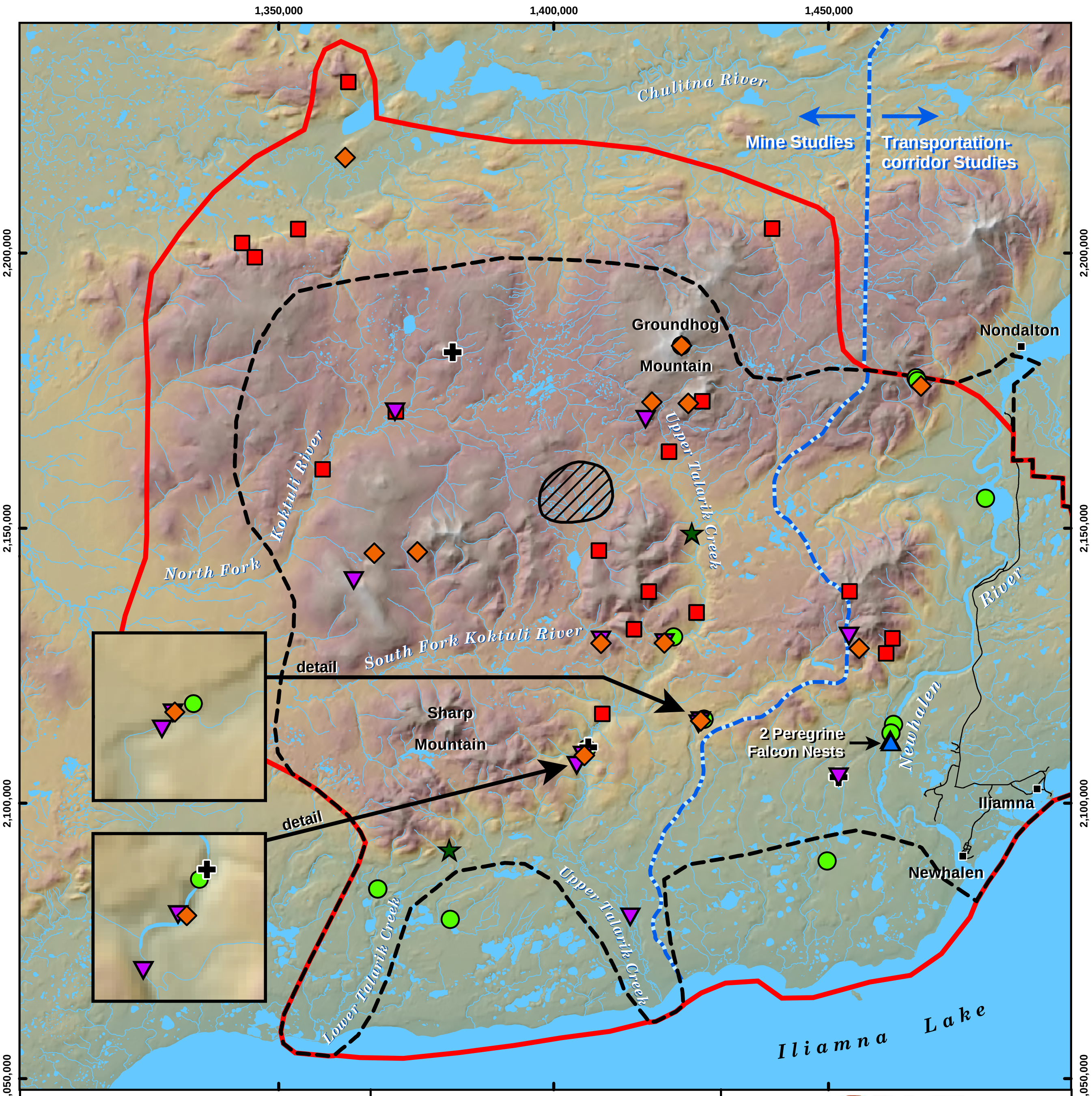


Figure 16.3-2
Survey Areas for Raptors, Mine Study Area, 2004 and 2005



Miles 0 2 4 6

Kilometers 0 2 4 6 8 10

Scale1:340,000

N

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

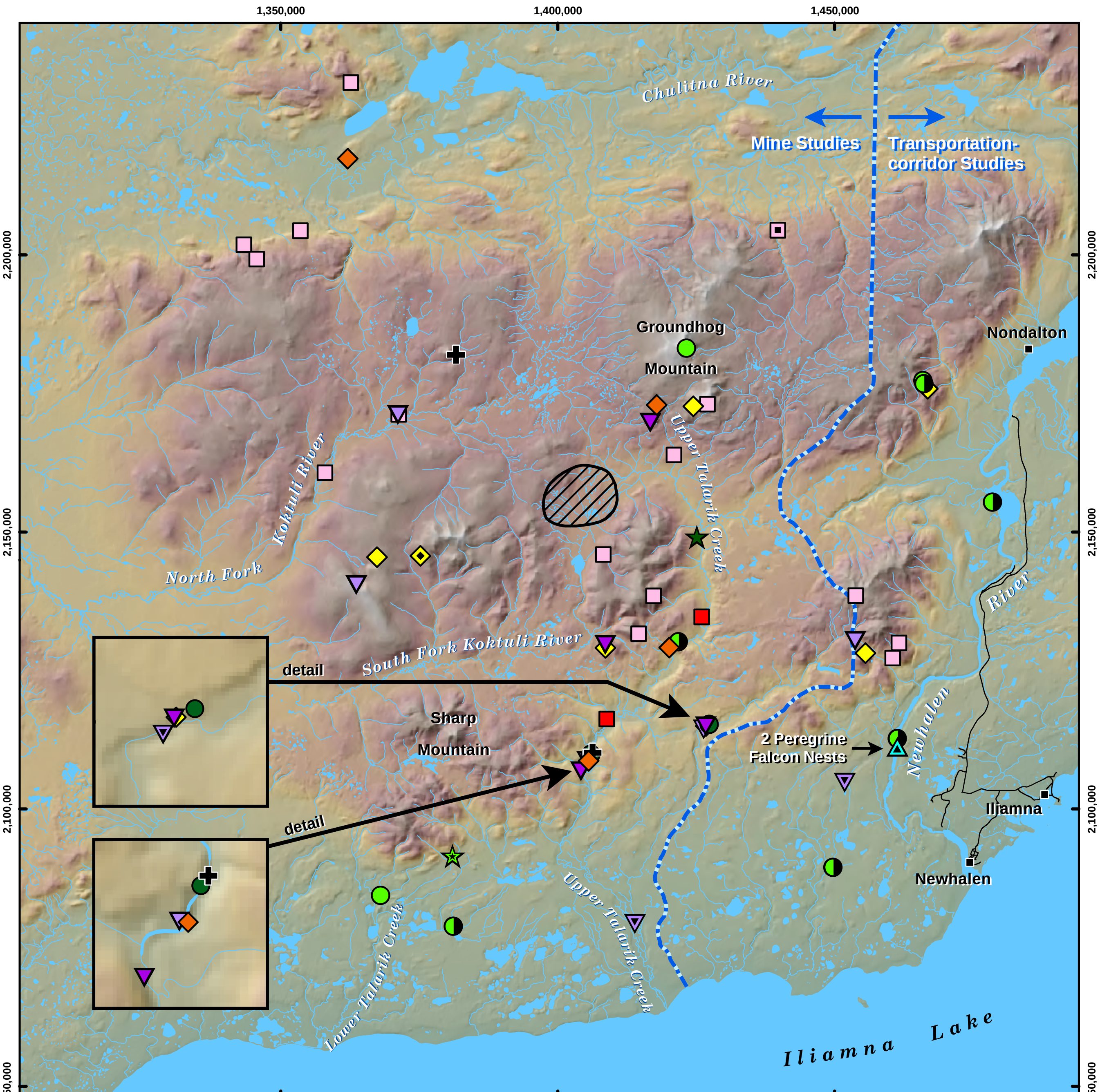
Legend

- Golden Eagle
- Gyrfalcon
- Rough-legged Hawk
- Unidentified Raptor
- Merlin
- Common Raven
- Peregrine Falcon
- 2004 Survey Area
- General Deposit Location
- 2005 Survey Area
- Existing Road

THE pebble PARTNERSHIP

Figure 16.3-3
Raptor Nest Distribution,
(Golden Eagle, Rough-legged Hawk, Merlin, Peregrine Falcon, Gyrfalcon, Unidentified Raptor, Common Raven),
Mine Study Area, 2004 and 2005

File: 16-3-3_RaptCliff04-05_Mine_PLP_EBD_v01.mxd	Date: June 29, 2010
Version: 1	Author: ABR-AZC



Miles: 0 2 4 6

Kilometers: 0 2 4 6 8 10

N

Scale1:340,000

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

Legend

	Inactive	Occupied	Successful
Golden Eagle			
Rough-legged Hawk			
Merlin			
Peregrine Falcon			
Gyrfalcon			
Unidentified Raptor			
Common Raven			

Raptor Survey Area

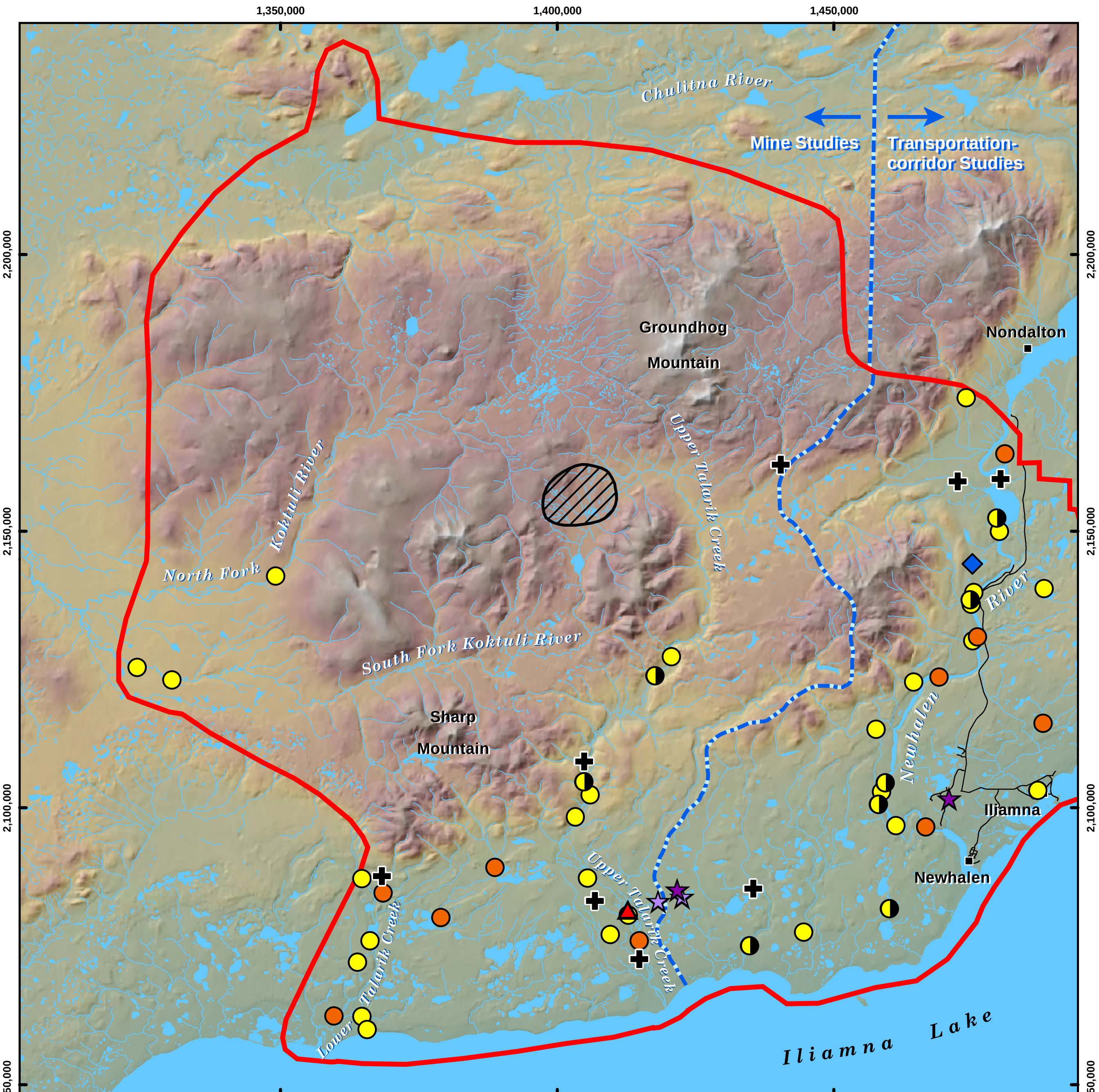
General Deposit Location

Existing Road

THE pebble PARTNERSHIP

Figure 16.3-4
Raptor Nest Distribution and Status (Golden Eagle, Rough-legged Hawk, Merlin, Peregrine Falcon, Gyrfalcon, Unidentified Raptor, Common Raven), Mine Study Area, 2005

File: 16-3-4_RaptCliff05_Mine_PLP_EBD_v01.mxd	Date: June 29, 2010
Version: 1	Author: ABR-AZC



Miles: 0 2 4 6

Kilometers: 0 2 4 6 8 10

N

Scale1:340,000

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

Legend

	Inactive	Occupied	Successful
Osprey	☆		★
Bald Eagle	●	◐	●
Red-tailed Hawk			◆
Great Horned Owl			▲
Unidentified Raptor	✚		

Raptor Survey Area

General Deposit Location

Existing Road

THE pebble PARTNERSHIP

Figure 16.3-5
Raptor Nest Distribution and Status, (Osprey, Bald Eagle, Red-tailed Hawk, Great Horned Owl, Unidentified Raptor), Mine Study Area, 2005

File: 16-3-5_RaptTree05_Mine_PLP_EBD_v01.mxd	Date: June 29, 2010
Version: 1	Author: ABR-AZC

APPENDICES

APPENDIX 16.3A

AIRCRAFT GUIDELINES TO AVOID WILDLIFE DISTURBANCE

AIRCRAFT GUIDELINES TO AVOID WILDLIFE DISTURBANCE

Helicopter and fixed-wing airplane support are essential for engineering work and environmental studies at the Pebble mine site and along the road/port corridor. Disturbance by aircraft and associated activities can negatively affect wildlife, however. The federal Airborne Hunting Act (16 USC § 742j-l) and accompanying regulations (50 CFR Part 19) prohibit harassment of wildlife. Harassment is defined as activities that “disturb, worry, molest, rally, concentrate, harry, chase, drive, herd, or torment” animals. Potential penalties include fines, revocation of licenses, and forfeiture of aircraft. Therefore, safe and practical guidelines are needed to reduce potential impacts on wildlife while accommodating essential aircraft support. The following guidelines provide a general code of conduct and specific recommendations for pilots and their passengers. All aircraft need to adhere to these guidelines, recognizing that some exceptions will be necessary during approved wildlife surveys.

GENERAL GUIDELINES

- Do not harass or pursue wildlife.
- Fly at 150 m (500 ft) above ground level or higher whenever possible.
- When wildlife are observed (especially bears, caribou, moose, wolves, raptor nests, flocks of waterfowl, seabirds, marine mammals), avoid flying directly overhead and maximize your lateral distance as quickly as possible, remaining at least 0.8 km (0.5 mi) away if possible.
- Avoid landing within 0.8 km (0.5 mi) of wildlife locations or key habitats [shown on the attached map]. This avoidance may require working at another site or coming back later.

These aircraft guidelines do not supersede established protocols developed to protect human life and safety.

BIRDS OF PREY (RAPTORS)

Cliff-nesting raptors include Golden Eagles, Gyrfalcons, and Peregrine Falcons. Tree-nesting raptors include Bald Eagles, Osprey, and Northern Goshawks.

- Precautions should be exercised from 15 March-31 August (near cliffs) and 15 April-31 August (near tree nests) if raptor nests are occupied.
- Avoid low-level (<150 m or <500 ft above nest height) and/or close flights (0.8 km or 0.5 mi) near nest sites. Occasional flights may be necessary in this zone, but routine flights should be as far away as are practical. The goal here is to avoid repeated disturbance during nesting.
- Approach nests and potential habitat along a visible path. Do not approach cliff nests from behind, which increases the chances for alarm responses.
- Do not land on the brink or top of cliffs or river bluffs. If landings must occur, land and take off 0.8 km (0.5 mi) or more away and restrict the amount of time spent at these sites.

- Leave nesting areas when disturbance is obvious. If raptors are disturbed, quickly move away from the site.

SEABIRD COLONIES AND MARINE MAMMAL HAULOUTS

Numerous seabirds nest in colonies and marine mammals use haulouts in areas near the port site alternatives. Follow these guidelines when in the area of the port sites:

- Restrictions are in effect from 1 May to 20 August for seabird colonies and throughout the year for marine mammal haulouts.
- Avoid low-level (<450 m or <1500 ft above colonies) and/or close flights (within 0.8 km or 0.5 mi lateral distance) near colonies and haulout areas. Occasional flights may be necessary in this zone, but routine flights should be as far away as practical.
- Do not land near (within 0.8 km or 0.5 mi of) colonies or haulouts. The amount of time spent near colonies and haulouts should be limited.
- If disturbance is obvious, leave quickly. If numerous birds are in the air or vocalizing, or seals/sea lions are entering the water, you are too close and are harassing the animals — leave immediately, flying directly away from the colony or haulout.

LAND MAMMALS

Caribou, moose, and furbearers are active year-round, whereas bears are active seasonally between April and November. The most sensitive time for disturbance of caribou and moose is the calving period in May. Take special care to avoid disturbing large groups of caribou (most likely in July) and bears congregated along salmon streams (July-September). It will not be possible to avoid all disturbances of mammals, but do all you can to minimize it.

- Follow the guidelines above (altitude 150 m or 500 ft agl altitude, 0.8 km or 0.5 mi lateral distance) when animals are spotted. Do not make low passes to “get a better look.”
- Avoid flying directly over female animals with dependent young (caribou and moose cows with calves and bear sows with cubs) and avoid active bear and wolf dens at any time.
- Avoid flying directly over caribou groups or bears along streams at any time.
- Cross the path of moving animals at right angles behind them whenever possible, rather than directly approaching or following them.

APPENDIX 16.3B

SEASONAL OCCURRENCE AND RELATIVE ABUNDANCE OF RAPTORS IN THE LAKE CLARK/ILIAMNA REGION

APPENDIX 16.3B

Seasonal Occurrence and Relative Abundance of Raptors in the Lake Clark/Iliamna Region with Notes on Probable Status in the Mine Study Area

		Relative Abundance [a]				
		Lake Clark [b]				Mine Study Area [c]
Common Name	**Scientific Name**	**Spring**	**Summer**	**Fall**	**Winter**	**Probable Status**
DIURNAL RAPTORS:						
Osprey	*Pandion haliaetus*	R	R, B	R		R, Breeding
Bald Eagle	*Haliaeetus leucocephalus*	C	C, B	C	R	C Breeding, U Winter
Northern Harrier	*Circus cyaneus*	C	U, B	C		U Breeding
Sharp-shinned Hawk	*Accipiter striatus*	U	U, B	U	R	R Visitor
Northern Goshawk	*Accipiter gentilis*	U	U, B	U	U	R Breeding
Red-tailed Hawk	*Buteo jamaicensis*	U	U, B	U		R Breeding
Rough-legged Hawk	*Buteo lagopus*	U		R		U Breeding
Golden Eagle	*Aquila chrysaetos*	U	U, B	U		U Breeding
American Kestrel [d]	*Falco sparverius*	R	R	R		AC
Merlin	*Falco columbarius*	U	U, B	U	CA	U Breeding
Peregrine Falcon	*Falco peregrinus*	R	R, B	R	CA	R Breeding
Gyrfalcon	*Falco rusticolus*	R	R, B	R	CA	U Breeding
OWLS:						
Great Horned Owl	*Bubo virginianus*	U	U, B	U	U	U Breeding
Snowy Owl	*Bubo scandiacus*			R	R	AC Migrant?
Northern Hawk-owl	*Surnia ulula*	R	R, B	R	R	R Breeding
Great Gray Owl	*Strix nebulosa*	R	R	R	R	R Breeding
Short-eared Owl	*Asio flammeus*	U	U, B	R	AC	U Breeding
Boreal Owl	*Aegolius funereus*	U	U, B	U	U	U Breeding
Northern Saw-whet Owl	*Aegolius acadicus*	U	U	U	U	Rare

Notes:

a. Relative abundance and breeding codes:
A=abundant, C=common, U=uncommon, R=rare, CA=casual, AC=accidental, and B= known nest records.

b. Main Source: National Park Service, Lake Clark National Park and Preserve Bird List (NPS, 2000).

c. This study and Williamson and Peyton, 1962.

d. Racine and Young, 1978.

16.4 Waterbirds-Mine Study Area

16.4.1 Introduction

The results of the 2004 and 2005 surveys for waterbirds and a 2006 survey for post-breeding swans in the mine study area are presented in this section. The surveys for waterbirds in 2004 and 2005 focused on recording the distribution and abundance of all waterbird species—with an emphasis on waterfowl—during the breeding season (pre-nesting, nesting, molting, and brood-rearing) and during spring and fall migration. The survey for swans in 2006 located brood-rearing groups in the mine study area and determined whether they were Tundra and/or Trumpeter swans. The Iliamna Lake region of the northern Alaska Peninsula is an important migration route for many species of waterbirds (swans, geese, ducks, loons, shorebirds, and gulls) moving to and from breeding areas in western and northern Alaska (King and Lensink, 1971; Platte and Butler, 1995; Conant and Groves, 2005). Important waterbird species that use the mine study area for breeding or staging include Tundra Swan, Common Loon, Harlequin Duck, Surf and Black scoters, Long-tailed Duck, and a diverse assemblage of dabbling and diving ducks (Williamson and Peyton, 1962). Swans and loons are key indicator species of the environmental health of lakes and wetlands and Harlequin Ducks of productive riparian areas because they are sensitive to contaminants and they return to the same nesting territory year after year, often reusing nest sites (Limpert and Earnst, 1994; Mitchell, 1994; McIntyre and Barr, 1997; Robertson and Goudie, 1999; Zwiefelhofer, 2004). Harlequin Duck, Surf and Black scoters, and Long-tailed Duck are considered species of conservation concern in Alaska because Harlequin Ducks require specialized or unique habitats for breeding (BLM, 2004) and because breeding populations of Black Scoter and Long-tailed Duck have declined (Audubon Alaska, 2005). All three of these sea ducks are vulnerable to marine oil spills in their coastal wintering areas and other contaminants in their breeding areas.

16.4.2 Study Objectives

The objectives of the waterbird studies were to collect baseline data on the occurrence of swans, geese, ducks, loons, and gulls during the spring, summer, and fall seasons in the mine study area. All species observed during surveys were recorded, but special emphasis was placed on indicator species (e.g., Tundra Swan and Harlequin Duck). This study had five specific objectives:

- Determine the distribution and abundance of waterbirds during spring and fall migration.
- Describe species composition of waterbirds using lakes, rivers, and wetlands during breeding, and spring and fall migration.
- Determine breeding areas for swans and Harlequin Ducks.
- Determine the productivity of waterfowl based on brood-rearing surveys.
- Delineate important areas used by waterbirds during breeding, and spring and fall migration.

16.4.3 Study Area

Waterbird studies were conducted during breeding (pre-nesting, nesting, molting, and brood-rearing) and during spring and fall migration within a 795-square-kilometer area in 2004 and a 1,135-square-kilometer area in 2005 in the vicinity of the deposit area. The mine study area for waterbirds in 2004 and 2005 encompassed the deposit area, plus a large buffer region (Figure 16.4-1). The selection of specific survey areas for each type of waterbird survey was based on what were considered suitable habitats for the species under investigation. Migration surveys covered all lakes and rivers in the mine study area, including outlying areas that might be of regional importance (i.e., Lower Talarik Creek and Nikabuna Lakes). Surveys for breeding waterfowl and swans included lakes, ponds, wetlands, and adjacent terrain in the mine study area. Surveys for pre-nesting and brood-rearing Harlequin Ducks followed all rivers and creeks in the mine study area.

The mine study area was divided into three *survey areas* for purposes of reporting fall and spring migration surveys: the mine survey area, South Talarik survey area, and Nikabuna Lakes survey area (Figure 16.4-2). This division was necessary because some survey areas either were not surveyed in both years or were not surveyed during both spring and fall within the same year.

- The mine survey area included all lakes, ponds, and wetlands, and all rivers originating in the headwater basins of the north and south forks of the Koktuli River and Upper Talarik Creek, an area with a radius of approximately 15 kilometers from the deposit. All waterbodies east of Upper Talarik Creek that are a part of the Upper Talarik drainage also were included in this survey area.
- The South Talarik survey area included Lower Talarik Creek and the lower quarter section of Upper Talarik Creek in both years because of the regional importance of these areas to waterbirds. The lakes between the two creeks were added to this survey area in 2005.
- The Nikabuna Lakes survey area was added in 2005 to include large lakes of regional importance for migrating waterbirds.

The mine study area lies in an ecological transition zone between the Bristol Bay-Nushagak Lowlands and Interior Forested Lowlands and Uplands (Gallant et al., 1995) where interior mixed spruce/hardwood forests grade into alpine and coastal tundra habitats. The mine study area is in an open, glaciated landscape at the headwaters of the north and south forks of the Koktuli River and Upper Talarik Creek and is largely dominated by subalpine and alpine vegetation. Terrain in the area varies from flat and gently rolling with numerous lakes and small ponds to mountainous with relatively few waterbodies. The wetter habitats in the area are most often dominated by graminoid vegetation, such as wet sedge and moist graminoid meadows, which occur in lowlands, in riverine areas, and in upland areas with gentle slopes and impeded drainage. Marsh habitats, with standing water, are relatively uncommon but occur most extensively in the wetlands north of Frying Pan Lake, in riverine areas, and in wetland areas surrounding the scattered lakes and ponds.

Habitats for waterbirds consist mostly of tundra dotted with small, shallow ponds; some larger, deep lakes; and meandering rivers. The small, shallow ponds provide feeding habitats for ducks and swans during nesting and brood-rearing. The larger, deep lakes provide nesting and feeding habitats for Common Loons and feeding habitats for ducks during molting and migration. The tundra and wetland habitats adjacent to ponds and lakes provide nesting habitat for swans, ducks, and loons. The marshland and tundra adjacent to Upper and Lower Talarik creeks and the north and south forks of Koktuli River flood during spring, creating important staging areas for waterbirds at a time when lakes are mostly frozen. As the water level drops in these creeks, many ducks, including Harlequin Ducks, nest and rear their young along them.

16.4.4 Previous Studies

Information on the use of the mine study area by waterbirds is limited to a few reconnaissance-level surveys conducted during previous mining exploration in the area, regional waterfowl surveys adjacent to the area, and miscellaneous avian investigations near Iliamna Lake. During reconnaissance surveys of the mine area for Cominco Alaska Exploration in the early 1990s, observations of swans were recorded (Smith, 1991). Seven Tundra Swans, including cygnets, were reported on a reconnaissance survey on August 29, 1990 (Terra Nord, 1990). A comprehensive swan survey was conducted on August 27, 1991, but the number of swans seen on that survey was not reported (Smith, 1991). Swan locations presented in the survey report were a collection of all swan observations recorded during the reconnaissance surveys for the primary purpose of identifying areas important to swans. Mallards, American Wigeon, scoters, and Red-breasted Mergansers also were noted as being present, but no data on numbers or habitats were reported. The survey report (Smith, 1991) presented known regional staging locations of waterfowl on the Kvichak and Naknek rivers derived from Alaska Department of Fish and Game maps.

Since 1957, U.S. Fish and Wildlife Service (USFWS) biologists have conducted annual surveys to estimate waterfowl populations in Alaska as part of the Alaska-Yukon Waterfowl Population Survey (e.g., Conant and Groves, 2004, 2005). The Bristol Bay region, 1 of 12 survey strata, encompasses an area of 50,000 square kilometers extending from the Ahklun Mountains on the west to the Aleutian Mountains on the east, and from Port Alsworth on the north to Port Heiden along Bristol Bay on the south. The mountains along the edge of the survey area give way to a vast basin of rolling hills and upland tundra, and eventually to a flat coastal plain. The mine study area is within the Bristol Bay waterfowl region, but the nearest sample transects are approximately 80 kilometers southwest of the deposit in predominantly coastal lowland habitat where lakes, ponds, and wetlands are extensive. Therefore, comparisons with these annual USFWS surveys are limited because of differences in habitat types between the two areas. In 1993 and 1994, an expanded waterfowl breeding-population survey was conducted over the entire Bristol Bay waterfowl region, which included transects within the mine study area, and waterbird density distribution maps were produced (Platte and Butler, 1995).

A few general bird studies have been conducted in the Lake Clark/Iliamna region and contain basic information on species occurrence, abundance, and habitat associations of waterbirds (e.g., Osgood, 1904; Gabrielson, 1944; Williamson and Peyton, 1962; Racine and Young, 1978; University of Alaska Museum, 2003; Ruthrauff et al., 2005). On the Alaska Peninsula south of the mine study area, spring and fall staging surveys have been conducted in the Port Moller area (Gill et al., 1981), along the Naknek River (Scharf, 1993; Meixell and Savage, 2004; Oligschlaeger and Schuster, 2004; Schuster, 2004), and along the southwestern coast of Alaska from the Yukon/Kuskokwim Delta to Unimak Island (Mallek and Dau, 2000 and 2002). Tundra Swan productivity and migratory behavior have been studied south of the mine study area between the Kvichak River and Unimak Island (Wilk, 1984, 1987, 1988; Dau and Sarvis, 2002; Doster, 2002). Surveys for breeding Harlequin Ducks have been conducted in the Alaska Peninsula/Becharof National Wildlife Refuge (Savage, 2000) south of the mine study area and in other areas in southwestern Alaska (Morgart, 1998; MacDonald, 2003; Zwiefelhofer, 2004).

16.4.5 Scope of Work

The research and field work for this study were conducted during April through October 2004, April through October 2005, and September 2006. The study was performed by Robert J. Ritchie, Ann M.

Wildman, and Jennifer H. Boisvert of ABR, Inc., Fairbanks and Anchorage, according to the approach described in Chapter 9 of the *Draft Environmental Baseline Studies, Proposed 2004 Study Plan* (NDM, 2004) and the *Draft Environmental Baseline Studies, 2005 Study Plans* (NDM, 2005). The scope of work for waterbird studies in 2004 and 2005 included the following:

- Identifying areas used by waterbirds during spring and fall migration.
- Determining the density of breeding waterfowl.
- Locating and mapping swan nest sites.
- Determining the use of rivers by Harlequin Ducks during pre-nesting and brood-rearing.
- Describing species composition and the use of lakes and wetlands by brood-rearing waterfowl.

In 2005, the scope of work was expanded to include the following:

- Identifying areas used by waterbirds during the summer molting period.
- Locating and mapping gull nest sites.

In mid-July 2006, Northern Dynasty Mines approved swan productivity and species delineation surveys commencing in mid-September 2006. The scope of work included the following:

- Locating and mapping swan brood-rearing groups.
- Determining whether breeding swans were Trumpeter or Tundra swans.

16.4.6 Methods

16.4.6.1 Waterbird Spring and Fall Migration Surveys

Fixed-wing aircraft were used for waterbird surveys every seven to 10 days during spring and fall migration in 2004 and 2005. In 2004, four migration surveys were conducted in spring (between April 21 and May 23), and five surveys were conducted in fall (between September 2 and October 21; Table 16.4-1). More surveys were conducted during 2005 than in 2004 to better cover the extent of the spring and fall migration periods. In 2005, five migration surveys were conducted in spring (between April 21 and May 23), and seven surveys were conducted in fall (between August 17 and October 12). (A sixth survey had been planned for April 15, 2005, to document the first arrival of migrating swans and geese, but it was prevented by poor weather conditions.) The April 21, 2005 survey was a reconnaissance survey to visit important staging locations conducted by only the pilot because weather prevented a biologist from getting to the area until April 24. The pilot was an experienced observer and counted the number of waterbirds by species-groups (i.e., swans, geese, ducks) at important staging locations identified during migration surveys in 2004.

Groups of lakes and sections of rivers (Figure 16.4-2) were selected and assigned unique identification numbers prior to field surveys. Selection criteria included geographic features and possible development plans.

Most of the mine survey area was surveyed in 2004 and 2005. Rivers in the mine survey area were surveyed in spring (both years) and fall (2005 only). Only one fall migration survey was conducted of all rivers and lakes in the South Talarik survey area, in mid-August 2005, because flying restrictions were placed over the area in late August to minimize disturbance to subsistence activities and continued through the remainder of the migration season. In addition to the mid-August survey, Lower Talarik Creek was surveyed on October 7 and 12, 2005. In fall 2004, reconnaissance surveys of Nikabuna and Long lakes, 20 kilometers north of the deposit, were conducted after researchers learned that large numbers of waterfowl used them during migration (Alsworth, pers. comm., 2004). Because of their regional importance to migrating waterfowl, these lakes were surveyed in spring and fall 2005.

Standard operating procedures for both years called for one observer and a pilot to conduct surveys in a Piper PA18 Super Cub. Exceptions included the first migration survey in April 2004, which was conducted with two observers and a pilot in a Cessna 206, and one survey in 2005, which was conducted with one observer in a Robinson 44 helicopter. All surveys were flown at 60 meters above ground level and a speed of 100 to 145 kilometers per hour. During a survey, the aircraft circled or crossed lakes and flew along rivers parallel to the river course to allow observers to view waterfowl on the water and along the shore.

The observer recorded all data on a hand-held tape recorder, including the waterbody identification number; percent ice cover; the number, sex, and species of birds; and whether the birds were on the water, on the shore, or flying. Nests and broods also were recorded. Data from tapes were transcribed onto data sheets and entered in a computer database for analysis. Some waterfowl species are difficult to identify to species during aerial surveys (e.g., Trumpeter and Tundra swans, Lesser and Greater scaups, Common and Barrow's goldeneyes, Common and Red-breasted mergansers), so in most cases, the observers were unable to distinguish species within these species-pairs. Any noteworthy incidental observations of raptors (e.g., Bald Eagle nests) or large mammals also were recorded on the tape recorder and with a GPS location.

Data were summarized by species, species-group, lake group or river segment, date of survey, and survey area. Waterfowl were categorized as a subgroup of waterbirds that included geese, swans, dabbling ducks, or diving ducks. Sea ducks (Harlequin Ducks, scoters, Long-tailed Ducks, goldeneyes, and mergansers) were lumped into diving ducks. Other waterbirds were categorized as loons, grebes, cormorants, shorebirds, gulls, terns, or jaegers. For presentation in figures of data on the distribution and abundance of waterbirds during spring and fall, the maximal number of birds seen in each lake group or river segment during each season was displayed.

16.4.6.2 Waterfowl Breeding-population Survey

Breeding-pair surveys were conducted on June 2, 2004, and May 27, 2005, using a Cessna 206 fixed-wing aircraft in the mine study area (Table 16.4-1). Surveys were flown at 45 meters above ground level at a speed of 145 kilometers per hour. Two observers, one on each side of the aircraft, recorded observations on hand-held tape recorders. Data recorded were transect number, species and number of birds, and observation type (e.g., male, pair, flock). Observers surveyed 400 meters on either side of the aircraft along 21 pre-selected transects, each 3.2 kilometers in length (Figure 16.4-3). Transects were spaced approximately 800 meters apart and were aligned to cover the largest possible number of waterbodies and wetlands in the mine study area. The survey followed the current USFWS *Standard*

Operating Procedures for Aerial Waterfowl Breeding Ground Population and Habitat Surveys (USFWS and CWS, 1987).

All data were transcribed from tape recorders after completion of the survey. Single male ducks and males in groups of less than five were recorded as drakes. A male in close association with a female was counted as a pair, but ducks in mixed-sex groupings in which pairs could not be identified and flocks of more than four drakes were counted as grouped birds, or flocks. Additional calculations were made prior to calculating densities. First, the number of single drakes and the number of pairs (drakes with females) were doubled to reflect the probable presence of two birds in each case. Second, flocks of drakes (less than five), except for scaup and swans, were doubled under the assumption that females were present and not seen. (Scaup, drakes, and unpaired swan observations are not doubled in the USFWS standard operating procedure [USFWS and CWS, 1987].) Third, single female ducks were not included in analysis under the assumption that doubling the number of single males accounts for single females in the population. Finally, a species-specific USFWS visibility correction factor was applied to correct for sightability of different species of ducks by observers (Conant and Groves, 2005).

16.4.6.3 Swan Nesting Survey

Aerial surveys to locate swan nests were conducted in the mine study area on June 3, 2004, and May 28, 2005 (Table 16.4-1). Although swan nests were recorded on all avian surveys, the migration and breeding-pair surveys focused primarily on water surfaces and shorelines and did not provide adequate coverage between lakes and ponds where swans may nest. In contrast, the swan-nesting survey was designed to cover both wetlands and the terrain surrounding wetlands.

The surveys were flown in a Cessna 206 fixed-wing aircraft with a pilot and two observers, one on each side of the aircraft. Surveys were conducted at 150 meters above ground level and a speed of 145 kilometers per hour. Researchers surveyed transects spaced 1.6 kilometers apart and recorded all nests within 800 meters of each side of the aircraft, providing 100 percent coverage for the wetlands surveyed. In 2004, transects over suitable habitats were designed during flight, whereas in 2005, transects were selected before the surveys and loaded as a route into the pilot’s onboard global positioning system (GPS; Figure 16.4-4). Both surveys methods followed USFWS protocol (USFWS, 1987) and standard survey techniques (King, 1973). Researchers deviated from transects to circle swans and determine nesting when needed. Nest locations were hand-mapped onto 1:63,360-scale USGS maps in both survey years and also recorded as a waypoint with a GPS in 2005.

The purpose of the swan productivity and species delineation survey in September 2006 was to search for swan broods and identify the swan species occurring in the study area. A survey was conducted on September 27 and 28 with two observers in a Robinson 44 helicopter flying at 150 meters above ground level and a speed of approximately 145 kilometers per hour. Because swan nesting territories often are reoccupied in successive years, researchers revisited locations of nesting swans identified during surveys flown in 2004 and 2005 to search for brood-rearing groups. Suitable nesting habitats between these locations also were searched. When swans were sighted, the helicopter circled and/or hovered nearby, sometimes descending to a lower altitude, while researchers attempted to identify swans with image-stabilizing 10-power binoculars. If the swan species could not be identified while the researchers were airborne, the helicopter landed at a site nearby where researchers could view the swans with a high-power spotting scope on a tripod. Swans were observed until identified or until they went out of view.

Swan species was determined mainly using morphological characteristics and, if possible, auditory characteristics (Sibley, 2000). Morphological criteria for adults included bill color (presence/absence of yellow lores), and head and bill shape. For young birds, Trumpeter Swan bills are always black at the base, whereas the bills of Tundra Swan young have pink at the base (Sibley, 2000).

16.4.6.4 Harlequin Duck Pre-nesting and Brood-rearing Surveys

One aerial survey for pre-nesting Harlequin Ducks was flown on May 25, 2004, and two surveys were flown in 2005, one on May 24 and one on May 29 (Table 16.4-1). Two aerial surveys for brood-rearing Harlequin Ducks were conducted in each year, but the timing of the surveys was different between years. In 2004, surveys were conducted on July 12 and August 2. In 2005, surveys were flown on July 28 and 29, and August 13 and 14.

Within the mine study area, Upper and Lower Talarik creeks, the north and south forks of Koktuli River, and a western drainage of Kaskanak Mountain, a tributary of the South Fork, were surveyed each year during the pre-nesting season (Figures 16.4-5 and 16.4-6). Additionally, in 2005, an eastern drainage of Kaskanak Mountain and a northeastern headwater drainage of Upper Talarik Creek were surveyed (Figure 16.4-6). During brood-rearing surveys in 2004, only the north and south forks of the Koktuli River and a section of Upper Talarik Creek were surveyed (Figure 16.4-5). The brood-rearing surveys in 2005 covered the same drainages as the 2005 pre-nesting surveys, except for the addition of a creek between Upper and Lower Talarik creeks (Figure 16.4-7).

All surveys were flown with two observers seated on the same side of a helicopter (Astar, Bell 206, Hughes 500, or Robinson 44), except for the August 2, 2004 survey which was flown with only one observer. Because no Harlequin Duck broods were seen on the July 12, 2004 survey, the only brood-rearing survey planned for 2004, a researcher conducted an opportunistic survey on August 2, 2004 after completing other avian surveys. Surveys were generally flown upriver at 45 meters above ground level and a speed of 65 kilometers per hour. The helicopter was positioned over the bank of the river to give the observers an unobstructed view of the entire width of the watercourse. In 2004, only locations of Harlequin Ducks were recorded, whereas in 2005, locations of all waterfowl were recorded to determine use of rivers by all waterfowl species.

For each observation, data recorded were a GPS waypoint; river name; species; total number of birds in the group; numbers of pairs, males, and females; number of young; the birds' location (i.e., on the water, shore, or flying); and stream flow (swift or placid). Water clarity (clear, turbid, or glacial) also was recorded for each stream.

16.4.6.5 Loon Observations During Breeding

Surveys designed specifically for recording loons during the breeding season were not conducted in the mine study area in 2004 or 2005. Observations of loons and their nests and broods were recorded as part of the spring and fall migration surveys and the waterbird brood-rearing surveys. Occurrences of adult loons, nests, and broods were summarized by species and lake group.

16.4.6.6 Gull Nesting Survey

A survey for nesting gulls was conducted on June 2, 2005, in the mine study area (Table 16.4-1). One observer in a Robinson 44 helicopter flew a zigzag pattern over lakes, ponds, and wetlands at an altitude of 45 meters above ground level and a speed of 65 kilometers per hour (Figure 16.4-8). Gull locations were marked on 1:63,360-scale USGS maps, and the species, number of birds, and presence of a nest were recorded.

16.4.6.7 Waterbird Brood-rearing Survey

Ground surveys for brood-rearing waterbirds were conducted July 9 through 13, 2004, and July 8 through 14, 2005 (Table 16.4-1). The survey area for brood-rearing waterbirds included wetlands, ponds, and lakes in selected locations in the mine study area (Figure 16.4-9). Selection criteria for survey sites in 2004 included the proximity of the waterbody to the deposit area, the relative abundance of birds recorded in different portions of the study area during the breeding-pair survey, and logistical considerations. In 2005, researchers broadened the ground survey area to include a greater sample of waterbodies around the 2004 survey sites. In both years, a few lakes were surveyed with a helicopter because of logistical constraints on getting to those lakes by foot.

Two or three observers traversed wetlands and circumnavigated ponds and lakes on foot to search for waterbird broods. Each waterbody was assigned an identification number prior to surveying and labeled on color aerial photographs used as field maps. GPS waypoints were taken of each waterbody during the survey for site verification. For each waterbody surveyed, researchers recorded species of waterbirds; number and sex of adults; and if a brood was present, the number of young and the brood age class. Brood ages for waterfowl (primarily ducks) were classified into one of seven age classes based on reference diagrams of age classes and of chick plumage patterns carried by researchers (Gollop and Marshall, 1954; Bellrose, 1976; Baicich and Harrison, 1997).

16.4.6.8 Waterbird Molting Survey

Fixed-wing aircraft were used to conduct two surveys for flocks of molting waterbirds during summer 2005, on July 26 and on August 11 (Table 16.4-1). The molting surveys were flown in a Piper PA18 Super Cub at 60 meters above ground level and a speed of 100 to 145 kilometers per hour, with one observer and a pilot. Researchers surveyed the same lakes in the mine study area west of Upper Talarik Creek that were surveyed during migration surveys (Figure 16.4-10).

The observer recorded all data on a hand-held tape recorder, including the waterbody identification number; the number, sex, and species of birds; and whether the birds were on the water, on the shore, or flying. Broods also were recorded. Data from tapes were transcribed onto data sheets and entered in a computer database for analysis. Data were summarized by species, species-group, lake group, and date of survey. For presentation in figures of data on the distribution and abundance of waterbirds during summer, the maximal number of birds seen in each lake group during either survey date was displayed.

16.4.7 Results and Discussion

Thirty-seven species of waterbirds were observed during nesting, brood-rearing, molting, and migration surveys in the mine study area (Table 16.4-2). Representatives from 10 taxa were recorded: geese (2 species), swans (1), ducks (19), loons (3), grebes (1), cormorants (1), shorebirds (5), gulls (3), terns (1), and jaegers (1). Twenty-one species were confirmed to breed in the mine study area based on the presence of a brood recorded during ground surveys for broods (Table 16.4-2). One additional species, Common Merganser, probably bred in the mine study area in 2004 and 2005 based on its presence in the area during the breeding season, the availability of suitable nesting habitats, and because the study area occurs within their general breeding range. Fifteen species were seen only occasionally and in small numbers and were assumed to be migrants through the area (Table 16.4-2). All waterfowl species observed were within their migration or breeding range (Bellrose, 1976).

No waterbird species that is listed as federally endangered or threatened was observed in the mine study area during surveys in 2004 and 2005 (USFWS, 2006). Some waterbird species that are not listed, however, are of conservation concern by governmental and non-governmental organizations because of apparent decreases in population abundance and/or population trends or because of a lack of data regarding population abundance and trends. Waterbird species of conservation concern are those that are classified as of concern by USFWS, the Bureau of Land Management, or the Alaska Department of Fish and Game (ADF&G) and/or are listed as of concern by non-governmental organizations focused on particular taxa (e.g., Partners in Flight, Alaska Shorebird Group) or by groups that use science extensively in conservation (e.g., Alaska Natural Heritage Program, Audubon Society). Species that occurred on at least two conservation lists are included as species of conservation concern. The rationale behind this approach to selecting species of conservation concern was that it relied primarily on information from groups of state and/or national experts in waterbird biology who used multiple criteria to determine the conservation status of each species.

Five species of waterbirds recorded during surveys in the mine study area are considered of conservation concern: Harlequin Duck, Surf Scoter, Black Scoter, Long-tailed Duck, and Red-throated Loon. A discussion of reasons why these five species are of conservation concern is presented in Chapter 17. Surveys for Harlequin Ducks found breeding pairs in the headwater drainages of the north and south forks of the Koktuli River and Upper Talarik Creek (see Section 16.4.7.5). Surf and Black scoters were seen in pairs on lakes in spring and in small staging flocks during spring and fall migration surveys (see Section 16.4.7.1). Only broods of Black Scoters were seen during the waterbird brood-rearing survey (see Section 16.4.7.8). Long-tailed Ducks were observed in pairs on lakes in spring and with broods in July (see Sections 16.4.7.1 and 16.4.7.8). Red-Throated Loons were recorded only in the South Talarik and Nikabuna Lakes survey areas during spring and fall migration surveys (see Sections 16.4.7.1 and 16.4.7.2).

16.4.7.1 Waterbird Spring Migration Surveys

Mine Survey Area

Temporal Patterns. In spring, the distribution and abundance of staging waterbirds in the mine survey area depended on the extent of open water on lakes and the amount of flooding in rivers. Lakes in the mine survey area were frozen and hardly discernable from surrounding terrain because of 95 to 99 percent snow and ice cover during the first migration survey of each year. On April 21, 2004, only one lake had a small amount of open water and 2 of the 39 waterbirds counted were found there; the remaining 37 waterbirds were found on the rivers, which were thawed and flowing. On April 24, 2005, seven lakes had a small amount of open water and the 72 waterbirds counted on that survey were about equally distributed on lakes and rivers. Most of these waterbirds were ducks (Mallard, Northern Pintail, goldeneye, and merganser), and a few geese and swans also were present.

By the second survey in early May of 2004 and 2005 (May 4 and 3, respectively), most lakes still had about 85 percent ice cover, and half of the waterbirds seen were concentrated in small mixed-species flocks on lakes where stream runoff created open water. All other waterbirds were recorded in rivers or the flooded marshland and tundra created by overflow along Upper Talarik Creek and the north and south forks of the Koktuli River. Similar numbers of waterbirds were seen on this second survey during both years (274 and 228 in 2004 and 2005, respectively; Tables 16.4-3 and 16.4-4). Ducks made up over 71 percent of the waterbirds recorded on this survey in both years, and most were dabbling ducks (Appendices 16.4A and 16.4B). Four species of dabbling ducks (American Wigeon, Mallard, Northern Pintail, and Green-winged Teal) and three types of diving ducks (scaup, goldeneyes, and mergansers) were present. Ten swans were observed each year in the survey area on the second survey. Shorebirds (Whimbrel, Black-bellied Plover, and yellowlegs), gulls (Bonaparte’s, Mew, and Glaucous-winged gulls) and Arctic Terns made up the remaining waterbirds seen (Appendices 16.4A and 16.4B).

By the third survey (May 14) each year, small, shallow lakes were ice-free, and large, deep lakes had about 50 percent ice cover. Waterfowl occupied many of the smaller, ice-free lakes and, like the previous survey, were concentrated near stream inlets on large lakes. A similar number of waterbirds was seen on this third survey in 2004 and 2005 (770 and 771, respectively), and more were using lakes (80 percent) than rivers (20 percent). Although the percentage of waterbirds found on rivers was lower than in late April and early May, the total number of birds on rivers continued to increase in mid-May (maximal numbers were 167 birds in 2004 and 161 in 2005). Ducks still were the most abundant species-group found on lakes and rivers (Tables 16.4-3 and 16.4-4), making up over 84 percent of all waterbirds in both years, and in contrast to the previous survey, diving ducks were more common than dabbling ducks. Waterbirds recorded on this survey that had not been seen on previous surveys were Gadwall, Northern Shoveler, Harlequin Duck, Long-tailed Duck, Surf Scoter, Black Scoter, and Common Loon (Appendices 16.4A and 16.4B).

By the last survey (May 23) of spring migration each year, only a small amount of ice remained on a few large lakes, and waterbirds were dispersed on lakes and rivers throughout the mine survey area. The relative number of birds in each species-group was similar in both years to the previous survey, but the total number of birds counted was higher in 2005 (1,075 birds) compared to 2004 (437 birds), mostly because of a greater number of ducks in 2005 (Tables 16.4-3 and 16.4-4). Large migratory flocks of up to 60 diving ducks, mostly scaup and some scoters, were observed in 2005, whereas at the same time in 2004, no flocks of greater than 10 ducks were seen. In both survey years, the number of swans and gulls recorded in the mine study area increased with each successive survey. Canvasback, White-winged Scoter, and Parasitic Jaeger were the only additional waterbird species recorded that had not been observed on previous surveys (Appendices 16.4A and 16.4B).

Spatial Patterns. During spring migration in 2004 and 2005, most waterbirds were found in lakes in the northern part of the mine survey area, from Frying Pan Lake to lakes in the North Fork Koktuli River drainage (Figures 16.4-11 and 16.4-12). The greatest concentration of waterbirds (114 birds in 2004 and 227 in 2005) seen on a spring survey was on lakes in the “Big Wiggly Lake” area. Similar numbers of waterbirds were counted in the lakes north of the North Fork Koktuli River in 2004 and 2005. A moderate number of waterbirds was found in both years in the lakes between the deposit area and Frying Pan Lake.

The lowest number of waterbirds was found in both years in lakes adjacent to the South Fork Koktuli River south of Frying Pan Lake. All rivers in the mine survey area were used by waterbirds during spring (Figures 16.4-11 and 16.4-12). The highest count of waterbirds using rivers in both years was on Upper Talarik Creek (87 birds in 2004 and 76 in 2005). Rivers throughout the region are recognized to be important waterfowl staging areas; the Naknek River is of particular importance on the Alaska Peninsula because it often is the first ice-free large body of water (Schuster, 2004).

Taxonomic Patterns. Twenty-four species of waterbirds were observed in 2004 and 2005 combined during spring migration surveys in the mine survey area (Appendices 16.4A and 16.4B). Only one pair of geese was observed in the mine survey area during migration surveys: a pair of Canada Geese along the North Fork Koktuli River on April 21, 2004 (Appendix 16.4A).

Swans were observed as single birds or pairs during spring surveys in both years in the mine survey area, and all probably nested in the area. The greatest number of swans counted during a spring survey in both years was 16 birds (Tables 16.4-3 and 16.4-4). During late April and early May, swans were seen feeding in flooded wetlands and at stream inlets to lakes when nearby nesting territories were covered with snow. Swans stage on rivers and other ice-free waterbodies and remain at those sites until ponds near nesting areas are open (Wilk, 1988). By mid-May, most swans were occupying territories and some were on nests. During aerial surveys, swans could not be identified to species, but during ground surveys in the mine survey area, all swans that were identified were Tundra Swans.

Five species of dabbling ducks (American Wigeon, Mallard, Northern Shoveler, Northern Pintail, and Green-winged Teal) were common (Appendices 16.4A and 16.4B). Most were distributed throughout the mine survey area on small lakes and probably nested nearby. Some small flocks (five to 23 birds) of dabblers staged on lakes in 2005. Scaup were the most common diving duck, and they staged on large lakes in flocks of up to 60 birds (Appendices 16.4A and 16.4B). In 2005, 458 scaup were counted on May 21. Goldeneyes and scoters (Surf, White-winged, and Black scoters) were observed on lakes in small flocks (five to 24 birds). Common and Red-breasted mergansers were seen on both lakes and rivers in flocks of up to 20 birds. The assemblage of ducks seen in the mine survey area and their timing and abundance during spring appeared to be in accordance, in general, with what has been recorded for other areas of the Alaska Peninsula (Bellrose, 1976; Gill et. al., 1981; Meixell and Savage, 2004; Oligschlaeger and Schuster, 2004; Schuster, 2004).

Common Loons arrived in the mine survey area in mid-May (Tables 16.4-3 and 16.4-4). The maximal counts of loons during spring surveys were nine birds in 2004 and 14 in 2005 (Appendices 16.4A and 16.4B). Most Common Loons recorded during the migration surveys probably nested in the mine survey area, as indicated by some nests and broods being found each year. Pacific Loons were occasionally seen in the mine survey area, and one nest was found on May 23, 2005 (see Section 16.4.7.6).

Gulls and terns were found in small flocks near rivers and lakes during spring surveys in the mine survey area. For two gull species, Bonaparte's and Mew gulls, some birds probably were migrants while others were local breeders, as evidenced by nests and broods found in the mine survey area. Glaucous-winged Gulls and Arctic Terns were seen foraging in small flocks. The highest number of gulls and terns occurred in both years on the May 23 survey: 83 birds were counted in 2004 and 104 in 2005 (Tables 16.4-3 and 16.4-4; Appendices 16.4A and 16.4B).

All shorebirds that could be identified during migration surveys, (i.e., Black-bellied Plover, yellowlegs, and Whimbrel) were single birds or in pairs and probably bred in the area. Some small flocks (8 to 12 birds) of unidentified small and medium-sized shorebirds were observed (Appendices 16.4A and 16.4B). The count of shorebirds ranged from 15 to 41 birds on spring surveys (Tables 16.4-3 and 16.4-4). Aerial surveys for shorebirds are most useful in identifying large flocks of birds, and no flock larger than 12 birds was seen in the mine survey area during spring.

South Talarik Survey Area

Lower Talarik Creek and the lower section of Upper Talarik Creek were important to staging birds during spring and fall migration in 2004 and 2005 (Tables 16.4-3 and 16.4-4; Figures 16.4-11, 16.4-12, and 16.4-13). During early spring, the creeks and the creek-outlet areas on Iliamna Lake provided foraging habitats for large numbers of migrating ducks and terns and smaller numbers of swans, loons, cormorants, shorebirds, and gulls. Before entering Iliamna Lake, Lower Talarik Creek merges with several lakes and creates a wetland area that is attractive to many waterbirds. A maximum of 355 waterbirds was observed using this area on May 14, 2005. Flocks of American Wigeon, scaup, mergansers, small shorebirds, Mew and Glaucous-winged gulls, and Arctic Terns foraged in the lakes and wetlands (Appendix 16.4B). In 2004, about 110 birds occurred there on May 14, and the species assemblage of birds was similar to 2005. From this wetland area to the headwater lakes of Lower Talarik Creek, mergansers and scaup staged in flocks of up to 20 birds, resulting in maximal counts of 75 and 90 birds in 2004 and 2005, respectively.

The outlet of Upper Talarik Creek into Iliamna Lake also is an attractive stopover location for flocks of migratory birds during spring (Figures 16.4-11 and 16.4-12). On a spring reconnaissance flight on April 21, 2005 by the survey pilot, 160 swans, 6 geese, and 65 ducks were observed. The timing of swan staging in the mine study area was similar to that recorded on the Naknek River in 2004, where Tundra Swans numbers also peaked in late April (Schuster, 2004). In 2004, researchers could not survey the outlet of Upper Talarik Creek during the first two spring surveys because of fog. On the lower section of Upper Talarik Creek, American Wigeon, scaup, merganser, and small shorebirds staged in flocks of up to 20 birds during spring in 2004 and 2005. Many other ducks, gulls, and terns also were observed; maximal numbers were 41 birds in 2004 and 66 birds in 2005 (Figures 16.4-11 and 16.4-12).

The lakes between Upper and Lower Talarik creeks were surveyed only in spring 2005. The number of waterbirds counted in each survey lake group ranged from 1 to 121 birds during spring (Figure 16.4-12), and the highest count for all lake groups combined was 388 birds on May 23, 2005. On that same survey, some large flocks of scaup and scoters (20 to 60 birds) were recorded.

Nikabuna Lakes Survey Area

Long Lake, the Chulitna River, and the three large lakes that comprise the Nikabuna Lakes and the rivers connecting them were used by large numbers of waterfowl during spring 2005. The maximal number of birds recorded on each of the four large lakes ranged from 173 to 707 birds (Figure 16.4-12). Swans were most numerous during the first survey on April 21 when 400 birds were observed (Table 16.4-4). By April 24, the number of swans had dropped to 165, and no more than 14 swans were recorded during the three remaining spring surveys. Greater White-fronted Geese and Canada Geese were observed in mixed and single-species flocks of 50 to 100 birds, with the peak number of 376 geese occurring on April 24 (Table 16.4-4; Appendix 16.4B). Greater White-fronted and Canada geese staged in moderate numbers on the Naknek River, and the date of peak abundance there in 2004 was April 14 (Schuster, 2004).

Ducks were the most abundant species-group observed on each survey between April 24 and May 23, 2005, ranging in number from 719 to 989 birds (Table 16.4-4). American Wigeon, Mallard, and Northern Pintail were common dabbling ducks (Appendix 16.4B), occurring in flocks of 100 to 200 birds. Scaup and goldeneyes made up over 70 percent of the diving ducks seen, and scoters and mergansers made up about 10 percent each. Flocks of diving ducks rarely exceeded 100 birds. Like other areas, dabbling duck numbers peaked in late April, whereas diving duck numbers peaked in mid-May (Appendix 16.4B).

All other waterbirds (loons, grebes, shorebirds, gulls, and terns) were observed as single birds, pairs, or small flocks in the Nikabuna Lakes survey area during spring (Table 16.4-4). The largest group was a migratory flock of 20 Red-necked Grebes seen on May 3. Red-throated and Common loons also were seen for the first time on May 3 (Appendix 16.4B). Yellowlegs and small shorebirds were common in flocks of less than five birds.

16.4.7.2 Waterbird Fall Migration Surveys

Mine Survey Area

Temporal Patterns. Similar to spring, ducks were the most abundant species-group during every survey (87 to 97 percent of all waterbirds). Numbers of ducks counted during each of the first three fall surveys (mid-August to early September) in 2005 were similar (938 to 958 ducks) and also were similar to the number recorded during the early September 2004 survey (956 birds; Tables 16.4-3 and 16.4-4). From mid-September to the end of October, the number of ducks decreased with each subsequent survey in both years. In 2004, the number of ducks in the mine survey area decreased by more than half between September 13 and 23 (610 and 214 birds, respectively). In contrast, the number of ducks in 2005 remained high through the end of September (617 ducks counted on September 29) and did not decrease substantially until early October, perhaps because mild weather in September 2005 allowed ducks to stay longer in the area. Warm fall weather along the Naknek River in 1993 apparently allowed waterfowl to remain in the area longer and caused individual species abundance to fluctuate over a number of weeks (Scharf, 1993).

Spatial Patterns. During fall migration of both years, waterbirds were found throughout the mine survey area, but most staging waterbirds were in single-species groups on large lakes. Consequently, those areas with large lakes tended to have the highest number of birds: Big Wiggly Lake, Frying Pan Lake, and an isolated lake in the northwestern part of the mine survey area (Figures 16.4-13 and 16.4-14). The maximal number of waterbirds counted in the Big Wiggly Lake area on a fall survey was 291 birds in 2004 and 260 in 2005. The maximal numbers in an area from the deposit area south to and including Frying Pan Lake were 291 birds in 2004 and 298 in 2005. Rivers in the mine survey area were not surveyed during fall 2004 and were only surveyed during the first three fall migration surveys in 2005. Harlequin Ducks, in groups of up to eight birds, were observed on the north and south forks of the Koktuli River through August. Mergansers and Mallards staged on the rivers in flocks of 15 and 50 birds, respectively.

Taxonomic Patterns. During fall migration surveys, 14 waterbird species were seen in 2004 and 20 species in 2005 in the mine survey area (Appendices 16.4A and 16.4B). Most swans were found in the northern half of the mine survey area, from Frying Pan Lake to the headwater basin of the North Fork Koktuli River. Smith (1991) reported that swans were seen most frequently in the headwater basins of Upper Talarik Creek and the North Fork Koktuli River during reconnaissance surveys in August 1991. The highest counts of swans observed during the 2004-2005 Pebble Project study in the mine survey area were 28 birds on September 13, 2004, and 38 on September 13, 2005 (Tables 16.4-3 and 16.4-4). Most of these birds were pairs of failed breeders and family brood-rearing groups, but a few small flocks (three to 11 birds) of staging adults were observed. By September, non-breeding swans are known to collect in flocks on large lakes or along coastal areas for fall staging (Limpert and Earnst, 1994). Family groups depart for staging areas at a later date.

Both dabbling and diving ducks staged in large flocks in the mine survey area. Five species of dabbling ducks (American Wigeon, Mallard, Northern Shoveler, Northern Pintail, and Green-winged Teal) commonly occurred in single-species flocks of up to 60 ducks. Scaup were the most common diving duck, and they staged on large lakes in flocks of up to 120 birds. In 2005, 423 scaup were counted on September 13 (Appendix 16.4B). Fall flock sizes of most diving ducks were larger in 2005 than in 2004. Goldeneyes were observed on lakes in flocks of up to 50 birds, and scoters and mergansers were in flocks of 20 birds. Some differences were apparent in migration timing between the dabbling and diving ducks. Dabbling ducks were most abundant during early to mid-September 2004 and mid-August to early September 2005, whereas numbers of diving ducks were highest in early September 2004, but remained high from mid-August through September 2005 (Appendices 16.4A and 16.4B).

A few Common Loons were counted on every survey until late September, and brood-rearing groups were seen on several occasions (see Section 16.4.7.6). Red-necked Grebes were observed each year, two on September 2, 2004, and one on each of three surveys between September 13 and October 7, 2005 (Appendices 16.4A and 16.4B). Shorebirds and gulls were recorded only on August 17, 2005.

South Talarik Survey Area

During fall 2004, the lake and wetland area near the mouth of Lower Talarik Creek was used by swans and many different species of ducks. Glaucous-winged Gulls were found in moderate numbers along the creek and at the creek mouth feeding on fish remains. The maximal number of waterbirds counted on Lower Talarik Creek during fall was 194 birds on September 13, 2004. At the mouth of the creek in the lakes and wetland area, the maximal number of 145 birds was recorded on September 2. Flocks of up to 50 dabbling and diving ducks were common. A flock of 31 and 35 swans was seen on September 23 and October 7, 2004, respectively. Fewer waterbirds were counted during fall 2004 on Upper Talarik Creek than on Lower Talarik Creek (Figure 16.4-13). Researchers found small flocks (less than 10 birds) of swans and Mallards and larger flocks (35 birds) of scaup on Upper Talarik Creek.

In 2005, only one fall survey of Upper Talarik Creek and the lakes between Upper and Lower Talarik creeks was conducted, on August 17, because flying restrictions were placed over the area in late August to minimize disturbance to subsistence activities and precluded any additional surveys of Upper Talarik Creek and most of the lakes to the west. In addition to August 17, Lower Talarik Creek was surveyed on October 7 and 12, 2005. On August 17, 262 waterbirds were counted in the lakes between the two creeks and their distribution was patchy, with most occurring in eight of the 26 lake groups. On Lower Talarik Creek and the wetland area near the outlet at Iliamna Lake, researchers observed flocks of dabbling ducks (94 birds), Glaucous-winged Gulls (82), and swans (10). Only a few mergansers, small shorebirds, and Glaucous-winged Gulls were found on the lower section of Upper Talarik Creek.

Nikabuna Lakes Survey Area

Two reconnaissance surveys were conducted of Nikabuna and Long lakes, 20 kilometers north of the deposit area, on September 23 and October 7, 2004, after researchers learned that large numbers of waterfowl used these lakes during migration (Alsworth, pers. comm., 2004). Concentrations of 357 swans and 954 ducks were observed there on September 23, 2004 (Table 16.4-3 and Appendix 16.4A).

The number of waterbirds observed using the Nikabuna Lakes survey area for staging during fall 2005 exceeded the number of birds recorded during spring 2005 by about four times (Table 16.4-4). The maximal numbers of birds counted on Nikabuna and Long lakes ranged from 400 to 2,000 during fall 2005 (Figure 16.4-14). The maximal number of waterbirds on the five survey sections of the Chulitna River ranged from 14 to 620 birds.

Swans and ducks were the most abundant species-groups that staged on the lakes and rivers in the Nikabuna Lakes survey area in fall 2005 (Table 16.4-4). The first flocks of staging swans were observed on October 7, when 167 birds were present. By the last survey on October 12, 333 swans were present. Large flocks of swans have been observed annually using Nikabuna Lakes and Chulitna Bay in Lake Clark National Park and Preserve for fall staging until the lakes freeze (Alsworth, pers. comm., 2004). On the Naknek River in 1993, swans were observed up until October 20, which was a week before ponds and riverbanks began freezing (Scharf, 1993).

The count of all ducks in the Nikabuna Lakes survey area during the seven fall surveys ranged from 1,943 to 4,997 birds (Table 16.4-4). The peak number of 4,997 birds occurred on September 6 when large numbers of both dabbling ducks (1,151) and diving ducks (3,846) were present (Appendix 16.4B). American Wigeon, Mallard, and Green-winged Teal were the most abundant dabbling ducks and commonly occurred in flocks of more than 80 birds. Scaup were the most abundant diving ducks, followed by scoters and goldeneyes. Scaup were commonly observed in flocks of more than 200 birds, and one flock of 1,200 was recorded. A large number of Surf Scoters (1,293 birds) was found on September 8, 2005 (Appendix 16.4B).

All other waterbirds (geese, loons, grebes, shorebirds, and gulls) were observed only in small numbers in the Nikabuna Lakes survey area during fall 2005 (Table 16.4-4). Only a few small flocks of Greater White-fronted Geese and Canada Geese were observed in late August and early September. A flock of 11 Red-throated Loons and a single adult were seen on August 17 (Appendix 16.4B). Six shorebirds were seen in the August 17 survey, and three gulls were seen in the October 12 survey.

16.4.7.3 Waterfowl Breeding-population Survey

During waterfowl breeding-population surveys, 27.2 square kilometers were sampled in the mine study area in 2004 and 2005 (Figure 16.4-3). Observers recorded more species of ducks and higher overall densities in 2004 (Table 16.4-5). Green-winged Teal, goldeneyes, and Long-tailed Duck were observed only in 2004, while Gadwall were observed only in 2005. At least four species were observed in both years: Mallard, Northern Pintail, scaup, and scoter. Observers recorded almost twice as many ducks during surveys in 2004 compared to 2005, resulting in annual densities of 12.2 ducks per square kilometer in 2004 and 6.8 ducks per square kilometer in 2005. Scaup accounted for over half of the observed ducks in each year, but their density was about 50 percent more in 2004 than in 2005. Goldeneyes were the second most common duck in 2004, but were not seen in 2005. The densities of Mallard and Green-winged Teal were the same in 2004, but in 2005, Mallard density was higher than the previous year, while no Green-winged Teal were seen. The densities of Northern Pintail and scoters were similar in both years. Twice as many swans were recorded in 2004 compared to 2005 (0.6 and 0.3 swans per square kilometer, respectively).

Surveys conducted by the USFWS in the Bristol Bay region had mean densities of 20.8 ducks per square kilometer in 2004 and 19.4 ducks per square kilometer in 2005 (Conant and Groves, 2004, 2005)—two to three times greater than duck densities observed in the mine study area by Pebble Project researchers. Researchers recorded eight species of ducks in the mine study area compared to 12 species in the entire Bristol Bay region during 2004 and 2005 (Conant and Groves, 2004, 2005). Species seen in the Bristol Bay region, but not in the mine study area, during waterfowl population surveys included American Wigeon (1.9 to 2.7 ducks per square kilometer)—one of the more commonly observed ducks, Blue-winged Teal (0 to 0.1 ducks per square kilometer), Northern Shoveler (1.6 to 1.7 ducks per square kilometer), and mergansers (0.2 to 0.3 ducks per square kilometer) (Conant and Groves, 2004, 2005).

Scaup were the most commonly observed duck in the mine study area during Pebble Project studies. Statewide trends have indicated an increase in tundra-nesting scaup (excluding the North Slope population) since the mid-1970s (Conant and Groves, 2005). This duck was the only species to occur at higher densities in the mine study area than in the Bristol Bay region during both 2004 and 2005. In the Bristol Bay region, scaup densities were 4.1 ducks per square kilometer in 2004 and 3.3 ducks per square kilometer in 2005 (Conant and Groves, 2004, 2005), while in the mine study area the densities were 6.3 ducks per square kilometer in 2004 and 3.6 ducks per square kilometer in 2005 (Table 16.4-5).

Differences in density and species composition between the Bristol Bay region and the mine study area may be a result of differences in the relative sizes of the survey areas and differences in habitat types. The mine study area included 27 square kilometers, whereas the Bristol Bay region surveyed by USFWS covered 238 square kilometers. The mine study area contains basins bordered by small mountains at elevations generally between 90 and 365 meters. The Bristol Bay survey area is mostly outwash and flood plains between 15 and 75 meters in elevation (Platte and Butler, 1995). Within the Bristol Bay region, some species, such as scaup and scoters, are distributed evenly across the survey area while others, such as Northern Pintail, Mallard, and Green-winged Teal, occur in smaller, disjunct patches (Platte and Butler, 1995). Another reason for differences in the densities of some waterfowl may be a difference in timing of the two surveys relative to the visual presence of dabbling and diving ducks during the breeding season. Dabbling ducks arrive on the breeding grounds and nest before diving ducks. Surveys in the mine study area appeared to have occurred too late to record breeding dabbling ducks adequately because American Wigeons were the most common waterfowl brood observed during ground surveys, yet they were not detected on the waterfowl breeding-population survey in both years (see Section 16.4.7.8 for more comparisons). The waterfowl breeding-population survey was planned to occur at a similar time to the USFWS surveys in the Bristol Bay region because the mine study area is within that region, but perhaps the coastal climate of the Bristol Bay lowlands, where the USFWS surveys take place, breaks up later than the mine study area which may have more of an interior climate.

The density of nesting swans recorded in the mine study area during the waterfowl breeding-population survey was 0.6 and 0.3 swans per square kilometer in 2004 and 2005, respectively (Table 16.4-5). Similar densities were recorded by other studies on the Alaska Peninsula; however, some of those surveys were conducted more than five years earlier and densities may have changed. The Tundra Swan population in

Alaska has gradually increased since 1964 (Conant and Groves, 2005). Annual swan density was 0.3 swans per square kilometer in 1993 and 1994 when a waterfowl breeding-population survey was conducted over the entire Bristol Bay region, which included transects within the mine study area (Platte and Butler, 1995). On the lower Alaska Peninsula, Dau and Sarvis (2002) conducted surveys in 2002 and reported densities of 0.2 swans per square kilometer at Izembek and 0.3 swans per square kilometer at Pavlof. The highest densities of swans (0.3 to 0.9 swans per square kilometer) on the lower Alaska Peninsula have been reported along the Bristol Bay coast and in broad drainage basins between the Naknek and Meshik rivers (Wilk, 1988). High densities of Tundra Swans in Alaska's lowlands are associated with an abundance of shallow waterbodies (King and Hodges, 1981).

16.4.7.4 Swan Nesting Survey

Swans were common breeding birds in the mine study area. Fourteen nests were found in 2004 and 15 nests in 2005 during the various surveys for waterbirds (Figure 16.4-4). The highest concentration of nests each year (eight in 2004, seven in 2005) was found in the area surrounding the headwaters of the North Fork Koktuli River. At three nest locations in the North Fork Koktuli River, swans used the same nest mound in both years. Tundra Swans commonly return to former nest sites, or at least to the same territory, every year (Wilk, 1988; Limpert and Earnst, 1994). In each year, five nests were distributed from the headwaters of Upper Talarik Creek to the headwaters of the South Fork Koktuli River. Additional nests (one in 2004 and three in 2005) were found in the middle and lower Upper Talarik Creek drainage (Figure 16.4-4). Nests were located near ponds, lakes, and wetlands containing emergent vegetation.

Tundra Swans are one of the first birds to arrive in spring on nesting grounds in Alaska (Limpert and Earnst, 1994). On the Alaska Peninsula, nesting habitats become available much earlier than in other major nesting areas because of early snowmelt and quickly moderating spring conditions (Wilk, 1987, 1988). The first swan nests in the mine study area were recorded during the migration survey on May 14 (two nests in 2004 and five nests in 2005). The phenology of nest initiation and hatch can be highly correlated with the progression of ice and snowmelt in spring (Babcock et al., 2002). On the Yukon-Kuskokwim Delta, the median initiation date for nesting Tundra Swans from 1988 to 2000 was May 17 (Babcock et al., 2002). In southwest Alaska, hatch takes place during the first half of June following a 30-day incubation period (Wilk, 1988).

Specific aerial surveys to identify and enumerate swan broods were not conducted in the mine study area in 2004 or 2005; however, swan broods were recorded during ground surveys for waterfowl broods and during fall-migration aerial surveys. During waterbird brood-rearing surveys in 2004, three broods of Tundra Swans were recorded at three locations in the mine study area: Frying Pan Lake (three young), Big Wiggly Lake (four young), and a large lake approximately 2 kilometers north-northeast of Frying Pan Lake (three young). During fall migration surveys in 2004, no more than three swan broods were counted on any survey. In 2005, one Tundra Swan brood (four young) was seen during brood-rearing surveys in a large lake approximately 2 kilometers north-northeast of Frying Pan Lake, and two broods were seen during a fall migration survey in early October in the North Fork Koktuli River drainage. Productivity surveys conducted on September 27 through 28, 2006, found one brood (two adults and four young) in the study area. Swan broods remained in the mine study area into mid-October in 2004 and 2005. Swans were observed on the Naknek River, south of the mine study area, until October 20, 1993, which was a week before ponds and riverbanks began freezing (Scharf, 1993). Swan departure dates can vary annually depending on the time of freeze-up.

The mine study area is on the eastern edge of the breeding range for Tundra Swans and the western edge for Trumpeter Swans. Population surveys for Tundra Swans have been conducted on the Alaska Peninsula south of Iliamna Lake between the Naknek River and Port Moller (Wilk, 1984; Doster, 2002), and surveys for Trumpeter Swans have occurred along western Cook Inlet from the Susitna River to Iniskin Bay (Conant et al., 2001). During aerial surveys in the mine study area in 2004 and 2005, researchers could not differentiate swan species (i.e., Trumpeter or Tundra); however, researchers were able to get close enough to some swans during ground surveys to identify them as Tundra Swans by sight or vocalization. No swans seen at close range during ground surveys were identified as Trumpeter Swans. The habitats of the mine study area (tundra with little relief, wet meadows, and numerous shallow lakes with littoral, emergent vegetation) are typical of Tundra Swan nesting habitats (Wilk, 1988). In late September 2006, researchers searched the study area for swans and, when swans were found, circled them in a helicopter or landed to identify the swans to species. All 27 adult swans encountered in the study area were identified as Tundra Swans.

During a faunal inventory of birds in the Iliamna Lake area in May through June 1958 and June 1959, researchers reported seeing a few swans in flight and identified them as Tundra Swans based on size alone, but the researchers recognized that both species could occur in the area (Williamson and Peyton, 1962). In June 2003, a University of Alaska class spent a week conducting field work near Iliamna Village. They identified a Trumpeter Swan pair and young at Pike Lake near the Iliamna airport and other pairs at lakes west of there. Both Trumpeter and Tundra swan populations have increased substantially since 1965 (Conant and Groves, 2005) to the point that their nesting ranges overlap in some areas (Bryant et al., 2005). In northwestern interior Alaska, recent studies have found sympatric nesting of Trumpeter and Tundra swans (Bryant et al., 2005). Both swan species used similar nesting habitats except that Trumpeter Swans preferred lakes with peninsulas and islands, while Tundra Swans preferred round or oval lakes (Bryant et al., 2005). The mine and transportation-corridor study areas may be in areas of nesting-range overlap between Trumpeter and Tundra swans. Trumpeter and Tundra swans are known to hybridize in captivity and may also hybridize in the wild (King, pers. comm., 2004).

16.4.7.5 Harlequin Duck Pre-nesting and Brood-rearing Surveys

Harlequin Ducks were found in three of four major drainages in the mine study area during pre-nesting and brood-rearing surveys in 2004 and 2005 (Figures 16.4-5 and 16.4-7). Fifty-nine Harlequin Ducks were observed on 134.3 kilometers of river (0.4 ducks per kilometer) in 2004 (Table 16.4-6). In the first pre-nesting survey in 2005, researchers counted 68 ducks on 148.0 kilometers of river (0.5 ducks per kilometer); 20 ducks (0.1 ducks per kilometer) were counted on the second survey (Table 16.4-7). Most Harlequin Ducks were found in pairs during all three surveys (71 percent in 2004; and 85 and 70 percent, respectively, during the two 2005 surveys).

In both years, close to half of Harlequin Duck pairs and total adults counted during pre-nesting occurred in the upper section of Upper Talarik Creek (Figures 16.4-5 and 16.4-6; Tables 16.4-6 and 16.4-7). Eleven pairs of Harlequin Ducks were counted on the Upper Talarik Creek in 2004 and 18 pairs in the first survey in 2005. In 2004, more Harlequin Ducks were found on the North Fork Koktuli River (six pairs, four males, and two females) than on the South Fork (four pairs and four males), while in the first survey in 2005, more Harlequin Ducks were seen on the South Fork (10 pairs) than on the North Fork (one pair and five males). Six of the 10 Harlequin Duck pairs on the South Fork in 2005 were in two drainages of Kaskanak Mountain, tributaries of the South Fork. The North Fork Koktuli River had more pairs counted on the second pre-nesting survey in 2005 (four pairs) than on the first survey (one pair). No Harlequin Ducks were found on the South Fork Koktuli River in the second pre-nesting survey of 2005. Researchers found no Harlequin Ducks on Lower Talarik Creek in 2004 and 2005.

Researchers visited 117.2 kilometers of the Upper Talarik Creek and Koktuli River drainages in 2004 during waterbird brood-rearing surveys in mid-July and again in early August. No Harlequin Duck broods were observed on either survey (Figure 16.4-5; Table 16.4-6). The scheduling of the brood-rearing surveys for 2005 was adjusted to differ from the 2004 dates (Table 16.4-1) because the mid-July survey conducted in 2004 was determined to be too early for detecting brood-rearing Harlequin Ducks. The reason for the absence of ducks on the early August survey in 2004 is unknown. Fisheries crews working in both drainages in 2004 verified breeding: single females and a brood were seen in Upper Talarik Creek and a brood was seen on the North Fork Koktuli River (Lawrence, pers. comm., 2004).

In 2005, Harlequin Duck broods were observed on Upper Talarik Creek and on both forks of the Koktuli River (Figure 16.4-7). Researchers counted 82 ducks on 155.5 kilometers of river (0.5 ducks per kilometer) on the first brood-rearing survey and 88 ducks (0.6 ducks per kilometer) on the second survey (Tables 16.4-7). A similar number of broods, females, and young were seen on both brood-rearing surveys, but the distribution and number per drainage differed slightly between surveys (Table 16.4-7). On the first survey, 14 broods, which consisted of 16 females and 60 young (mean brood size = 4.3 young per brood), were observed; 6 additional females were seen without young on that survey. On the second survey, 15 broods (17 females with 58 young; mean brood size = 3.9 young per brood) were observed; 13 additional females were seen without young. The highest numbers of broods recorded by drainage for the two brood-rearing surveys were seven broods each on Upper Talarik Creek and the North Fork Koktuli River and three broods on the South Fork Koktuli River. A total of 71 young were counted in these 17 broods. No broods were seen on Lower Talarik Creek. The distribution of broods on Upper Talarik Creek and both forks of the Koktuli River was similar to the distribution of pairs during pre-nesting (Figures 16.4-6 and 16.4-7).

Linear densities (ducks per kilometer) of pre-nesting Harlequin Ducks within the mine study area were generally lower than those reported for surveys done within the past 10 years in other areas of southwest Alaska (Morgart, 1998; MacDonald, 2003; Zwiefelhofer, 2004). Linear densities ranged from 1.5 to 2.3 ducks per kilometer in Togiak National Wildlife Refuge (MacDonald, 2003) and 1.3 to 1.7 ducks per kilometer in the Kilbuck Mountains (Morgart, 1998). The densities within the mine study area in 2004 (0.4 ducks per kilometer) and 2005 (0.5 ducks per kilometer) were similar to the density in two watersheds surveyed in Kodiak National Wildlife Refuge in 2004 (0.4 ducks per kilometer; Zwiefelhofer, 2004).

Densities of Harlequin Ducks in the mine study area in 2005 were slightly higher during brood-rearing (0.6 ducks per kilometer) than during pre-nesting (0.5 ducks per kilometer). At Togiak National Wildlife Refuge, densities of Harlequin Ducks were lower during brood-rearing (0.6 to 0.8 ducks per kilometer) than during pre-nesting (1.5 to 2.3 ducks per kilometer; MacDonald, 2003), but some broods may have been flight capable at the time of the brood surveys and, therefore, may have been missed. Mean brood size of 4.3 young per brood in the mine study area was similar to that found in recent years in other areas of southwest Alaska: 3.1 to 4.0 young per brood in Kodiak National Wildlife Refuge (Zwiefelhofer, 2004), 3.4 to 3.8 young per brood in Togiak National Wildlife Refuge (MacDonald, 2003), 4.3 young per brood in Alaska Peninsula/Becharof National Wildlife Refuge (Savage, 2000), and 4.4 young per brood in the Kuskokwim Mountains (McCaffery, 1996).

During pre-nesting surveys in the mine study area, all Harlequin Ducks were observed in swift waters of Upper Talarik Creek or of the two forks of the Koktuli River. During brood-rearing, all but four Harlequin Duck groups were found in swift water. Three brood-rearing groups were observed in placid waters of Upper Talarik Creek and the South Fork Koktuli River, and a group of three adults was seen on the North Fork Koktuli River. Fast, clear-water rivers with mid-stream islands are preferred nesting and brood-rearing habitats of Harlequin Ducks (Bengtson, 1966; Crowley, 1994; Robertson and Goudie, 1999), and that type of habitat is particularly abundant on the main fork of Upper Talarik Creek from its headwaters to a point east of Sharp Mountain. Harlequin Ducks forage entirely on animal prey, including stream invertebrates and fish roe (Bengtson, 1972; Vermeer, 1983; Fischer and Griffin, 2000). The presence of broods on Upper Talarik Creek and both the north and south forks of the Koktuli River indicate that the characteristics of these streams meet the requirements of breeding Harlequin Ducks. Harlequin Ducks are an indicator species of high-quality, productive riparian habitats (MacDonald, 2003; Zwiefelhofer, 2004).

During aerial surveys for brood-rearing Harlequin Ducks in 2005, broods of all waterfowl species were recorded for Upper Talarik Creek and the north and south forks of the Koktuli River. The results of those waterfowl species are reported on in Section 16.4.7.8.

16.4.7.6 Loon Observations during Breeding

Common, Pacific, and Red-throated loons were observed in the mine study area during spring and fall migration surveys. Red-throated Loons appeared to be migrants or uncommon breeders because they were observed only in early spring (May 3, 2005) and early fall (August 17, 2005). A pair of birds was seen on Iliamna Lake at the mouth of Upper Talarik Creek, and a pair and a flock of 11 birds were seen in the Nikabuna Lakes survey area. Red-throated Loons were considered uncommon in the Lake Clark/Iliamna Lake region during earlier avian surveys (Osgood, 1904; Racine and Young, 1978), but breeding was documented in the Iliamna area in 1959 by Williamson and Peyton (1962). Red-throated Loons are more numerous on the Alaska Peninsula south of Iliamna Lake (Cahalane, 1944; Gill et al., 1981).

Pacific Loons were uncommon breeders in the mine study area and were observed only in spring. A Pacific Loon nest was found on a small lake in the North Fork Koktuli River drainage about 5 kilometers north of Big Wiggly Lake (Figure 16.4-15). An observation of an adult on a large lake in the South Fork Koktuli River drainage occurred on a migration survey on May 21, 2005, and on the waterbird brood-rearing survey on July 11, 2005. Pacific Loons also were observed near the mouth of Lower Talarik Creek and on the Chulitna River near Nikabuna Lakes. Earlier avian surveys considered Pacific Loons to be abundant in the Lake Clark/Iliamna Lake region (Osgood, 1904; Gabrielson, 1944; Williamson and Peyton, 1962; Racine and Young, 1978), although Cahalane (1944) observed that they were absent from the interior of the Alaska Peninsula near Katmai National Monument, (now Katmai National Park and Preserve) even where suitable habitats existed. In June 2003, a University of Alaska class spent a week conducting field work near Iliamna Village and did not report any Pacific Loons (University of Alaska Museum, 2003).

Common Loons were seen in a number of large lakes in the mine study area (Figure 16.4-15) and were observed repeatedly during spring and fall migration surveys. Breeding Common Loons occupy nest lakes as soon as enough water has formed around the edge to allow them to take off and land. Common Loons were first able to occupy nest lakes in the mine study area between May 3 and 14 in 2004 and 2005, and they left the nest lakes between September 13 and 23 in 2004 and September 14 and 30 in 2005. During fall surveys, no more than seven loons were recorded on a survey.

Common Loons were found in eight survey lake groups in 2004 in the mine survey area and 13 survey lake groups in 2005 in the Nikabuna Lakes, South Talarik, and mine survey areas (Figure 16.4-15). Three lakes were confirmed as breeding areas by the presence of a nest or a brood seen on migration or brood-rearing surveys. Another three lakes were suspected to be breeding areas because of the repeated presence of loons seen during migration surveys. Of these six nest lakes, three were large lakes east of Upper Talarik Creek and the other three were large lakes west of Upper Talarik Creek (Big Wiggly Lake, a large lake southwest of Frying Pan Lake in the South Fork Koktuli River drainage, and the large lake just south of Sharp Mountain). A brood of one young was seen on Big Wiggly Lake on September 3, 2004, and a nest was found there on June 2, 2005 on the gull nesting survey (Figure 16.4-15). No brood was seen on Big Wiggly Lake in 2005. Two broods, each with one young, were observed in 2004 on two lakes in the mine study area east of Upper Talarik Creek (Figure 16.4-15). No nests or broods were found on those two lakes in 2005, but Common Loons frequently were seen there and on other nearby lakes. Common Loons occasionally were observed on a large lake in the northwest part of the survey area and on another large lake across the North Fork Koktuli River from Big Wiggly Lake.

In Alaska, the highest densities of Common Loons occur in the lake regions of Bristol Bay and the Kenai Peninsula (Groves et al., 1996). The Iliamna Lake region is located on the eastern edge of the Bristol Bay nesting grounds and has, within its mosaic of forest and tundra habitats, many lakes that can support Common Loons (Williamson and Peyton, 1962). Common Loons were not reported during some earlier avian surveys in the region (Osgood, 1904; Hurley, 1931; Cahalane, 1944), but Gabrielson (1944) observed many adults on the Kvichak River in mid-July 1940. Common Loons were classified as uncommon in Lake Clark National Park (Racine and Young, 1978) and in the Iliamna Lake area (Williamson and Peyton, 1962). Williamson and Peyton (1962) felt that Common Loons should have been more prevalent in 1958 and 1959, given the large number of apparently suitable nesting lakes with abundant fish in the Iliamna Lake area.

Pacific and Common loons differ in many of their breeding requirements, although some overlap occurs. The Common Loon prefers large, clear lakes with fish that usually have extensive complex shorelines (Barr, 1973, 1996; McIntyre and Barr, 1997). Reported territory sizes range from 0.2 to 0.8 square kilometers (Barr, 1973; Kerekes et al., 1994). Their diet is primarily live fish, and their foraging habitats are usually littoral zones with good underwater visibility within the nest lake (McIntyre and Barr, 1997). In contrast, Pacific Loons are generalists that occupy a variety of lakes ranging from shallow to relatively large, deep lakes (0.1 to 0.9 square kilometers; Russell, 2002). Their diet consists mainly of fish and aquatic invertebrates, and during the breeding season they may forage in their nest pond or on nearby lakes, rivers, and nearshore marine waters (Russell, 2002).

Lakes that meet the selection criteria for nesting Common Loons are limited in the mine study area, and the numbers of nesting Common Loons probably are limited by the number of lakes that meet the size, complexity, water-quality, prey-availability, and territorial requirements.

16.4.7.7 Gull Nesting Survey

Both Bonaparte’s and Mew gulls were seen during the gull nesting survey in 2005, but only nests of Mew Gulls were identified (Figure 16.4-8). Six nests of Mew Gulls were found in wetland areas of the South Fork Koktuli River drainage: four nests north of Frying Pan Lake and two nests approximately 2 kilometers north-northeast of Frying Pan Lake. Mew Gulls commonly are found nesting in small, loosely organized colonies when nesting in inland areas (Vermeer and Devito, 1986). During the waterbird brood-rearing survey in mid-July, young were found at the two nests approximately 2 kilometers north-northeast of Frying Pan Lake (one and two young). Another brood of Mew Gulls (two young) was found on the brood-rearing survey in the North Fork Koktuli River drainage, indicating that a Mew Gull nested in that area as well. Although no nests of Bonaparte’s Gulls were located, a brood was found near Big Wiggly Lake during the ground brood-rearing survey in 2004. Mew Gulls have strong nest-site tenacity, and Bonaparte’s Gulls are known to return to the same general area from year to year (Burger and Gochfeld, 2002; Moskoff and Bevier, 2002).

Adult Bonaparte’s and Mew gulls also were seen feeding and/or loafing on lakes during the gull nesting survey (Figure 16.4-8). Six Bonaparte’s Gulls were in a flock on Big Wiggly Lake and a single bird and a pair was seen in other areas of the North Fork Koktuli River drainage. Thirteen Mew Gulls in five groups were seen in the North Fork Koktuli River drainage, two adults were on Frying Pan Lake, and a flock of four adults was on a lake in the Upper Talarik Creek drainage.

Earlier avian surveys conducted at Iliamna Lake led researchers to suspect that Bonaparte’s Gulls were uncommon breeders, as indicated by the behavior of paired adults (Osgood, 1904; Williamson and Peyton, 1962; University of Alaska Museum, 2003) and the presence of two young learning to fly (Gabrielson, 1944). Mew Gulls were considered a common gull of the Iliamna area and were assumed to be breeding based on the presence of colonies, although no nests were found on earlier surveys (Williamson and Peyton, 1962) or in 2003 by the University of Alaska Museum group (2003). Glaucous-winged Gulls, which were only seen in the mine study area during spring migrations surveys, are known to nest in colonies on an island in Iliamna Lake (Williamson and Peyton, 1962; University of Alaska Museum, 2003).

16.4.7.8 Waterbird Brood-rearing Survey

Brood-rearing surveys for waterbirds were conducted in five different drainage regions of the mine study area (Figure 16.4-9) and encompassed 118 waterbodies in 2004 and 369 in 2005 (Table 16.4-8). The distribution of groups of brood-rearing waterbirds in the mine study area was patchy; broods were found in 33 percent of the lakes sampled in 2004 and in 26 percent in 2005. Concentrations of brood-rearing waterbirds occurred in both years in lowland lakes in the central part of the North Fork Koktuli River drainage, in upland and lowland lakes north of Frying Pan Lake in the South Fork Koktuli River drainage, in Frying Pan Lake, and in lakes in the floodplain of the lower South Fork Koktuli River drainage (Figures 16.4-16 and 16.4-17). Fewer broods were recorded in the Upper Talarik north and south drainages, probably because that area has fewer lakes than the Koktuli River drainages. However, the numbers of broods found per lake surveyed were similar for the Upper Talarik north drainage and the three Koktuli River drainage regions (approximately 0.5 broods per lake).

At least 17 species of waterbirds were recorded with broods in the mine study area (Table 16.4-8). Most broods were of duck species (75 percent in 2004 and 88 percent in 2005). Ten duck species were identified, including eight species recorded in both years. Dabbling ducks made up 71 and 75 percent of the broods in 2004 and 2005, respectively. American Wigeon and Green-winged Teal broods were common in both 2004 and 2005. Northern Pintail broods were uncommon in 2004, but abundant in 2005. One-third of the Northern Pintail broods in 2005 were seen in the lower South Fork Koktuli River drainage, an area where none were seen in 2004. Mallard and Northern Shoveler broods were the least common dabbling duck in both years. Scaup broods were the most common diving duck in both years and the third most common duck brood seen each year. All scaup broods identified to species were Greater Scaup. Fewer than five Black Scoter broods or Long-tailed Duck broods were seen in either year. A Common Goldeneye brood was seen in 2004, and a Red-breasted Merganser brood was seen in 2005. Other waterbird broods encountered during the ground brood-rearing survey included Tundra Swan, Common Loon, Semipalmated Plover, Greater Yellowlegs, Least Sandpiper, Bonaparte's Gull, and Mew Gull.

Classification of age of broods seen during the waterbird brood-rearing survey (Appendix 16.4C) allowed an estimate of the timing of nesting for some species and an evaluation of whether the breeding-population survey was timed correctly to detect most breeding ducks. Nest initiation can be calculated by back-dating (subtracting the age of young and the incubation period). The earliest nesting ducks started incubation about May 1. In both years, about two-thirds of the ducks started incubating between May 25 and June 7. Northern Pintails are the earliest nesting dabbling ducks, whereas American Wigeon, Mallard, Northern Shoveler, and Green-winged Teal begin breeding one to two weeks later. Because of their later arrival on nesting grounds, diving ducks initiate nesting later than dabbling ducks. Most (92 percent) of the diving duck broods in both years were younger than 18 days old, indicating that incubation did not commence until early June. Scaup had the youngest broods, with many being one to seven days old (suggesting nest initiation dates of June 15). Some scaup were found on nests during the brood-rearing survey.

American Wigeons were not detected on the waterfowl breeding-population survey in both years, yet they were the most common waterfowl brood observed during ground surveys. Green-winged Teal were not detected on the breeding-population survey in 2005, but they were the fourth most common brood seen on ponds during ground surveys and the most common brood seen on streams during the brood-rearing survey for Harlequin Ducks in late July. Scaup were the most abundant duck observed on the waterfowl breeding-population survey and they were the third most abundant brood seen during ground surveys. The waterfowl breeding-population surveys appear to have occurred too late to record breeding dabbling ducks adequately, but were timed correctly to record breeding diving ducks. The waterfowl breeding-population survey was planned to occur at a similar time to the USFWS surveys in the Bristol Bay region because the mine study area is within that region, but perhaps the coastal climate of the Bristol Bay lowlands, where the USFWS surveys take place, breaks up later than the mine study area which may have more of an interior climate.

During aerial surveys for brood-rearing Harlequin Ducks in 2005, broods of all waterfowl species were recorded for Upper Talarik Creek and the north and south forks of the Koktuli River. Broods of nine species of ducks were seen on the rivers: five dabbling duck species and four diving duck species (Table 16.4-9). During the first Harlequin Duck survey that occurred in late July, dabbling ducks constituted 75 percent of 61 duck broods recorded. Green-winged Teal was the most common species, followed by Mallard, American Wigeon, Northern Pintail, and Northern Shoveler. By the second Harlequin Duck survey in mid-August, only five dabbling duck broods were seen, indicating that most dabbler young probably were capable of flight by that time. The numbers of diving duck broods seen on the first and second surveys were similar, 15 and 17 broods, respectively. Red-breasted Merganser broods were the most common diving duck brood on both surveys, followed by Common Merganser, unidentified scaup, and unidentified goldeneye. For both surveys, Upper Talarik Creek supported the most broods, followed by the South Fork Koktuli River and the North Fork Koktuli River. Red-breasted Merganser was the most common duck observed on rivers during brood-rearing surveys for Harlequin Ducks in the Kilbuck Mountains and in Togiak National Wildlife Refuge (Morgart, 1998; MacDonald, 2003).

16.4.7.9 Waterbird Molting Survey

During molting surveys in 2005, 13 species of waterbirds were found in the mine study area. On July 26, 264 birds were counted in 37 flocks, with only three flocks larger than 15 birds (Table 16.4-10). The greatest number of birds (451 in 53 flocks) was recorded on August 11. Only seven of those flocks contained more than 15 birds, and these larger flocks of waterfowl were found on large lakes including Big Wiggly Lake, Frying Pan Lake, and other large lakes adjacent to the north and south forks of the Koktuli River. Consequently, those areas with large lakes tended to have the highest number of birds (Figure 16.4-10).

Scaups were the most common waterfowl species seen during molting surveys (Table 16.4-10), comprising 61 percent of the birds seen on the first survey and 50 percent on the second survey. In addition, scaups composed the largest flocks of waterbirds recorded; one flock of 60 birds was seen on July 26, and two flocks—one of 35 birds and one of 45 birds—were seen on August 11. Mallard, Green-winged Teal, and mergansers were the only other waterbird species recorded in flocks more than 15 birds.

Brood-rearing groups made up 21 to 32 percent of the flocks seen during these molting aerial surveys. On July 26, 78 young in 12 broods, with three to 10 young and one female per brood, were recorded. On August 11, 11 broods were seen, with one to five females and three to 30 young per group, for a total of 20 females and 109 young.

16.4.8 Summary

Ponds, lakes, rivers, and wetlands in the mine study area supported a diverse assemblage of waterbirds in 2004 and 2005 during breeding and during spring and fall migration. Thirty-seven species were observed in the mine study area, 21 of which were recorded as breeding based on the presence of a nest or a brood. Breeding waterbirds included representatives from five taxa: swans, ducks, loons, shorebirds, and gulls.

Waterbirds used lakes and rivers for staging throughout the mine study area during spring and fall migration. In the mine survey area, swans and dabbling ducks (American Wigeon, Mallard, Northern Shoveler, Northern Pintail, Green-winged Teal) arrived in late April to early May and fed in mixed-species flocks on rivers and open water on lakes created by stream runoff. Many of these birds probably nested in the area. Diving ducks (scaups, scoters, Long-tailed Ducks, Buffleheads, goldeneyes, and mergansers) arrived in mid- to late May and staged on rivers and lakes. Some of these diving ducks probably nested in the area, while others in small flocks (approximately 60 birds) were resting and feeding on lakes before continuing their migration. During fall migration, both dabbling and diving ducks staged in flocks of 60 to 120 birds in the mine survey area, using primarily large lakes. Concentrations of birds occurred in both seasons in the northern half of the mine survey area from Frying Pan Lake north to the lakes in the North Fork Koktuli River basin. Upper Talarik Creek was the creek most heavily used by dabbling and diving ducks in the mine survey area. Some dabbling and diving ducks stayed in the mine survey area to molt during late summer.

Nikabuna and Long lakes, and the outlets of Upper and Lower Talarik creeks are important stopover sites for large flocks of waterfowl within 20 kilometers of the deposit. In the South Talarik survey area, Upper and Lower Talarik creeks and their outlets at Iliamna Lake were important staging locations for swans, ducks, and gulls during spring. Almost 200 swans were recorded at the mouth of Upper Talarik Creek in late April 2005. Lower Talarik Creek, particularly the area of lakes and wetlands near the outlet, supports large flocks of ducks, gulls, and terns during both spring and fall. Nikabuna and Long lakes (in the Nikabuna Lakes survey area) were important staging areas for swans, geese, and ducks during spring and fall. In late April, hundreds of swans, Greater White-fronted and Canada geese, and dabbling and diving ducks staged at the lakes. From August to mid-October, thousands of ducks (2,000 to 5,000 birds) were counted on the lakes and hundreds of swans congregated on the lakes starting in early October.

Swans were common breeding birds in the mine study area in 2004 and 2005. Ground observations confirmed that Tundra Swans were present. About half of the 14 swan nests found in 2004 and 15 nests in 2005 were found around the lakes in the North Fork Koktuli River drainage. Many swans returned to the same territories in 2005 and some to the same nest sites used in 2004.

Harlequin Ducks also were common breeding birds in the mine study area in 2004 and 2005. Fifty-nine Harlequin Ducks were counted in 2004 during pre-nesting surveys in the mine study area, and 68 and 20 were counted in 2005 on the first and second surveys, respectively. Harlequin Ducks were most numerous on Upper Talarik Creek during pre-nesting in both years, followed by the North Fork Koktuli River in 2004 and the South Fork in 2005. In 2005, broods were most common on Upper Talarik Creek and the North Fork Koktuli River, but also occurred on the South Fork Koktuli River. The highest numbers of broods recorded by drainage for the two brood-rearing surveys in 2005 were seven broods each on Upper Talarik Creek and the North Fork Koktuli River and three broods on the South Fork Koktuli River. A total of 71 young were counted in these 17 broods.

Common Loons nested in the mine study area in 2004 and 2005 on Big Wiggly Lake and in 2004 on two lakes east of Upper Talarik Creek. Another three lakes were suspected to be breeding areas because of the repeated presence of Common Loons. One Pacific Loon nest was found in the northern part of the North Fork Koktuli River drainage in 2005.

A survey for nesting gulls in 2005 found two small colonies of Mew Gulls. One colony of two nests and another of four nests were found north of Frying Pan Lake. Two broods were found at the colony of two nests, while the other colony was not surveyed for broods during ground surveys. Another Mew Gull brood was found in the North Fork Koktuli River drainage. Bonaparte’s Gulls were seen during the gull survey in 2005, but no nests were found. A Bonaparte’s Gull brood was seen near Big Wiggly Lake in 2004.

Eighteen species of waterbird broods were recorded in the mine study area during ground and aerial surveys in 2004 and 2005. Brood-rearing groups were found on 33 percent of the lakes sampled in 2004 (69 broods) and 26 percent in 2005 (168 broods). In 2004, 75 percent of 69 broods were ducks and, in 2005, 88 percent of 168 broods were ducks. American Wigeon, Northern Pintail, and scaup were the most common broods seen on lakes, while Red-breasted Merganser, Green-winged Teal, and Mallard broods were more common on rivers. Brood distribution was patchy, with most broods found in lowland lakes in the central part of the North Fork Koktuli River drainage, in upland and lowland lakes north of Frying Pan Lake in the South Fork Koktuli River drainage, in Frying Pan Lake, and in lakes in the floodplain of the lower South Fork Koktuli River drainage.

During the summer molting period, small flocks of ducks and numerous brood-rearing groups were present in the mine study area. Scaup were the most common duck, in flocks of 35 to 60 birds, and were found on Big Wiggly Lake, Frying Pan Lake, and other large lakes adjacent to the north and south forks of Koktuli River. Brood-rearing groups made up 21 to 32 percent of the flocks seen during the two surveys conducted.

16.4.9 References

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16.4.10 Glossary

Disjunct—of a population of a species, widely separated geographically or ecologically from other populations of the same species.

Graminoid—the technical name for grasses, which includes the "true grasses" of the Poaceae (or Gramineae) family, sedges (Cyperaceae), and rushes (Juncaceae).

Littoral—the region of the shore of a lake or sea or ocean.

Phenology—the study of the seasonal timing of life cycle events (changes in plants and animals).

Sympatric—describing different species or populations that live in the same geographical area.

Taxa—a taxonomic category or group, such as a phylum, order, family, genus or species.

TABLES

TABLE 16.4-1
Waterbird Surveys Conducted in the Mine Study Area, 2004 and 2005

Year/ Survey Type	Target Species	Purpose	Survey Date	Aircraft	Altitude (meters)	Method
2004						
Aerial	Waterfowl	Spring Migration	Apr 21	C206	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 4	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 14	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 23	Cub	60	Lake-to-Lake
Aerial	Harlequin Duck	Pre-nesting	May 25	H500	45	Stream
Aerial	Waterfowl	Breeding	Jun 2	C206	45	Transect
Aerial	Swans	Nesting	Jun 3	C206	150	Transect
Ground	Waterfowl	Brood-rearing	Jul 9-13	—	—	Lake-to-Lake
Aerial	Harlequin Duck	Brood-rearing	Jul 12	Astar	45	Stream
Aerial	Harlequin Duck	Brood-rearing	Aug 2	H500	45	Stream
Aerial	Waterfowl	Fall Migration	Sep 2	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 13	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 23	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Oct 7	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Oct 21	Cub	60	Lake-to-Lake
2005						
Aerial	Waterfowl	Spring Migration	Apr 21[a]	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	Apr 24	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 3	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 14-15	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 21-23	Cub	60	Lake-to-Lake
Aerial	Harlequin Duck	Pre-nesting	May 24	R44	45	Stream
Aerial	Waterfowl	Breeding	May 27	C206	45	Transect
Aerial	Swans	Nesting	May 28	C206	150	Transect
Aerial	Harlequin Duck	Pre-nesting	May 29	B206/R44	45	Stream
Aerial	Gulls	Nesting	Jun 2	R44	60	Lake-to-Lake
Ground	Waterfowl	Brood-rearing	Jul 8-14	—	—	Lake-to-Lake
Aerial	Waterfowl	Molting	Jul 26	Cub	60	Lake-to-Lake
Aerial	Harlequin Duck	Brood-rearing	Jul 28-29	R44	45	Stream
Aerial	Waterfowl	Molting	Aug 11	Cub	60	Lake-to-Lake
Aerial	Harlequin Duck	Brood-rearing	Aug 13-14	R44	45	Stream
Aerial	Waterfowl	Fall Migration	Aug 17-19	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Aug 27, 29	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 6, 8	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 13-14	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 30	R44	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Oct 7	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Oct 12	Cub	60	Lake-to-Lake

Notes: a. Reconnaissance survey conducted by pilot only.

TABLE 16.4-2
Status of Waterbird Species Observed during Aerial and Ground Surveys, Mine Study Area, 2004-2005

Common Name	Scientific Name	Status
Greater White-fronted Goose	*Anser albifrons*	Migrant
Canada/Cackling Goose[a]	*Branta spp.*	Migrant
Tundra Swan[b]	*Cygnus columbianus*	Confirmed Breeder
Gadwall	*Anas strepera*	Migrant
American Wigeon	*Anas americana*	Confirmed Breeder
Mallard	*Anas platyrhynchos*	Confirmed Breeder
Northern Shoveler	*Anas clypeata*	Confirmed Breeder
Northern Pintail	*Anas acuta*	Confirmed Breeder
Green-winged Teal	*Anas crecca*	Confirmed Breeder
Canvasback	*Aythya valisineria*	Migrant
Ring-necked Duck	*Aythya collaris*	Migrant
Greater Scaup[c]	*Aythya marila*	Confirmed Breeder
Harlequin Duck	*Histrionicus histrionicus*	Confirmed Breeder
Surf Scoter	*Melanitta perspicillata*	Migrant
White-winged Scoter	*Melanitta fusca*	Migrant
Black Scoter	*Melanitta nigra*	Confirmed Breeder
Long-tailed Duck	*Clangula hyemalis*	Confirmed Breeder
Bufflehead	*Bucephala albeola*	Migrant
Common Goldeneye[d]	*Bucephala clangula*	Confirmed Breeder
Hooded Merganser	*Lophodytes cucullatus*	Migrant
Common Merganser	*Mergus merganser*	Probable Breeder
Red-breasted Merganser	*Mergus serrator*	Confirmed Breeder
Red-throated Loon	*Gavia stellata*	Migrant
Pacific Loon	*Gavia pacifica*	Confirmed Breeder
Common Loon	*Gavia immer*	Confirmed Breeder
Red-necked Grebe	*Podiceps grisegena*	Migrant
Double-crested Cormorant	*Phalacrocorax auritus*	Migrant
Black-bellied Plover	*Pluvialis squatarola*	Confirmed Breeder
Semipalmated Plover	*Charadrius semipalmatus*	Confirmed Breeder
Greater Yellowlegs	*Tringa melanoleuca*	Confirmed Breeder
Whimbrel	*Numenius phaeopus*	Confirmed Breeder
Least Sandpiper	*Calidris minutilla*	Confirmed Breeder
Bonaparte's Gull	*Larus philadelphia*	Confirmed Breeder
Mew Gull	*Larus canus*	Confirmed Breeder
Glaucous-winged Gull	*Larus glaucescens*	Migrant
Arctic Tern	*Sterna paradisaea*	Migrant
Parasitic Jaeger	*Stercorarius parasiticus*	Migrant
Long-tailed Jaeger[e]	*Stercorarius longicaudus*	Probable Breeder

Notes:

a. Canada Geese (Branta canadensis) probably are the primary Branta spp. in the mine study area, but Cackling Geese (B. hutchinsii) may be present.

b. Tundra Swans were confirmed to occur in the mine study area, although Trumpeter Swans also may be present.

c. Greater Scaup were confirmed to occur in the mine study area, although Lesser Scaup also may be present.

d. Common Goldeneyes were confirmed to occur in the mine study area, although Barrow's Goldeneyes also may be present.

e. Long-tailed Jaeger not recorded on waterbirds surveys but commonly observed in June during surveys for landbirds.

TABLE 16.4-3
Numbers of Waterbirds by Species-group Observed during Spring and Fall Migration Surveys, Mine Study Area, 2004

Survey Area/ Species-Group	Spring				Fall				
	Apr 21[a]	May 4[b]	May 14	May 23	Sep 2	Sep 13	Sep 23	Oct 7	Oct 21[a]
Mine[c]									
Geese	2	0	0	0	0	0	0	0	0
Swans	2	10	11	16	25	28	16	17	5
Ducks	35	224	663	308	956	610	214	173	98
Loons	0	0	9	5	7	4	0	0	0
Grebes	0	0	0	0	2	0	0	0	0
Shorebirds	0	15	41	23	0	0	0	0	0
Gulls/Terns	0	25	46	83	0	0	0	0	0
Jaegers	0	0	0	2	0	0	0	0	0
Subtotal	**39**	**274**	**770**	**437**	**990**	**642**	**230**	**190**	**103**
South Talarik[d]									
Swans	—	2	5	1	2	2	31	44	—
Ducks	—	28	104	75	124	105	104	166	—
Loons	—	0	0	1	0	0	0	0	—
Cormorants	—	0	2	6	0	0	3	0	—
Shorebirds	—	0	23	2	0	0	0	0	—
Gulls/Terns	—	0	62	4	136	89	47	10	—
Subtotal	**—**	**30**	**196**	**89**	**262**	**196**	**185**	**220**	**—**
Nikabuna Lakes[e]									
Swans	—	—	—	—	—	—	357	2	—
Ducks	—	—	—	—	—	—	954	895	—
Subtotal	—	—	—	—	—	—	1,311	897	—
TOTAL[f]	**39**	**304**	**966**	**526**	**1,252**	**838**	**415**	**410**	**103**

Notes:

a. No survey was conducted of rivers in the South Talarik survey area.

b. A partial survey of rivers in the South Talarik survey area was flown; river outlets were not surveyed because of fog.

c. Includes lakes and rivers of the headwaters of Upper Talarik Creek and the north and south forks of the Koktuli River (Figure 16.4-2).

d. Includes the southern-most section (approximately 2.5 kilometers) of Upper Talarik Creek and all of Lower Talarik Creek (Figure 16.4-2).

e. September 23 and October 7 were reconnaissance surveys and the area surveyed covered only a part of that surveyed in 2005. Only swans and ducks were counted.

f. Includes subtotals from mine and South Talarik survey areas; subtotals from Nikabuna Lakes survey area not included.

TABLE 16.4-4
Numbers of Waterbirds by Species-group Observed during Spring and Fall Migration Surveys, Mine Study Area, 2005

	Spring					Fall						
Survey Area/ Species-Group	**Apr 21**[a]	**Apr 24**	**May 3**	**May 14-15**	**May 21-23**	**Aug 17-19**	**Aug 27, 29**	**Sep 6, 8**	**Sep 13-14**	**Sep 30**	**Oct 7**	**Oct 12**
Mine[b]												
Swans	0	4	10	15	16	36	23	22	38	27	24	16
Ducks	27	68	162	651	917	938	939	958	825	617	166	128
Loons	0	0	0	5	14	2	3	2	2	0	0	0
Grebes	0	0	0	0	0	0	0	0	1	1	1	0
Shorebirds	0	0	22	20	24	12	0	0	0	0	0	0
Gulls/Terns	0	0	34	80	104	2	0	0	0	0	0	0
Subtotal	**27**	**72**	**228**	**771**	**1,075**	**990**	**965**	**982**	**866**	**645**	**191**	**144**
South Talarik[c]												
Geese	6	0	9	0	0	0	—	—	—	—	0	0
Swans	164	6	16	13	8	38	—	—	—	—	2	14
Ducks	90	212	210	210	536	334	—	—	—	—	45	172
Loons	0	0	2	0	6	1	—	—	—	—	0	0
Cormorants	0	0	0	2	0	0	—	—	—	—	0	0
Shorebirds	0	1	14	37	18	4	—	—	—	—	0	0
Gulls/Terns	1	10	74	233	84	84	—	—	—	—	3	6
Subtotal	**261**	**229**	**325**	**495**	**652**	**461**	**—**	**—**	**—**	**—**	**50**	**192**
Nikabuna Lakes[d]												
Geese	150	376	5	116	0	20	0	6	0	0	0	0
Swans	400	165	8	6	14	40	70	17	0	6	167	333
Ducks	350	821	721	989	719	2,657	4,659	4,997	2,060	2,488	1,943	3,138
Loons	0	0	7	2	5	17	3	1	0	1	0	0
Grebes	0	0	27	3	1	0	1	0	0	0	1	0
Shorebirds	0	0	9	43	33	6	0	0	0	0	0	0
Gulls/Terns	0	8	0	9	7	0	0	0	0	0	0	3
Subtotal	**900**	**1,370**	**777**	**1,168**	**779**	**2,740**	**4,733**	**5,021**	**2,060**	**2,495**	**2,111**	**3,474**
TOTAL	**1,188**	**1,671**	**1,330**	**2,434**	**2,506**	**4,191**	**5,698**	**6,003**	**2,926**	**3,140**	**2,352**	**3,810**

Notes:

a. Reconnaissance survey conducted by pilot only.

b. Includes lakes and rivers of the headwaters of Upper Talarik Creek and the north and south forks of the Koktuli River (Figure 16.4-2).

c. Includes lakes and rivers south of Sharp Mountain (Figure 16.4-2). No surveys flown from August 27 through September 30. Only Lower Talarik Creek surveyed on October 7 and 12.

d. Includes Nikabuna and Long lakes and a section of the Chulitna River (Figure 16.4-2).

TABLE 16.4-5
Numbers and Densities of Waterfowl Observed during Breeding-population Surveys, Mine Study Area, 2004-2005

Year/ Species	Males	Pairs	Grouped Birds[a]	Indicated Total No. Birds[b]	Visibility Correction Factor[c]	Corrected Total No. Birds[d]	Density[e] (birds/ km²)	Composition (% of total)
2004								
Mallard	1	3	0	8	4.01	32	1.2	10
Northern Pintail	2	1	0	6	3.05	18	0.7	6
Green-winged Teal	1	1	0	4	8.36	33	1.2	10
Unidentified scaup[f]	7	14	54	89	1.93	172	6.3	52
Unidentified scoter	2	3	4	14	1.17	16	0.6	5
Long-tailed Duck	1	1	0	4	1.87	8	0.3	2
Unidentified goldeneye	1	6	0	14	3.61	51	1.9	15
TOTAL DUCKS						**330**	**12.2**	**100**
Unidentified swan[f]	6	5	0	16	1	16	0.6	
2005								
Gadwall	0	1	0	2	3.04	6	0.2	3
Mallard	3	3	0	12	4.01	48	1.8	26
Northern Pintail	0	3	0	6	3.05	18	0.7	10
Unidentified scaup[f]	12	7	25	51	1.93	98	3.6	53
Unidentified scoter	3	3	0	12	1.17	14	0.5	8
TOTAL DUCKS						**184**	**6.8**	**100**
Unidentified swan[f]	0	4	0	8	1	8	0.3	

Notes:

a. Grouped birds are those that occurred in flocks; no assumptions as to the number of pairs were made.

b. Indicated Total No. Birds = (number of males in groups [less than 5 birds] x 2) + (number of pairs x 2) + number of birds in groups more than 4 birds.

c. Visibility Correction Factor developed by USFWS (Conant and Groves, 2005).

d. Corrected Total No. Birds = Indicated Total No. Birds x Visibility Correction Factor.

e. Density based on corrected total number of birds in 27.2 square kilometers (km²) sample area.

f. Males and single birds not doubled in calculating indicated total number of birds.

TABLE 16.4-6
Numbers of Harlequin Ducks Observed during Pre-nesting and Brood-rearing Aerial Surveys, Mine Study Area, 2004

	Pre-nesting[a]				Brood-rearing[b]		
Location	**Single Male**	**Single Female**	**Pairs**	**Total Birds[c]**	**Females**	**Young**	**Total Birds**
North Fork Koktuli	4	2	6	18	0	0	0
South Fork Koktuli	4	0	4	12	0	0	0
Upper Talarik	7	0	11	29	0	0	0
Lower Talarik	0	0	0	0	—	—	—
TOTAL	**15**	**2**	**21**	**59**	**0**	**0**	**0**

Notes:

a. Survey was flown May 25.

b. Two surveys were flown: July 12 and August 2.

c. Total = (number of single males) + (number of single females) + (number of pairs x 2).

TABLE 16.4-7
Numbers of Harlequin Ducks Observed during Pre-nesting and Brood-rearing Aerial Surveys, Mine Study Area, 2005

	Pre-nesting				Brood-rearing			
Survey/ Location	**Single Male**	**Single Female**	**Pairs**	**Total Birds[a]**	**Females**	**Young**	**Total Birds**	**No. Broods**
First Surveyb								
North Fork Koktuli	5	0	1	7	10	20	30	5
South Fork Koktuli[c]	0	0	10	20	2	8	10	2
Upper Talarik[d]	5	0	18	41	10	32	42	7
Lower Talarik	0	0	0	0	0	0	0	0
TOTAL	**10**	**0**	**29**	**68**	**22**	**60**	**82**	**14**
Second Surveye								
North Fork Koktuli	2	0	4	10	12	31	43	7
South Fork Koktuli[c]	0	0	0	0	5	8	13	3
Upper Talarik[d]	4	0	3	10	13	19	32	5
Lower Talarik	0	0	0	0	0	0	0	0
TOTAL	**6**	**0**	**7**	**20**	**30**	**58**	**88**	**15**

Notes:

a. Total = (number of single males) + (number of single females) + (number of pairs x 2).

b. Pre-nesting survey was flown May 24 and brood-rearing survey July 28-29.

c. Includes observations from two drainages on Kaskanak Mountain that drain into the South Fork Koktuli River.

d. Includes observations from a northeastern tributary.

e. Pre-nesting survey was flown May 29 and brood-rearing survey August 13-14.

TABLE 16.4-8
Numbers of Waterbird Broods Observed on Ponds and Lakes during Ground Surveys in Drainage Basin Survey Areas, Mine Study Area, 2004-2005

Year/ Species	Drainage Basin Survey Areas					
	North Fork Koktuli	Upper South Fork Koktuli	Lower South Fork Koktuli	Upper Talarik North	Upper Talarik South	Total
2004						
Tundra Swan	1	1	0	0	0	2
American Wigeon	8	3	5	1	0	17
Mallard	0	1	0	0	0	1
Northern Shoveler	1	0	2	1	0	4
Northern Pintail	3	2	0	0	0	5
Green-winged Teal	6	3	1	0	0	10
Greater Scaup	1	0	0	0	0	1
Unidentified scaup	0	8	0	0	0	8
Black Scoter	0	3	0	0	0	3
Long-tailed Duck	1	0	0	0	0	1
Common Goldeneye	0	0	0	1	0	1
Unidentified duck	0	0	1	0	0	1
Common Loon	1	0	0	0	0	1
Semipalmated Plover	3	4	0	0	0	7
Greater Yellowlegs	1	0	3	0	1	5
Least Sandpiper	0	1	0	0	0	1
Bonaparte's Gull	1	0	0	0	0	1
TOTAL	**27**	**26**	**12**	**3**	**1**	**69**
No. lakes surveyed	57	28	13	8	12	118
2005						
Tundra Swan	0	1	0	0	0	1
American Wigeon	18	6	7	4	0	35
Mallard	3	3	2	3	0	11
Northern Shoveler	6	2	5	0	0	13
Northern Pintail	17	5	11	3	0	36
Green-winged Teal	6	5	3	1	0	15
Greater Scaup	4	2	0	3	0	9
Unidentified scaup	3	8	3	3	1	18
Black Scoter	1	0	0	0	0	1
Long-tailed Duck	2	2	1	0	0	5
Unidentified goldeneye	1	0	0	0	0	1
Red-breasted Merganser	1	0	0	0	0	1
Unidentified merganser	0	2	0	0	0	2
Unidentified duck	0	1	0	0	0	1

Year/ Species	North Fork Koktuli	Upper South Fork Koktuli	Lower South Fork Koktuli	Upper Talarik North	Upper Talarik South	Total
	Drainage Basin Survey Areas					
Semipalmated Plover	3	1	2	0	0	6
Greater Yellowlegs	6	1	0	1	0	8
Least Sandpiper	0	1	1	0	0	2
Mew Gull	1	2	0	0	0	3
TOTAL	**72**	**42**	**35**	**18**	**1**	**168**
No. lakes surveyed	159	87	67	33	23	369

TABLE 16.4-9
Numbers of Waterfowl Broods (Excluding Harlequin Ducks) Observed on Rivers during Brood-rearing Aerial Surveys for Harlequin Ducks, Mine Study Area, 2005

Survey/ Location	Unidentified Swan	American Wigeon	Mallard	Northern Shoveler	Northern Pintail	Green-winged Teal	Unidentified Scaup	Unidentified Goldeneye	Common Merganser	Red-breasted Merganser	Total
First Survey[a]											
North Fork Koktuli	0	1	4	1	1	5	0	0	1	1	14
South Fork Koktuli[b]	0	2	3	0	0	8	2	0	1	3	19
Upper Talarik[c]	0	5	7	0	1	8	0	0	1	4	26
Lower Talarik	0	0	0	0	0	0	0	0	2	0	2
TOTAL	**0**	**8**	**14**	**1**	**2**	**21**	**2**	**0**	**5**	**8**	**61**
Second Survey[d]											
North Fork Koktuli	0	0	0	0	0	1	0	0	0	3	4
South Fork Koktuli[b]	0	0	0	1	0	0	0	0	0	7	8
Upper Talarik[c]	0	0	2	0	0	1	0	1	1	5	10
Lower Talarik	1	0	0	0	0	0	0	0	0	0	1
TOTAL	**1**	**0**	**2**	**1**	**0**	**2**	**0**	**1**	**1**	**15**	**23**

Notes:

a. Survey was flown July 28-29.

b. Includes observations from two drainages on Kaskanak Mountain that drain into the South Fork Koktuli River.

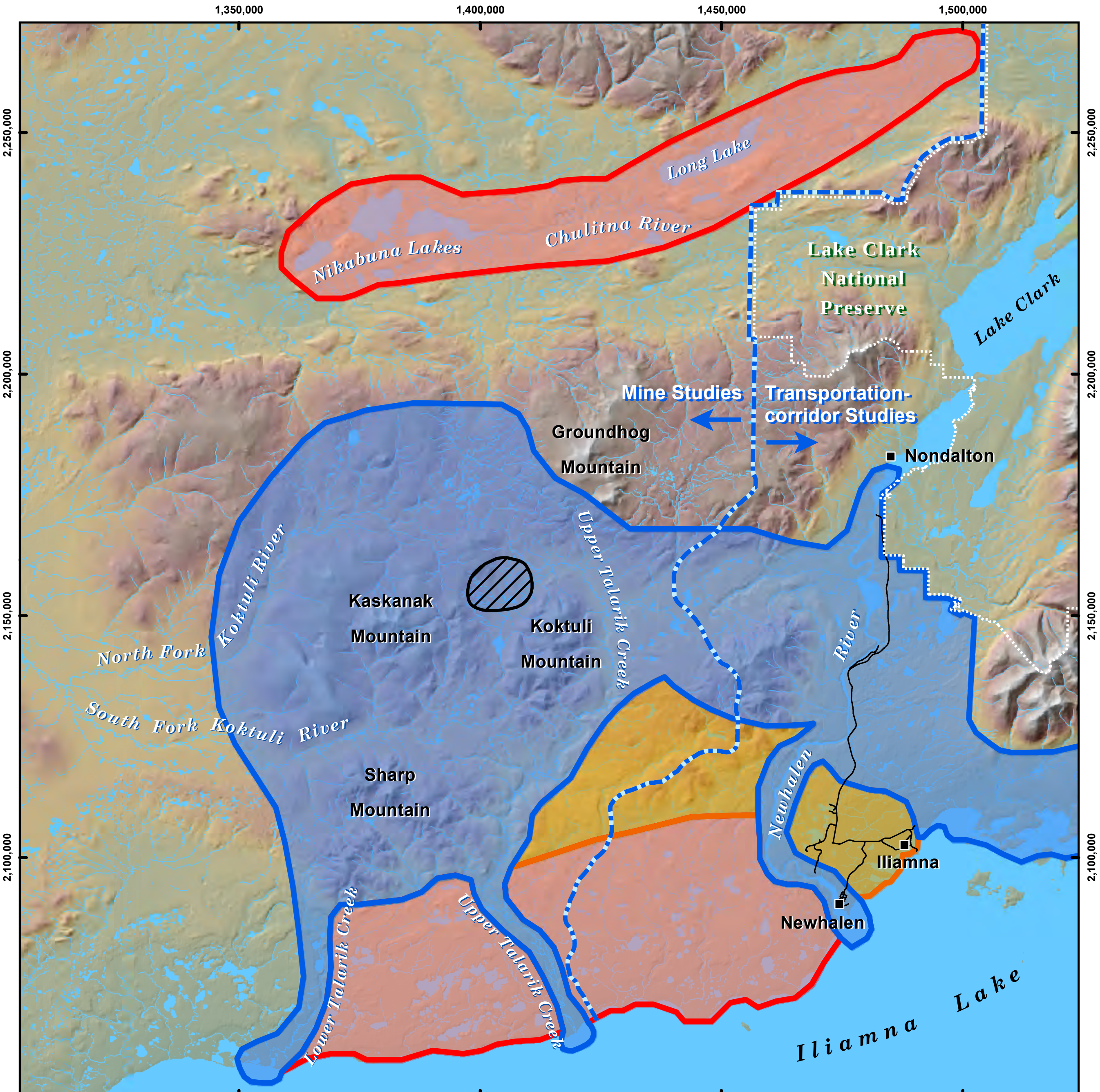
c. Includes observations from a northeastern tributary.

d. Survey was flown August 13-14.

TABLE 16.4-10
Numbers of Waterbirds Observed during Summer Molting Surveys, Mine Study Area, 2005

	Flock Size									
	1-15		16-30		31-45		46-60		Total	
Date/ Species	**No. Flocks**	**No. Birds**	**No. Flocks**	**No. Birds**	**No. Flocks**	**No. Birds**	**No. Flocks**	**No. Birds**	**No. Flocks**	**No. Birds**
July 26										
Unidentified swan	2	4	0	0	0	0	0	0	2	4
Northern Pintail	2	14	0	0	0	0	0	0	2	14
Unidentified dabbling duck	1	6	0	0	0	0	0	0	1	6
Unidentified scaup	12	85	1	16	0	0	1	60	14	161
Black Scoter	1	3	0	0	0	0	0	0	1	3
Unidentified scoter	1	10	0	0	0	0	0	0	1	10
Unidentified goldeneye	1	1	0	0	0	0	0	0	1	1
Unidentified merganser	3	8	1	18	0	0	0	0	4	26
Unidentified duck	6	33	0	0	0	0	0	0	6	33
Common Loon	2	3	0	0	0	0	0	0	2	3
Unidentified yellowlegs	1	1	0	0	0	0	0	0	1	1
Mew Gull	1	1	0	0	0	0	0	0	1	1
Arctic Tern	1	1	0	0	0	0	0	0	1	1
TOTAL	**34**	**170**	**2**	**34**	**0**	**0**	**1**	**60**	**37**	**264**
August 11										
Unidentified swan	11	23	0	0	0	0	0	0	11	23
American Wigeon	8	43	0	0	0	0	0	0	8	43
Mallard	1	5	1	25	0	0	0	0	2	30
Northern Shoveler	4	26	0	0	0	0	0	0	4	26
Northern Pintail	5	40	0	0	0	0	0	0	5	40
Green-winged Teal	2	14	1	30	0	0	0	0	3	44
Unidentified scaup	8	65	3	79	2	80	0	0	13	224
Unidentified diving duck	1	3	0	0	0	0	0	0	1	3
Unidentified duck	3	13	0	0	0	0	0	0	3	13
Common Loon	3	5	0	0	0	0	0	0	3	5
TOTAL	**46**	**237**	**5**	**134**	**2**	**80**	**0**	**0**	**53**	**451**

FIGURES



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Kilometers: 0 2 4 6 8 10 12

N

Scale1:390,000

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

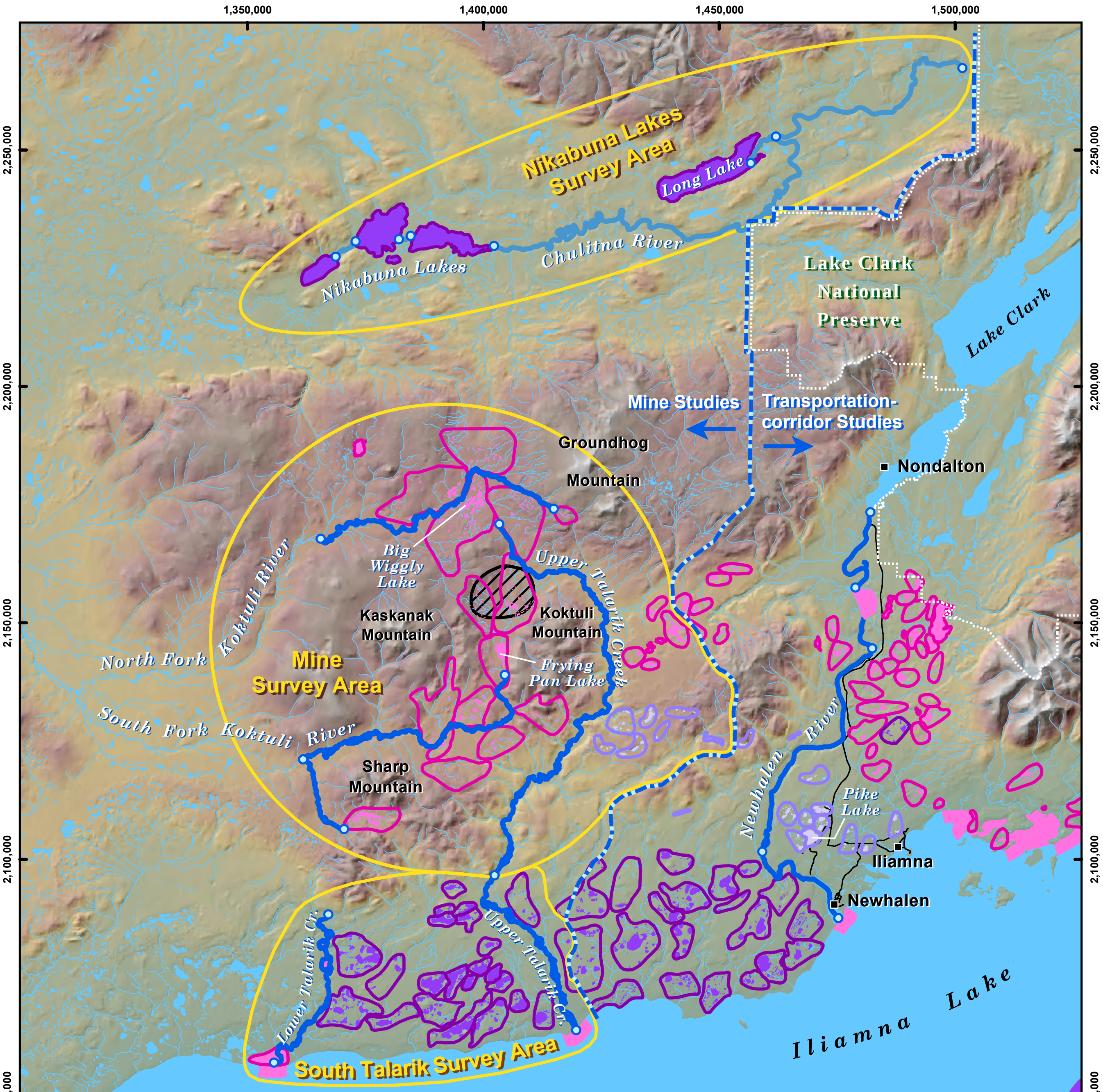
Legend

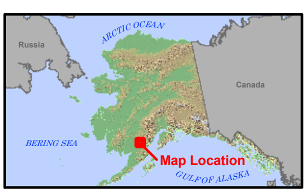
- 2004 Study Area
- 2005 Study Area
- 2004 and 2005 Study Area
- General Deposit Location
- Existing Road

THE pebble PARTNERSHIP

Figure 16.4-1
Study Area for Breeding and Staging Waterbirds, Mine Study Area, 2004 and 2005

File: 16-4-1_Waterbird_SA_Mine_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC





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Kilometers: 0 2 4 6 8 10 12

N

Scale1:400,000

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

Legend

Year Surveyed

Lake Group	Lake and Bay	River Segment
2004	2004	Segment Endpoint
2005	2005	2005
2004 & 2005	2004 & 2005	2004 & 2005

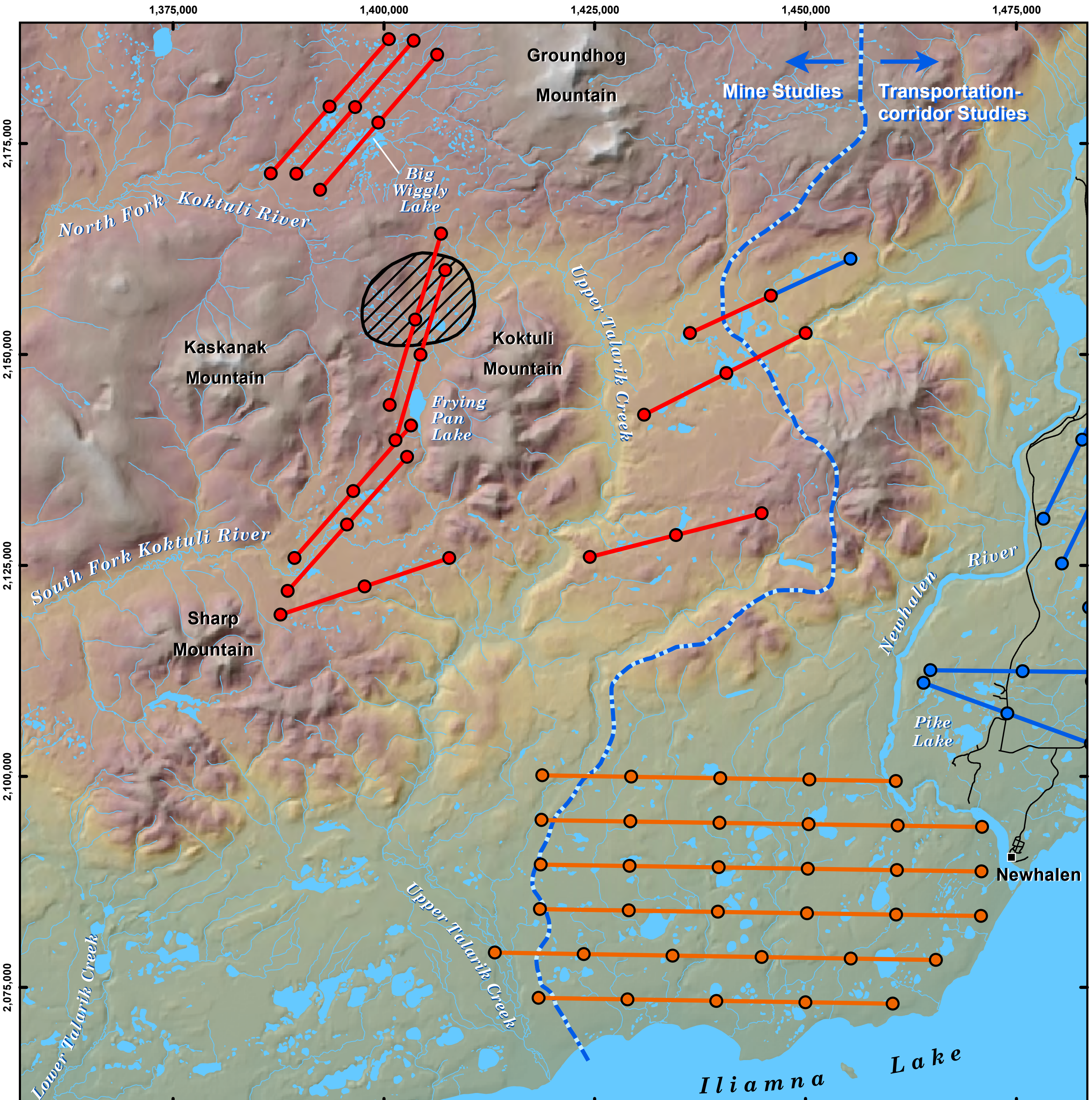
General Deposit Location

Existing Road

THE pebble PARTNERSHIP

Figure 16.4-2
Lakes, Bays, and Rivers Surveyed for Staging Waterbirds during Spring and Fall Migration, Mine Study Area, 2004 and 2005

File: 16-4-2_StagingSASprFall_Mine_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC



Miles 0 1 2 3 4 5

Kilometers 0 2 4 6 8

Scale1:225,000

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

Legend

Breeding Pair Transect

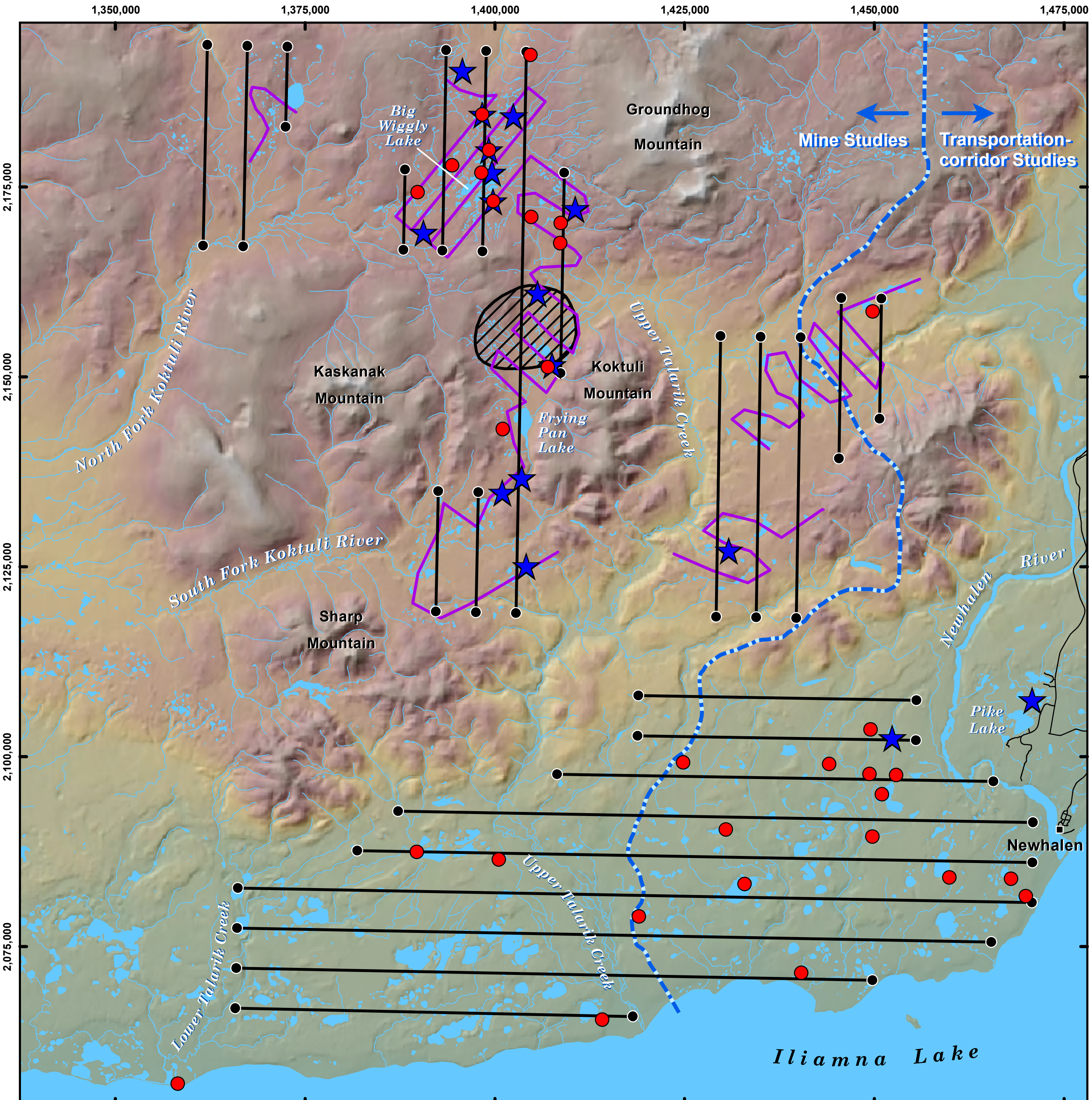
- 3.2 km — Mine Study Area, 2004 and 2005
- 3.2 km — Transportation-corridor Study Area, 2004 and 2005
- 3.2 km — Transportation-corridor Study Area, 2005 only

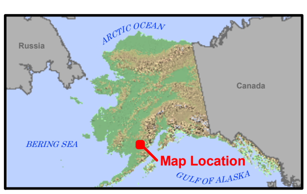
- General Deposit Location
- Existing Road

THE pebble PARTNERSHIP

Figure 16.4-3
Transects for Waterfowl Breeding-population Survey, Mine Study Area, 2004 and 2005

File: 16-4-3_BrPairTransects_Mine_PLP_EBD_v01.mxd	Date: Sept. 20, 2010
Version: 1	Author: ABR-AZC





Miles: 0 1 2 3 4 5

Kilometers: 0 2 4 6 8

Scale1:250,000

N

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

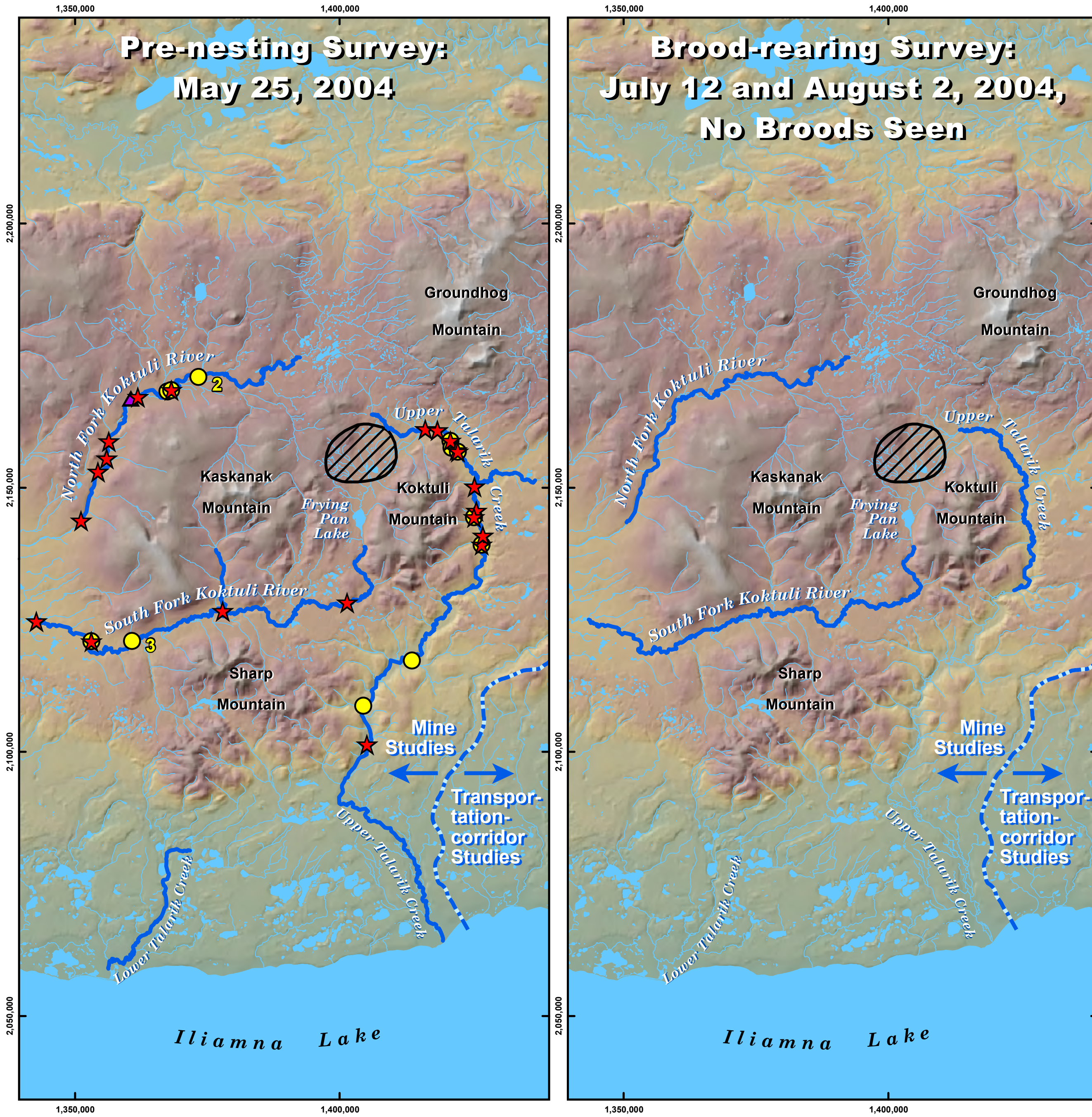
Legend

- 2004 Nest
- 2005 Nest
- 2004 Survey Transect
- 2005 Survey Transect
- General Deposit Location
- Existing Road

THE pebble PARTNERSHIP

Figure 16.4-4
Swan Nesting Locations,
Mine Study Area,
2004 and 2005

File: 16-4-4_SwanNesting_Mine_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.4-5
Harlequin Duck
Pre-nesting Locations and
Brood-rearing Survey Areas,
Mine Study Area, 2004

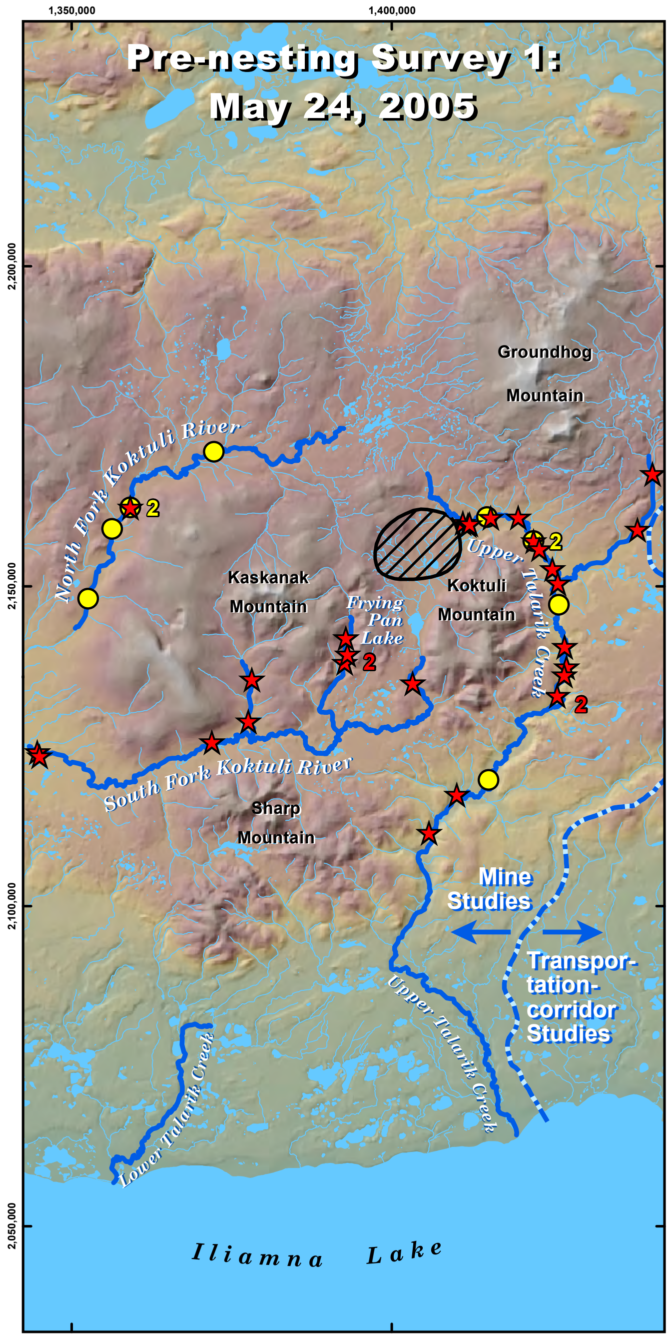
Legend

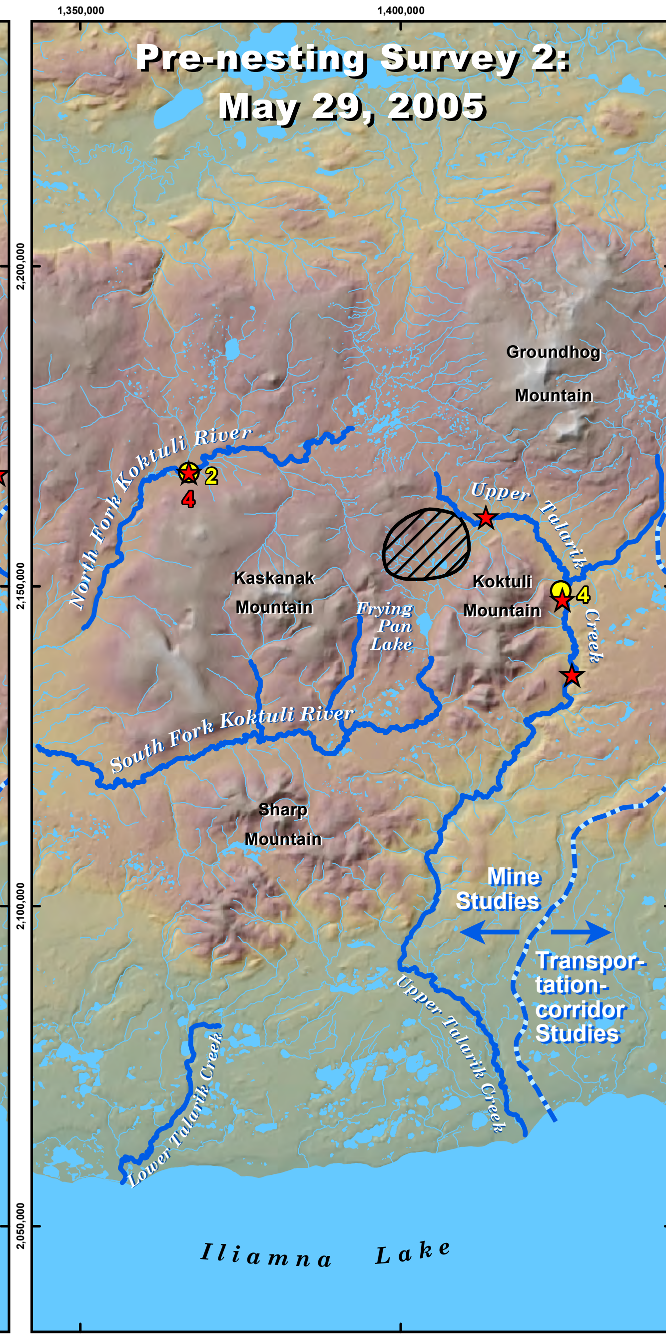
Pairs
Males (# birds >1)
Female
Survey Stream
General Deposit Location

Miles: 0 1 2 3 4 5 6 7
Kilometers: 0 2 4 6 8 10 12
N
Scale 1:360,000

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

File: 16-4-5_HADUPreNest04_Mine_PLP_EBD_v01.mxd	Date: Sept. 20, 2010
Version: 1	Author: ABR-AZC





THE pebble PARTNERSHIP

Figure 16.4-6
Harlequin Duck
Pre-nesting Locations,
Mine Study Area, 2005

Legend

- Pairs (# pairs >1)
- Males (# birds >1)
- Survey Stream
- General Deposit Location

Miles 0 1 2 3 4 5 6 7

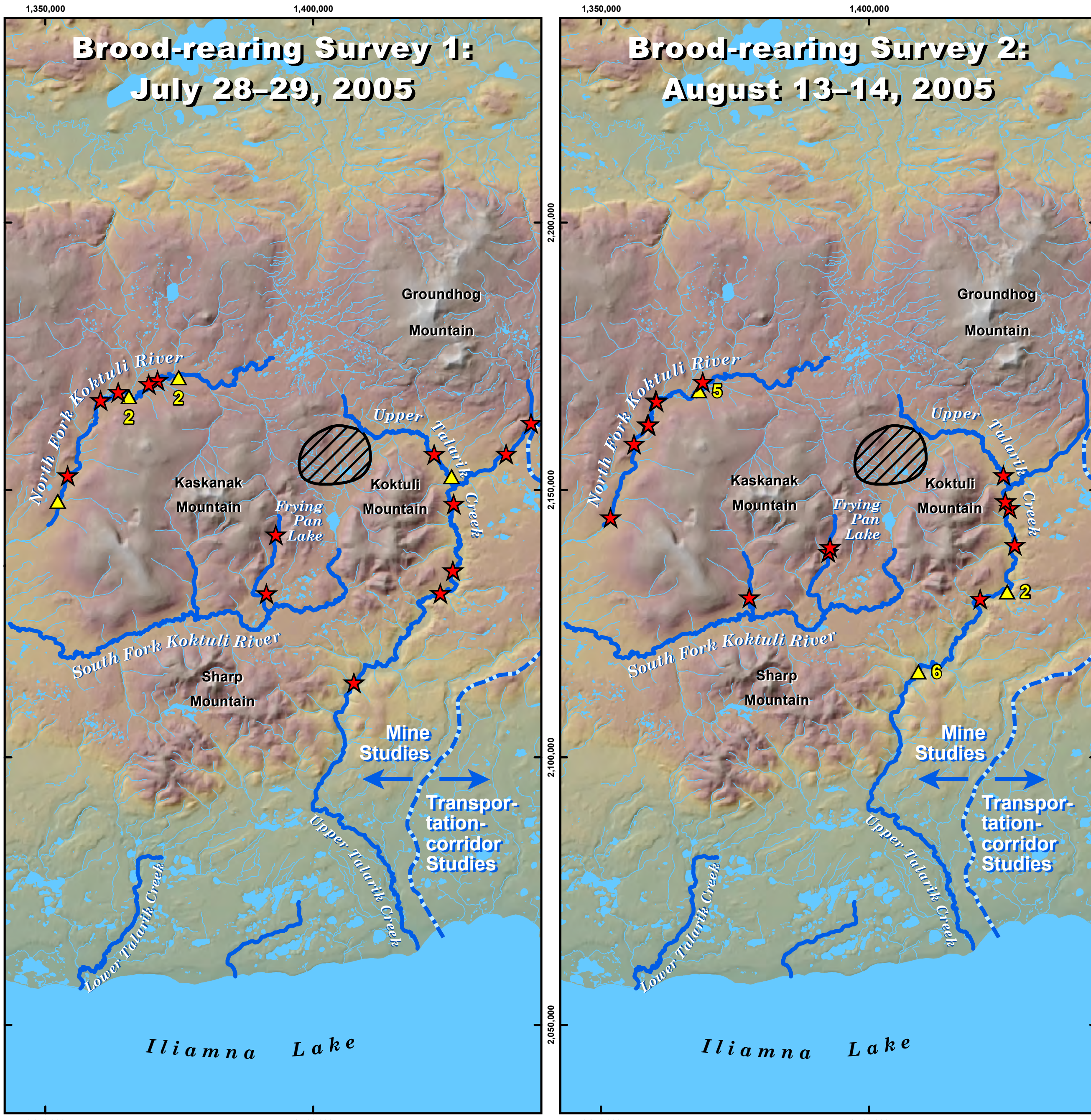
Kilometers 0 2 4 6 8 10 12

N

Scale 1:360,000

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

File: 16-4-6_HADUPreNest05_Mine_PLP_EBD_v01.mxd	Date: Sept. 21, 2010
Version: 1	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.4-7
Harlequin Duck
Brood-rearing Locations,
Mine Study Area, 2005

Legend

- Brood
- Females (# birds >1)
- Survey Stream
- General Deposit Location

Miles: 0 1 2 3 4 5 6 7

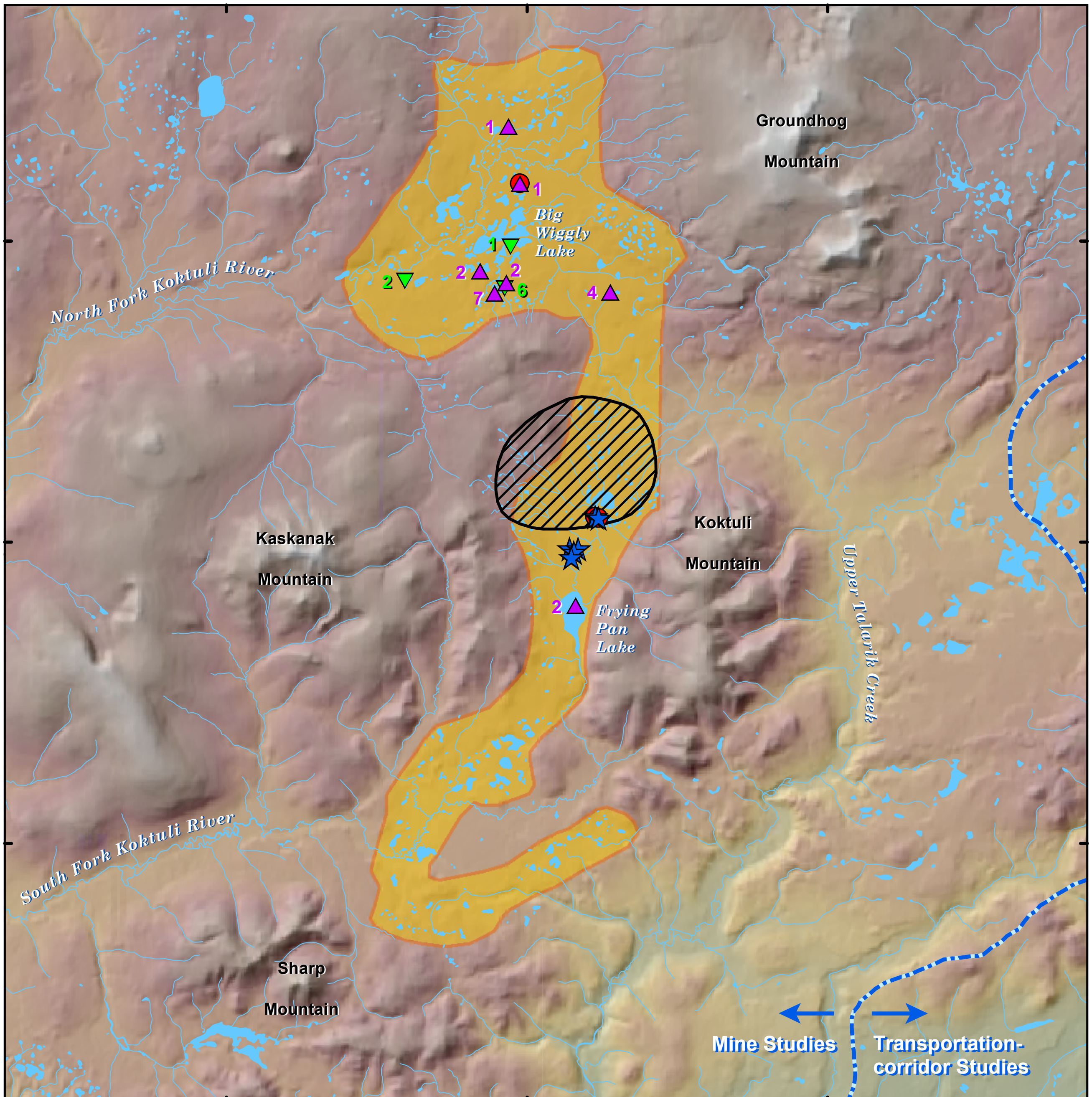
Kilometers: 0 2 4 6 8 10 12

N

Scale 1:360,000

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

File: 16-4-7_HADUBrdRear05_Mine_PLP_EBD_v01.mxd	Date: Sept. 21, 2010
Version: 1	Author: ABR-AZC



Miles: 0 1 2 3

Kilometers: 0 1 2 3 4 5

N

Scale1:160,000

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

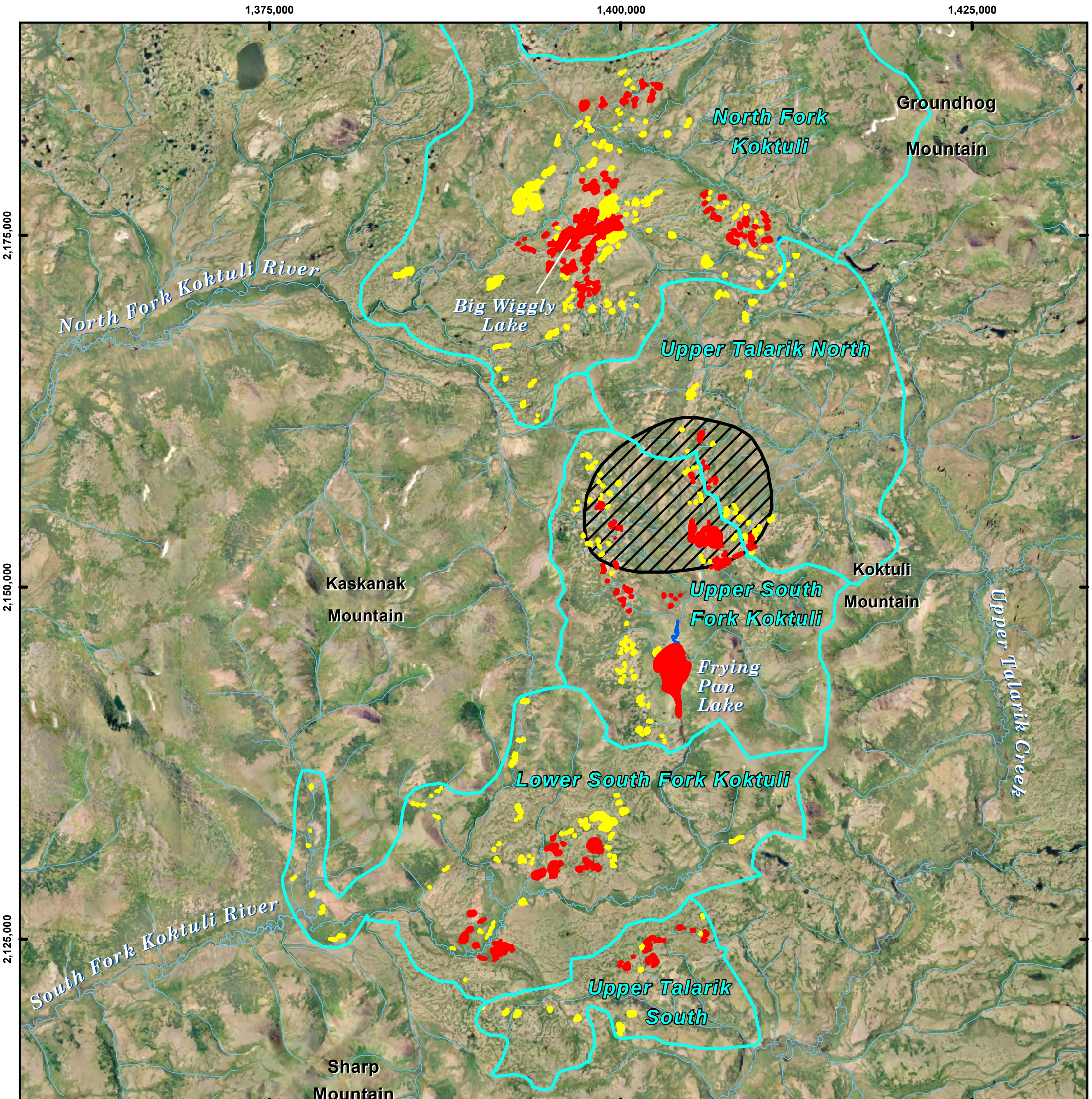
Legend

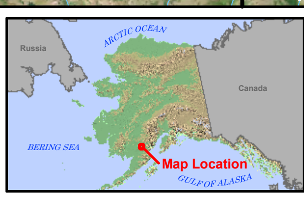
- Mew Gull Nest
- Mew Gull Brood
- Mew Gull Adults (# of birds)
- Bonaparte's Gull Adults (# of birds)
- Gull Survey Area
- General Deposit Location

THE pebble PARTNERSHIP

Figure 16.4-8
Bonaparte's and Mew Gull Locations, Mine Study Area, 2005

File: 16-4-8_GullNesting_Mine_PLP_EBD_v01.mxd	Date: Sept. 21, 2010
Version: 1	Author: ABR-AZC





N

Miles: 0 1 2 3

Kilometers: 0 1 2 3 4 5

Scale 1:135,000

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

Background imagery: color orthophotography for the Pebble mine area based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Image credit: Kodiak Mapping Inc., Eagle Mapping Ltd., Resource Data, Inc.

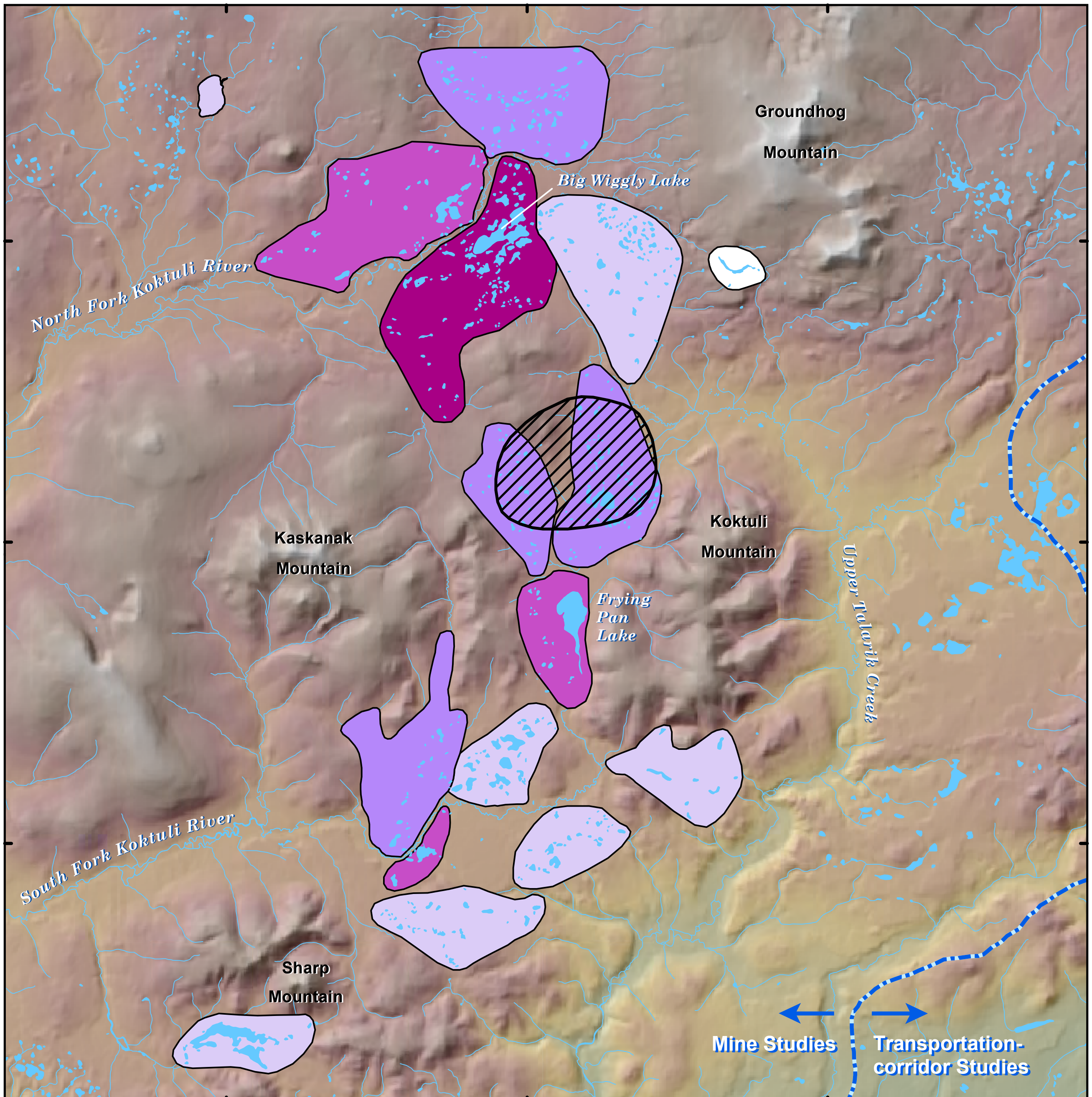
Legend

- Surveyed 2004
- Surveyed 2005
- Surveyed 2004 and 2005
- Drainage Basin Survey Area
- General Deposit Location

THE pebble PARTNERSHIP

Figure 16.4-9
Lakes Surveyed for Brood-rearing Waterbirds, Mine Study Area, 2004 and 2005

File: 16-4-9_BroodSurvLakes_Mine_PLP_EBD_v01.mxd	Date: Sept. 21, 2010
Version: 1	Author: ABR-AZC



Miles 0 1 2 3

Kilometers 0 1 2 3 4 5

Scale1:160,000

N

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

Legend

Maximal Number of Birds

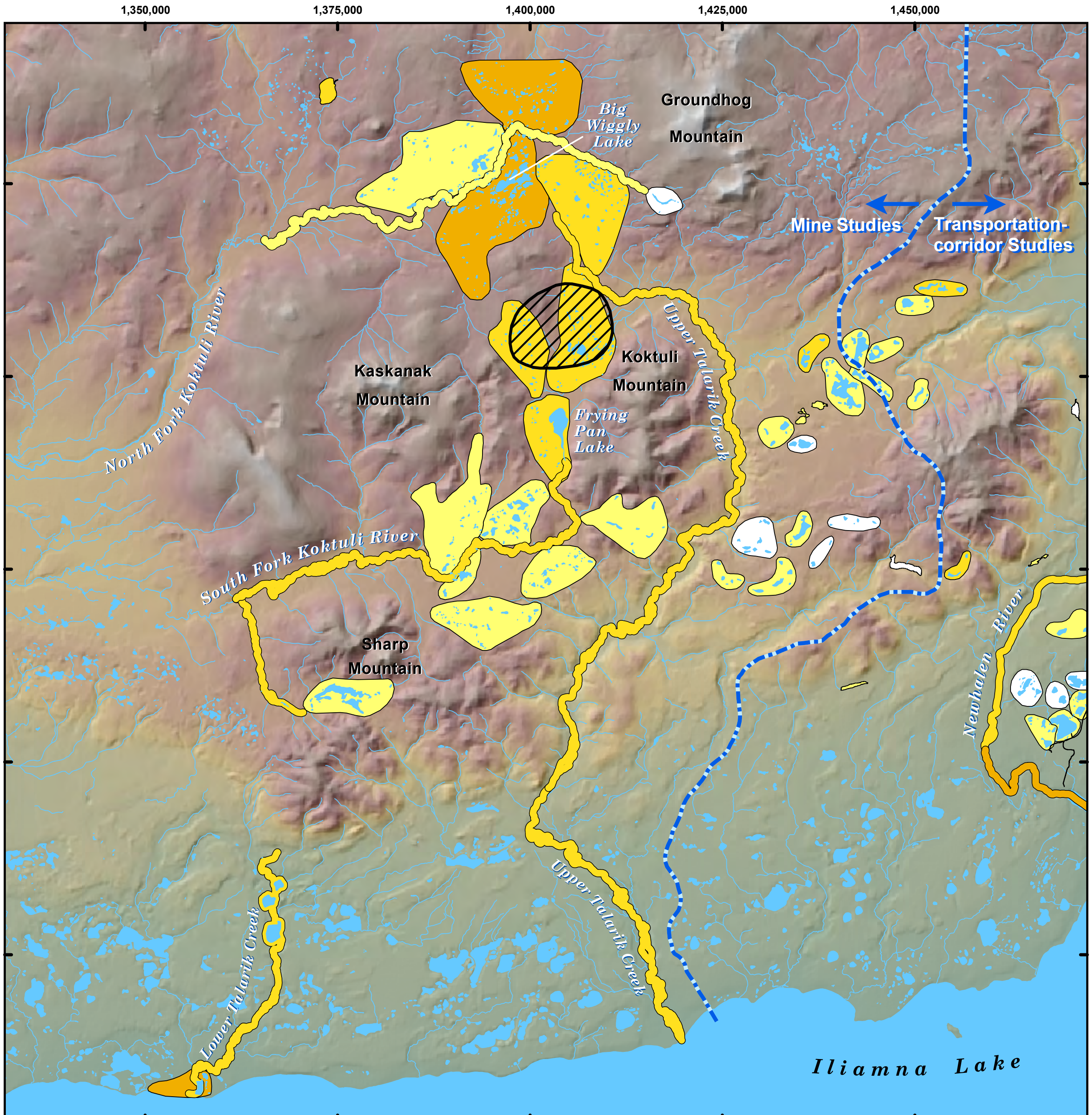
- 0
- 1 – 25
- 26 – 50
- 51 – 100
- 101 – 150

General Deposit Location

THE pebble PARTNERSHIP

Figure 16.4-10
Distribution and Abundance (Maximal Number) of Molting Waterbirds, Mine Study Area, 2005

File: 16-4-10_MoltDistSum05_Mine_PLP_EBD_v01.mxd	Date: Sept. 21, 2010
Version: 1	Author: ABR-AZC



Miles: 0 1 2 3 4 5

Kilometers: 0 2 4 6 8

Scale1:250,000

N

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

Legend

Maximal Number of Birds

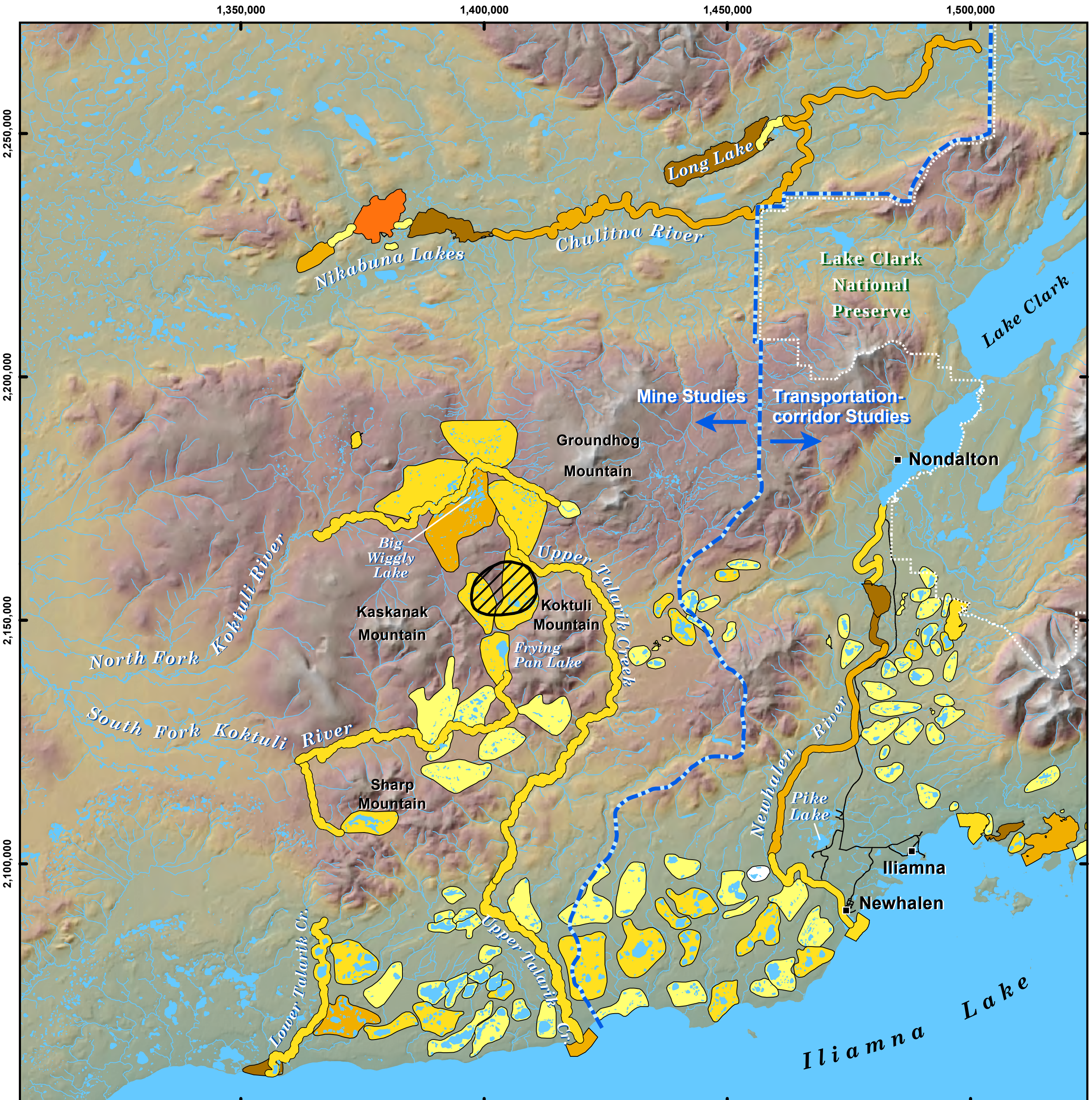
- 0
- 1 – 25
- 26 – 100
- 101 – 250

- General Deposit Location
- Existing Road

THE pebble PARTNERSHIP

Figure 16.4-11
Distribution and Abundance (Maximal Number) of Staging Waterbirds during Spring Migration, Mine Study Area, 2004

File: 16-4-11_MigrDistSpr04_Mine_PLP_EBD_v01.mxd	Date: Sept. 21, 2010
Version: 1	Author: ABR-AZC



Miles: 0 2 4 6 8

Kilometers: 0 2 4 6 8 10 12

N

Scale1:390,000

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

Legend

Maximal Number of Birds

- 0
- 1 – 25
- 26 – 100
- 101 – 250
- 251 – 500
- 501 – 1000

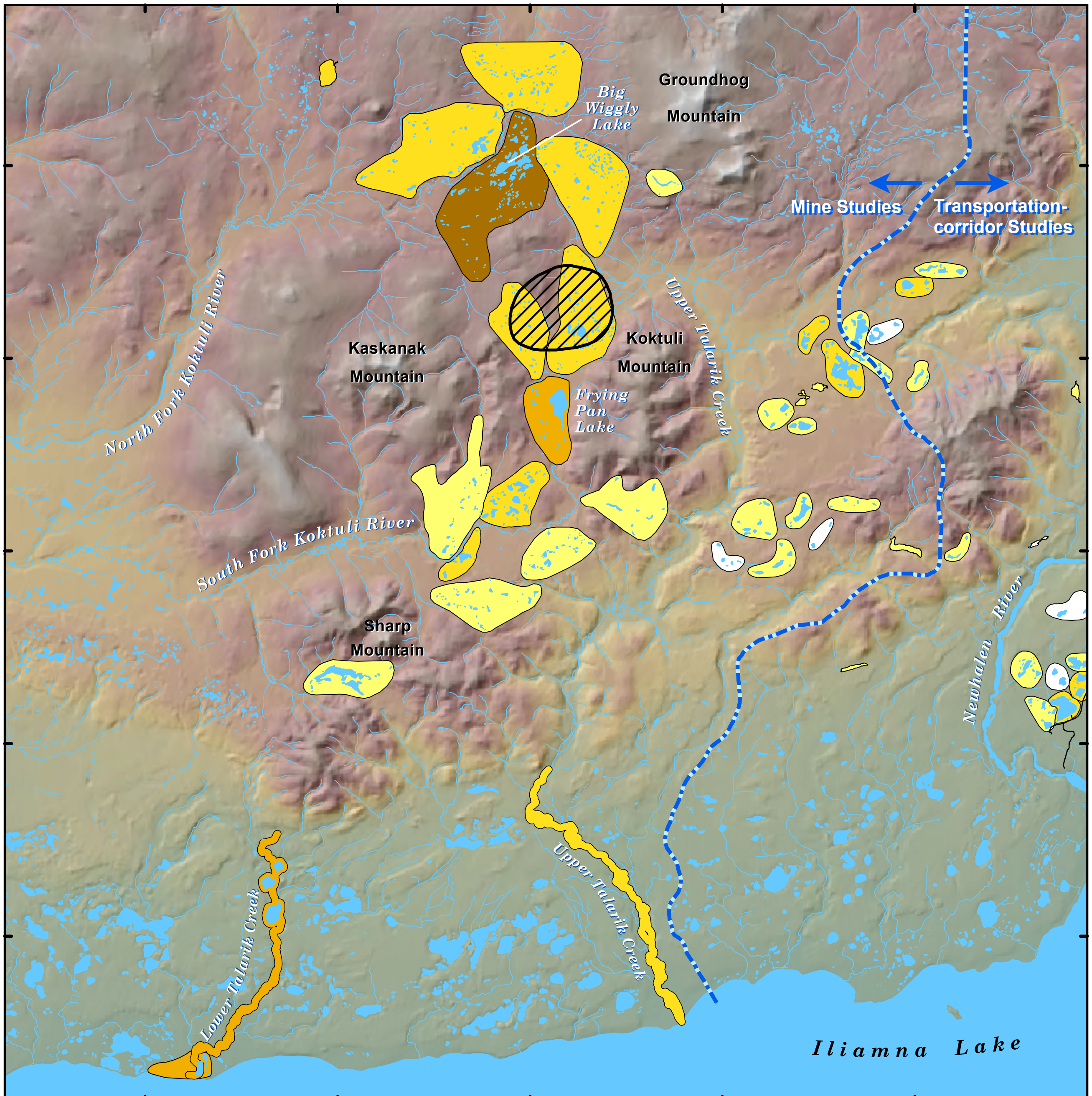
General Deposit Location

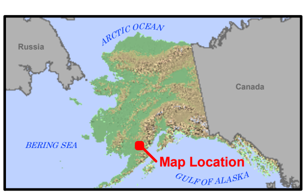
Existing Road

THE pebble PARTNERSHIP

Figure 16.4-12
Distribution and Abundance (Maximal Number) of Staging Waterbirds during Spring Migration, Mine Study Area, 2005

File:16-4-12_MigrDistSpr05_Mine_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC





Miles 0 1 2 3 4 5

Kilometers 0 2 4 6 8

Scale1:250,000

N

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

Legend

Maximal Number of Birds

- 0
- 1 – 25
- 26 – 100
- 101 – 250
- 251 – 500

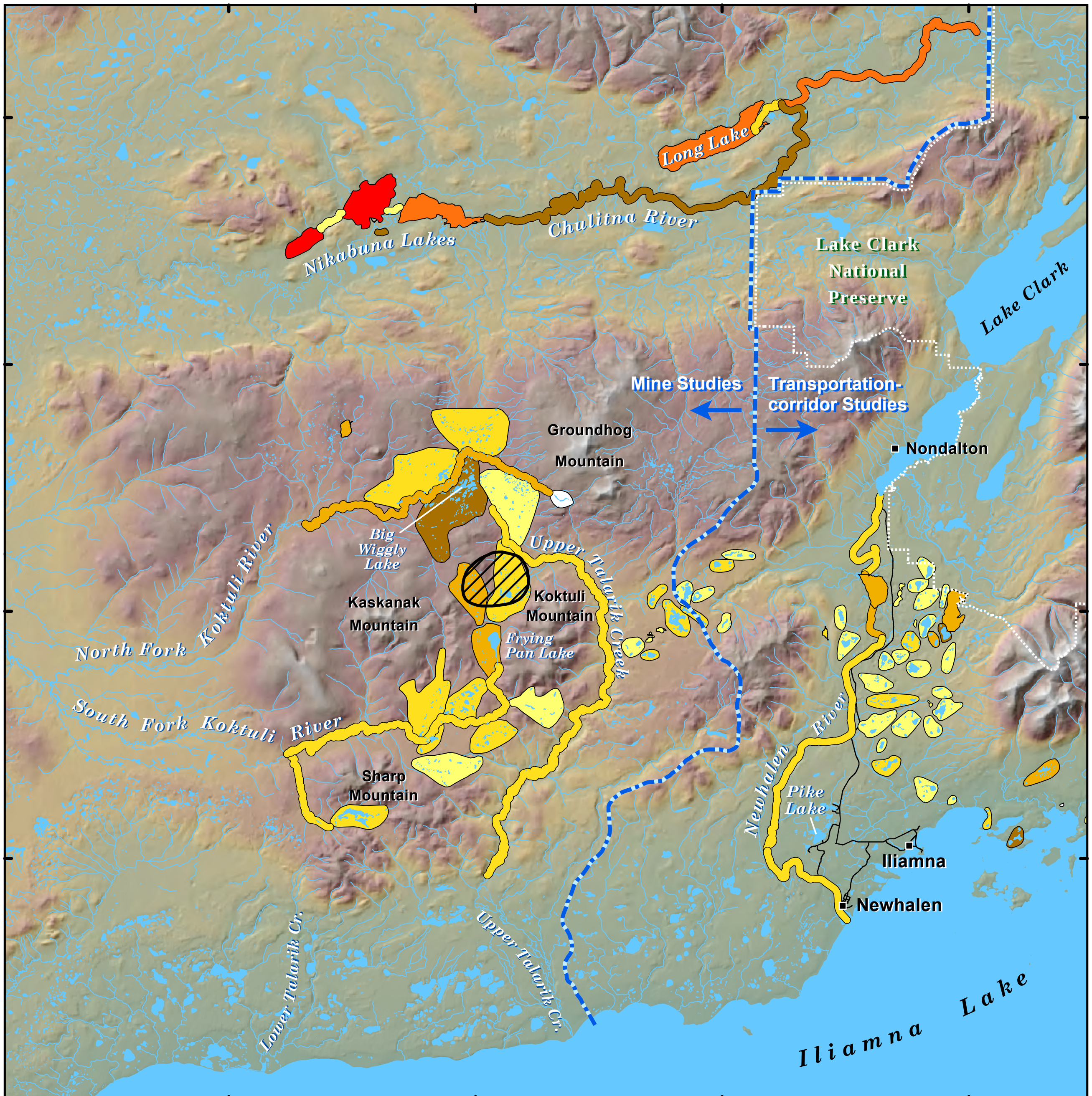
General Deposit Location

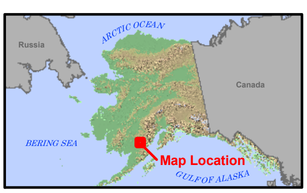
Existing Road

THE pebble PARTNERSHIP

Figure 16.4-13
Distribution and Abundance (Maximal Number) of Staging Waterbirds during Fall Migration, Mine Study Area, 2004

File: 16-4-13_MigrDistFall04_Mine_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC





Miles: 0 2 4 6 8

Kilometers: 0 2 4 6 8 10 12

N

Scale1:390,000

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

Legend

Maximal Number of Birds

- 0
- 1 – 25
- 26 – 100
- 101 – 250
- 251 – 500
- 501 – 1000
- 1001 – 2000

General Deposit Location

Existing Road

THE pebble PARTNERSHIP

Figure 16.4-14
Distribution and Abundance (Maximal Number) of Staging Waterbirds during Fall Migration, Mine Study Area, 2005

File: 16-4-14_MigrDistFall05_Mine_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC

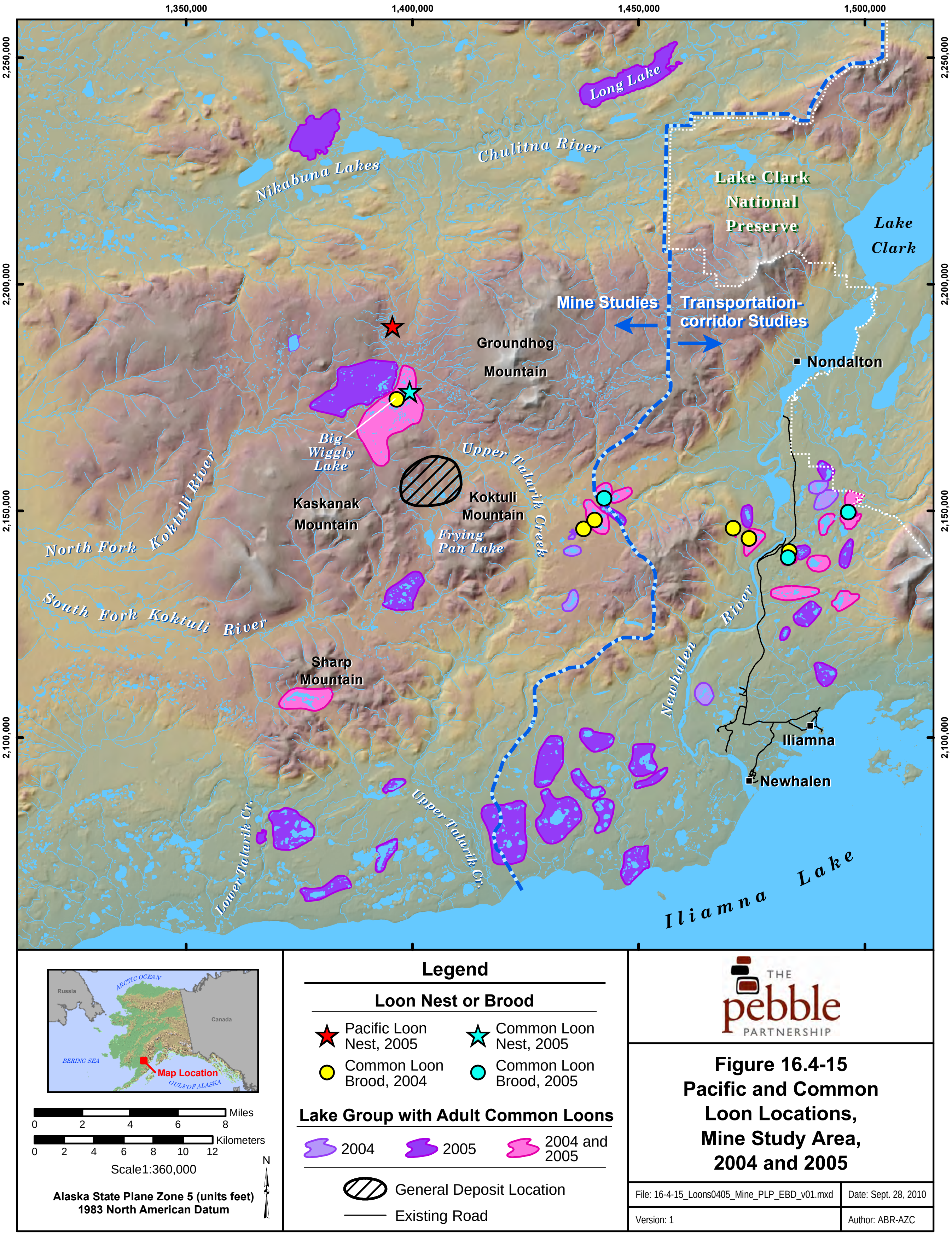
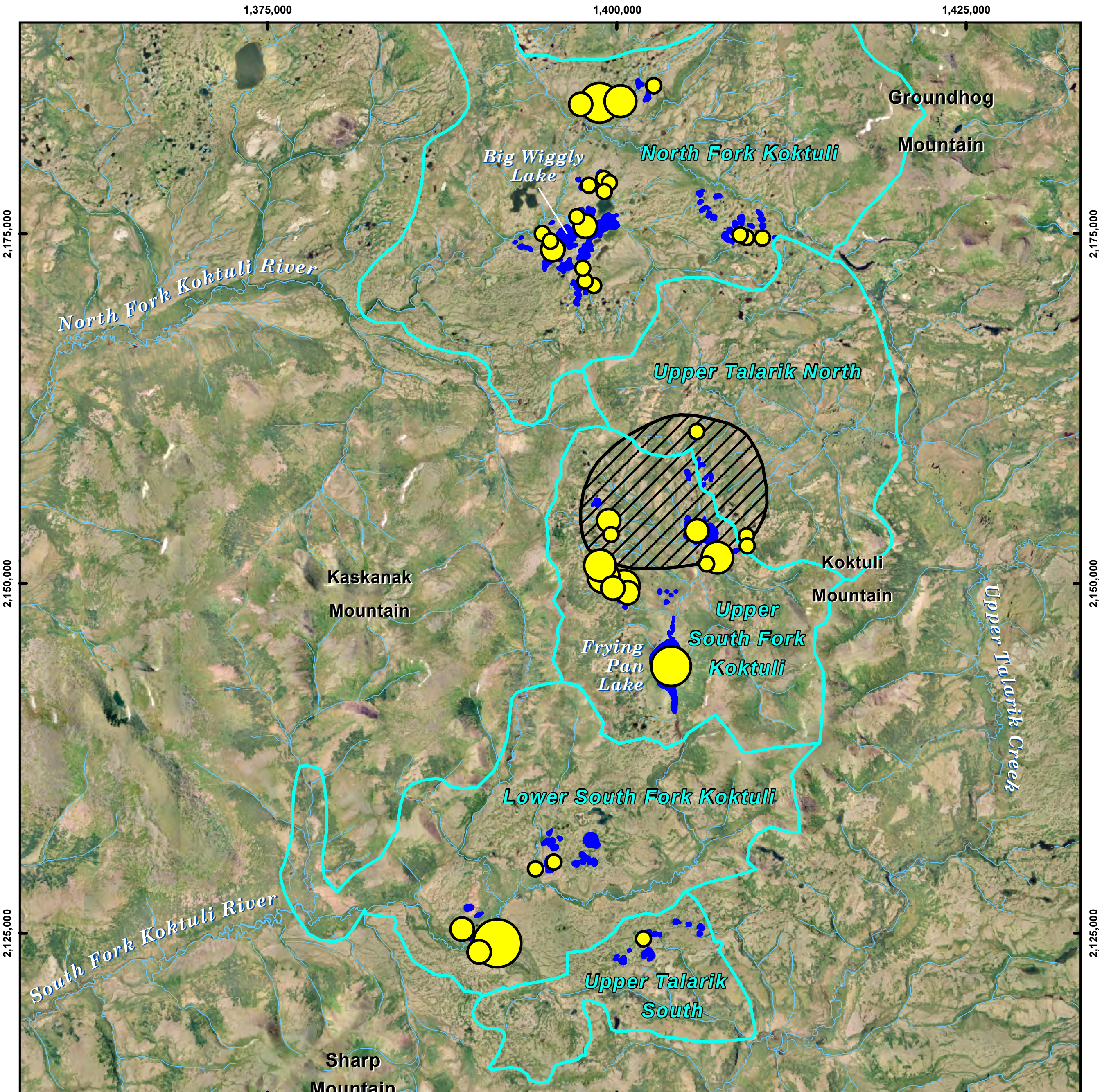
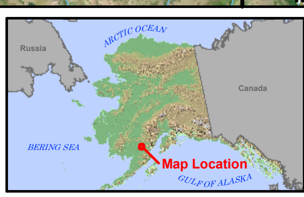


Figure 16.4-15
Pacific and Common Loon Locations, Mine Study Area, 2004 and 2005

File: 16-4-15_Loons0405_Mine_PLP_EBD_v01.mxd	Date: Sept. 28, 2010
Version: 1	Author: ABR-AZC





N

Miles
0 1 2 3

Kilometers
0 1 2 3 4 5

Scale 1:135,000

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

Background imagery: color orthophotography for the Pebble mine area based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Image credit: Kodiak Mapping Inc., Eagle Mapping Ltd., Resource Data, Inc.

Legend

Number of Broods

1 2 3 4 6

Brood Survey Lake

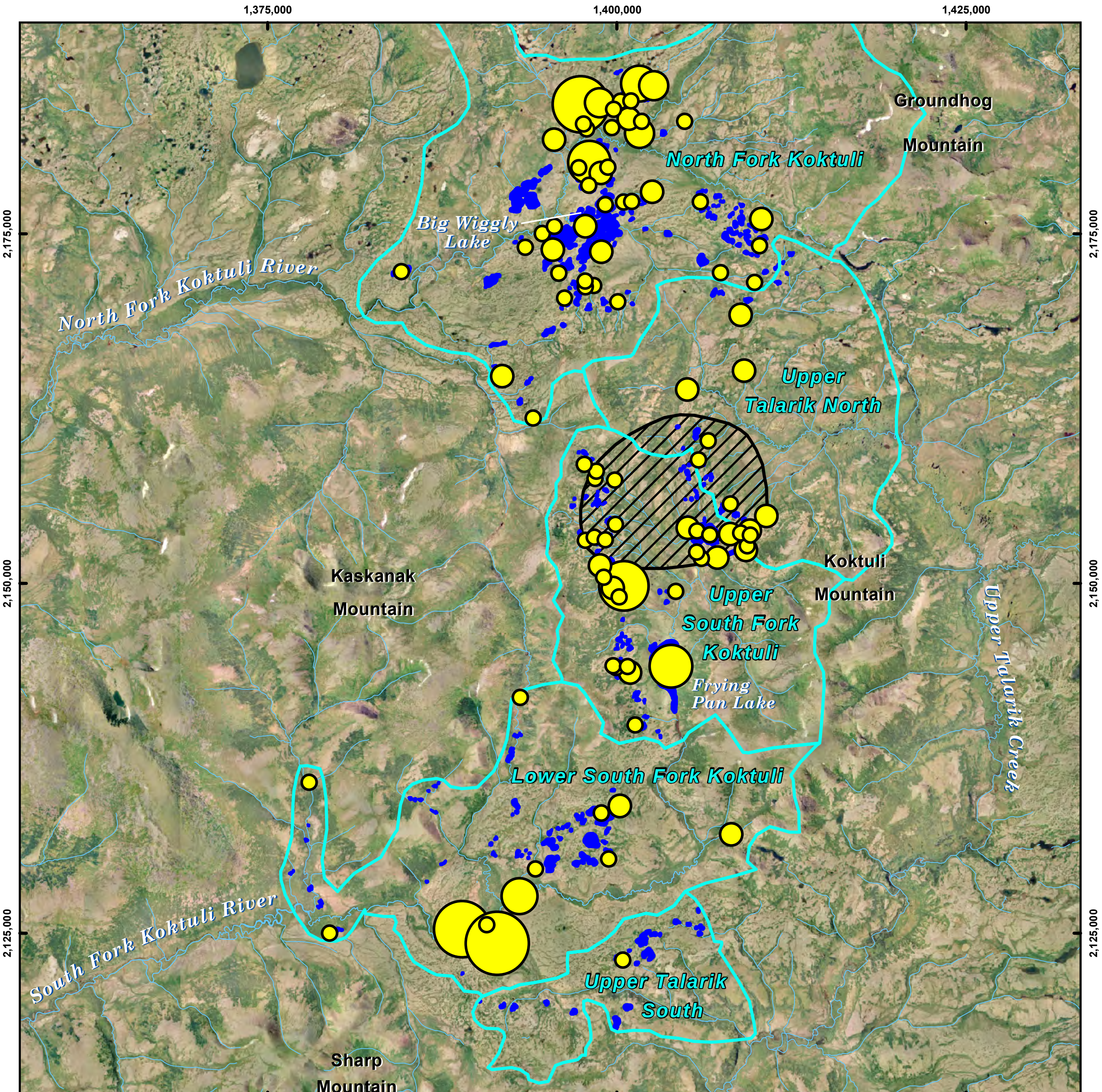
Drainage Basin Survey Area

General Deposit Location

THE pebble PARTNERSHIP

Figure 16.4-16
Location and Number of Waterbird Broods, Mine Study Area, 2004

File: 16-4-16_WBBroods04_Mine_PLP_EBD_v01.mxd	Date: Sept. 22, 2010
Version: 1	Author: ABR-AZC



N

Miles: 0 1 2 3

Kilometers: 0 1 2 3 4 5

Scale 1:135,000

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

Background imagery: color orthophotography for the Pebble mine area based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Image credit: Kodiak Mapping Inc., Eagle Mapping Ltd., Resource Data, Inc.

Legend

Number of Broods

1 2 3 4 5

6 7 13

Brood Survey Lake

Drainage Basin Survey Area

General Deposit Location

THE pebble PARTNERSHIP

Figure 16.4-17
Location and Number of Waterbird Broods, Mine Study Area, 2005

File: 16-4-17_WBBroods05_Mine_PLP_EBD_v01.mxd	Date: Sept. 22, 2010
Version: 1	Author: ABR-AZC

APPENDICES

APPENDIX 16.4A

NUMBERS OF WATERBIRDS OBSERVED DURING SPRING AND FALL MIGRATION SURVEYS, MINE STUDY AREA, 2004

APPENDIX 16.4A
Numbers of Waterbirds (by species-group and species) Observed during Spring and Fall Migration Surveys, Mine Study Area, 2004

SURVEY AREA / Species-Group / Species	Spring				Fall				
	Apr 21[a]	May 4[b]	May 14	May 23	Sep 2	Sep13	Sep 23	Oct 7	Oct 21
MINE[c]									
Waterfowl									
Canada/Cackling Goose	2	0	0	0	0	0	0	0	0
Unidentified swan	2	10	11	16	25	28	16	17	5
American Wigeon	0	24	40	20	20	76	0	0	0
Mallard	13	38	31	22	60	113	103	66	41
Northern Shoveler	0	0	12	0	0	0	0	0	0
Northern Pintail	4	58	75	9	55	55	4	0	0
Green-winged Teal	0	31	33	7	11	24	3	2	0
Unidentified dabbling duck	0	3	0	0	172	123	6	0	0
Unidentified scaup	0	8	351	137	136	97	60	23	0
Harlequin Duck	0	0	2	0	0	0	0	0	0
Surf Scoter	0	0	0	2	0	0	0	0	6
White-winged Scoter	0	0	0	6	0	0	13	0	0
Black Scoter	0	0	10	27	0	0	4	1	0
Unidentified scoter	0	0	0	4	2	0	0	0	0
Unidentified goldeneye	1	30	39	45	19	6	0	0	0
Common Merganser	0	5	8	12	0	0	0	14	14
Red-breasted Merganser	0	0	31	5	0	0	0	43	30
Unidentified merganser	6	4	16	5	69	47	11	18	4
Unidentified diving duck	0	0	0	0	91	19	0	1	0
Unidentified duck	11	23	15	7	321	50	10	5	3
Waterfowl Total	39	234	674	324	981	638	230	190	103
Loons/Grebes									
Common Loon	0	0	9	5	7	4	0	0	0
Red-necked Grebe	0	0	0	0	2	0	0	0	0
Loon/Grebe Total	0	0	9	5	9	4	0	0	0
Shorebirds									
Black-bellied Plover	0	0	7	0	0	0	0	0	0
Unidentified yellowlegs	0	3	10	2	0	0	0	0	0
Whimbrel	0	2	0	0	0	0	0	0	0
Large shorebird	0	0	1	0	0	0	0	0	0
Medium shorebird	0	8	18	20	0	0	0	0	0
Small shorebird	0	2	5	1	0	0	0	0	0
Shorebird Total	0	15	41	23	0	0	0	0	0

SURVEY AREA Species-Group Species	Spring				Fall				
	Apr 21[a]	May 4[b]	May 14	May 23	Sep 2	Sep13	Sep 23	Oct 7	Oct 21
Gulls/Terns/Jaegers									
Bonaparte's Gull	0	2	3	14	0	0	0	0	0
Mew Gull	0	23	14	31	0	0	0	0	0
Glaucous-winged Gull	0	0	0	30	136	89	46	10	0
Unidentified gull	0	0	15	0	0	0	0	0	0
Arctic Tern	0	0	14	9	0	0	0	0	0
Parasitic Jaeger	0	0	0	2	0	0	0	0	0
Gull/Tern/Jaeger Total	0	25	46	85	136	89	47	10	0
SUBTOTAL MINE	39	274	770	437	990	642	230	190	103
SOUTH TALARIK[d]									
Waterfowl									
Unidentified swan	—	2	5	1	2	2	31	44	—
American Wigeon	—	0	15	0	0	0	0	0	—
Mallard	—	9	6	9	0	3	69	43	—
Northern Shoveler	—	0	5	0	0	5	0	0	—
Northern Pintail	—	0	14	2	0	0	0	0	—
Green-winged Teal	—	3	4	0	0	0	0	8	—
Unidentified dabbling duck	—	0	0	0	64	10	0	0	—
Unidentified scaup	—	0	31	8	0	0	0	82	—
Harlequin Duck	—	0	0	2	0	0	0	0	—
Long-tailed Duck	—	0	0	2	0	0	0	0	—
Bufflehead	—	2	0	0	0	0	0	0	—
Unidentified goldeneye	—	1	3	2	0	2	0	0	—
Common Merganser	—	1	5	2	0	0	0	11	—
Red-breasted Merganser	—	0	4	0	0	0	0	14	—
Unidentified merganser	—	10	17	48	10	5	22	0	—
Unidentified duck	—	2	0	0	50	80	13	8	—
Waterfowl Total	—	30	109	76	126	107	135	120	—
Loons									
Pacific Loon	—	0	0	1	0	0	0	0	—
Cormorants									
Double-crested Cormorant	—	0	2	6	0	0	3	0	—
Shorebirds									
Black-bellied Plover	—	0	3	0	0	0	0	0	—
Large shorebird	—	0	2	2	0	0	0	0	—
Medium shorebird	—	0	8	0	0	0	0	0	—
Small shorebird	—	0	10	0	0	0	0	0	—
Shorebird Total	—	0	23	2	0	0	0	0	—

SURVEY AREA Species-Group Species	Spring				Fall				
	Apr 21[a]	May 4[b]	May 14	May 23	Sep 2	Sep13	Sep 23	Oct 7	Oct 21
Gulls/Terns									
Mew Gull	—	0	16	1	0	0	0	0	—
Glaucous-winged Gull	—	0	0	0	136	89	46	10	—
Unidentified gull	—	0	11	0	0	0	1	0	—
Arctic Tern	—	0	35	3	0	0	0	0	—
Gull/Tern Total	—	0	62	4	136	89	47	10	—
SUBTOTAL SOUTH TALARIK	—	30	196	89	262	196	185	220	—
NIKABUNA LAKES[e]									
Waterfowl									
Unidentified swan	—	—	—	—	—	—	357	2	—
American Wigeon	—	—	—	—	—	—	84	0	—
Mallard	—	—	—	—	—	—	161	0	—
Green-winged Teal	—	—	—	—	—	—	10	6	—
Unidentified scaup	—	—	—	—	—	—	150	338	—
Unidentified scoter	—	—	—	—	—	—	8	0	—
Bufflehead	—	—	—	—	—	—	0	2	—
Common Merganser	—	—	—	—	—	—	0	125	—
Red-breasted Merganser	—	—	—	—	—	—	0	14	—
Unidentified merganser	—	—	—	—	—	—	6	148	—
Unidentified diving duck	—	—	—	—	—	—	0	11	—
Unidentified duck	—	—	—	—	—	—	535	251	—
Waterfowl Total	—	—	—	—	—	—	1,311	897	—
SUBTOTAL NIKABUNA LAKES	—	—	—	—	—	—	1,311	897	—
TOTAL[f]	39	304	966	526	1,252	838	415	410	103

Notes:

a. No survey was conducted of rivers in the South Talarik survey area.

b. A partial survey of rivers in the South Talarik survey area was flown; river outlets were not surveyed due to fog.

c. Includes lakes and rivers of the headwaters of Upper Talarik Creek and the north and south forks of the Koktuli River (Figure 16.4-2).

d. Includes the southern-most section (approximately 2.5 kilometers) of Upper Talarik Creek and all of Lower Talarik Creek (Figure 16.4-2).

e. September 23 and October 7 were reconnaissance surveys and the area surveyed covered only a part of that surveyed in 2005. Only swans and ducks were counted.

f. Includes subtotals from mine and South Talarik survey areas; subtotals for Nikabuna Lakes survey area not included.

APPENDIX 16.4B

NUMBERS OF WATERBIRDS OBSERVED DURING SPRING AND FALL MIGRATION SURVEYS, MINE STUDY AREA, 2005

APPENDIX 16.4B

Numbers of Waterbirds (by species-group/species) Observed during Spring and Fall Migration Surveys, Mine Study Area, 2005

SURVEY AREA / Species-Group / Species	Spring					Fall						
	Apr 21[a]	Apr 24	May 3	May 14-15	May 21-23	Aug 17-19	Aug 27, 29	Sep 6, 8	Sep 13-14	Sep 30	Oct 7	Oct 12
MINE[b]												
Waterfowl												
Unidentified swan	0	4	10	15	16	36	23	22	38	27	24	16
Gadwall	0	0	0	6	6	0	0	0	0	0	0	0
American Wigeon	0	0	11	24	52	120	124	52	45	25	0	0
Mallard	0	29	18	39	59	54	86	90	48	75	41	50
Northern Shoveler	0	0	0	23	19	79	4	84	7	0	1	0
Northern Pintail	0	19	45	39	53	101	76	12	8	12	0	0
Green-winged Teal	0	0	24	10	4	101	88	65	25	16	1	0
Unidentified dabbling duck	0	0	4	0	2	5	30	4	29	2	0	10
Canvasback	0	0	0	0	3	0	0	0	0	0	0	0
Unidentified scaup	0	0	4	377	458	281	303	397	423	350	73	38
Harlequin Duck	0	0	0	6	0	37	24	34	4	0	0	0
Surf Scoter	0	0	0	6	0	0	18	0	0	0	0	0
Black Scoter	0	0	0	0	40	0	0	0	31	28	0	0
Unidentified scoter	0	0	0	4	99	15	0	44	4	0	0	0
Long-tailed Duck	0	0	0	7	4	0	0	0	0	0	0	0
Bufflehead	0	0	0	0	0	0	4	0	0	0	0	10
Unidentified goldeneye	0	12	15	49	47	9	120	103	82	20	27	20
Common Merganser	0	0	0	2	18	0	0	0	0	0	1	0
Red-breasted Merganser	0	0	0	0	35	0	0	0	0	0	20	0
Unidentified merganser	0	0	7	51	5	132	62	73	105	84	0	0
Unidentified diving duck	0	0	0	0	4	0	0	0	3	1	0	0
Unidentified duck	27	8	34	8	9	4	0	0	11	4	2	0
Waterfowl Total	27	72	172	666	933	974	962	980	863	644	190	144

SURVEY AREA / Species-Group / Species	Spring					Fall						
	Apr 21[a]	Apr 24	May 3	May 14-15	May 21-23	Aug 17-19	Aug 27, 29	Sep 6, 8	Sep 13-14	Sep 30	Oct 7	Oct 12
MINE Continued												
Loon/Grebes												
Pacific Loon	0	0	0	0	3	0	0	0	0	0	0	0
Common Loon	0	0	0	5	10	2	3	2	2	0	0	0
Unidentified loon	0	0	0	0	1	0	0	0	0	0	0	0
Red-necked Grebe	0	0	0	0	0	0	0	0	1	1	1	0
Loon/Grebe Total	0	0	0	5	14	2	3	2	3	1	1	0
Shorebirds												
Black-bellied Plover	0	0	2	0	0	0	0	0	0	0	0	0
Unidentified yellowlegs	0	0	1	9	12	2	0	0	0	0	0	0
Whimbrel	0	0	0	3	0	0	0	0	0	0	0	0
Large shorebird	0	0	2	0	0	0	0	0	0	0	0	0
Medium shorebird	0	0	3	0	0	0	0	0	0	0	0	0
Small shorebird	0	0	14	8	12	10	0	0	0	0	0	0
Shorebird Total	0	0	22	20	24	12	0	0	0	0	0	0
Gulls/Terns												
Bonaparte's Gull	0	0	0	4	0	0	0	0	0	0	0	0
Mew Gull	0	0	7	10	22	1	0	0	0	0	0	0
Glaucous-winged Gull	0	0	0	22	7	1	0	0	0	0	0	0
Unidentified gull	0	0	14	16	55	0	0	0	0	0	0	0
Arctic Tern	0	0	13	28	20	0	0	0	0	0	0	0
Gull/Tern Total	0	0	34	80	104	2	0	0	0	0	0	0
SUBTOTAL MINE	27	72	228	771	1,075	990	965	982	866	645	191	144

SURVEY AREA Species-Group Species	Spring Apr 21[a]	 Apr 24	 May 3	 May 14-15	 May 21-23	Fall Aug 17-19	 Aug 27, 29	 Sep 6, 8	 Sep 13-14	 Sep 30	 Oct 7	 Oct 12
SOUTH TALARIK[c]												
Waterfowl												
Canada/Cackling Goose	6	0	9	0	0	0	—	—	—	—	0	0
Unidentified swan	164	6	16	13	8	38	—	—	—	—	2	14
Gadwall	0	0	0	2	4	0	—	—	—	—	0	0
American Wigeon	0	10	10	46	25	62	—	—	—	—	7	0
Mallard	0	18	26	14	9	167	—	—	—	—	0	3
Northern Shoveler	0	0	10	1	4	7	—	—	—	—	0	5
Northern Pintail	0	0	31	9	13	8	—	—	—	—	2	0
Green-winged Teal	0	0	5	0	0	42	—	—	—	—	0	0
Unidentified dabbling duck	0	20	2	0	0	0	—	—	—	—	0	0
Ringed-neck Duck	0	0	0	0	1	0	—	—	—	—	0	0
Unidentified scaup	0	0	0	101	182	25	—	—	—	—	12	0
Harlequin Duck	0	0	0	0	1	0	—	—	—	—	0	0
Black Scoter	0	0	0	0	3	0	—	—	—	—	0	0
Unidentified scoter	0	0	0	0	114	0	—	—	—	—	0	0
Long-tailed Duck	0	0	0	8	0	0	—	—	—	—	0	0
Bufflehead	0	0	26	0	0	0	—	—	—	—	0	0
Unidentified goldeneye	0	6	11	5	13	0	—	—	—	—	0	5
Common Merganser	0	0	0	0	20	0	—	—	—	—	0	0
Red-breasted Merganser	0	0	0	0	41	0	—	—	—	—	23	0
Unidentified merganser	0	4	72	23	99	23	—	—	—	—	0	8
Unidentified diving duck	0	0	0	0	1	0	—	—	—	—	0	1
Unidentified duck	90	154	17	1	6	0	—	—	—	—	1	150
Waterfowl Total	260	218	235	223	544	372	—	—	—	—	47	186

SURVEY AREA Species-Group Species	Spring Apr 21[a]	Apr 24	May 3	May 14-15	May 21-23	Fall Aug 17-19	Aug 27, 29	Sep 6, 8	Sep 13-14	Sep 30	Oct 7	Oct 12
SOUTH TALARIK Continued												
Loons												
Red-throated Loon	0	0	2	0	0	0	—	—	—	—	0	0
Common Loon	0	0	0	0	6	1	—	—	—	—	0	0
Loon Total	0	0	2	0	6	1	—	—	—	—	0	0
Cormorants												
Double-crested Cormorant	0	0	0	1	0	0	—	—	—	—	0	0
Unidentified cormorant	0	0	0	1	0	0	—	—	—	—	0	0
Cormorant Total	0	0	0	2	0	0	—	—	—	—	0	0
Shorebirds												
Unidentified yellowlegs	0	1	0	1	11	2	—	—	—	—	0	0
Medium shorebird	0	0	2	0	0	0	—	—	—	—	0	0
Small shorebird	0	0	12	36	7	2	—	—	—	—	0	0
Shorebird Total	0	1	14	37	18	4	—	—	—	—	0	0
Gulls/Terns												
Bonaparte's Gull	1	0	0	0	6	0	—	—	—	—	0	0
Mew Gull	0	0	0	24	5	0	—	—	—	—	0	0
Glaucous-winged Gull	0	0	0	19	6	84	—	—	—	—	3	6
Unidentified gull	0	10	38	29	26	0	—	—	—	—	0	0
Arctic Tern	0	0	36	161	41	0	—	—	—	—	0	0
Gull/Tern Total	1	10	74	235	84	84	—	—	—	—	3	6
SUBTOTAL SOUTH TALARIK	261	229	325	495	652	461	—	—	—	—	50	192

SURVEY AREA Species-Group Species	Spring					Fall						
	Apr 21[a]	Apr 24	May 3	May 14-15	May 21-23	Aug 17-19	Aug 27, 29	Sep 6, 8	Sep 13-14	Sep 30	Oct 7	Oct 12
NIKABUNA LAKES[d]												
Waterfowl												
Greater White-fronted Goose	0	230	5	112	0	20	0	0	0	0	0	0
Canada/Cackling Goose	0	136	0	4	0	0	0	6	0	0	0	0
Unidentified goose	150	10	0	0	0	0	0	0	0	0	0	0
Unidentified swan	400	165	8	6	14	40	70	17	0	6	167	333
Gadwall	0	0	0	8	6	0	0	0	0	0	0	0
American Wigeon	0	4	52	123	87	819	387	381	69	0	173	0
Mallard	0	115	17	56	90	1,077	501	225	47	8	78	186
Northern Shoveler	0	0	9	58	92	49	223	226	8	0	0	10
Northern Pintail	0	236	53	59	14	32	214	0	16	0	2	2
Green-winged Teal	0	0	4	18	2	16	66	319	2	0	21	35
Unidentified dabbling duck	0	94	0	0	0	0	0	0	56	55	0	210
Canvasback	0	6	40	0	0	0	0	0	0	0	0	0
Ringed-neck Duck	0	0	22	4	0	0	0	0	0	0	0	0
Unidentified scaup	0	4	341	280	189	571	3,092	2,528	1,189	850	293	697
Surf Scoter	0	0	4	57	9	0	0	1,293	0	0	1	0
White-winged Scoter	0	0	0	1	0	0	0	4	0	10	13	0
Black Scoter	0	0	0	0	19	0	0	0	15	0	0	0
Unidentified scoter	0	0	0	0	100	0	90	0	0	0	0	0
Long-tailed Duck	0	0	0	14	2	0	0	0	0	8	0	0
Bufflehead	0	6	25	4	0	0	0	0	0	30	43	47
Unidentified goldeneye	0	123	93	202	30	35	5	12	197	14	991	815
Hooded Merganser	0	0	0	0	1	0	0	0	0	0	0	0
Common Merganser	0	27	0	3	15	0	0	0	0	0	42	0
Red-breasted Merganser	0	0	0	0	31	0	0	0	0	0	7	0
Unidentified merganser	0	25	3	75	10	54	81	9	12	13	0	409

SURVEY AREA Species-Group Species	Spring Apr 21[a]	 Apr 24	 May 3	 May 14-15	 May 21-23	Fall Aug 17-19	 Aug 27, 29	 Sep 6, 8	 Sep 13-14	 Sep 30	 Oct 7	 Oct 12
NIKABUNA LAKES, Continued												
Unidentified diving duck	0	0	1	5	3	4	0	0	310	660	8	159
Unidentified duck	350	181	57	22	19	0	0	0	139	840	271	568
Waterfowl Total	900	1,362	734	1,111	733	2,717	4,729	5,020	2,060	2,494	2,110	3,471
Loons/Grebes												
Red-throated Loon	0	0	4	0	0	12	2	0	0	0	0	0
Pacific Loon	0	0	0	0	2	0	0	0	0	0	0	0
Common Loon	0	0	3	2	3	5	0	1	0	1	0	0
Unidentified loon	0	0	0	0	0	0	1	0	0	0	0	0
Red-necked Grebe	0	0	27	0	1	0	1	0	0	0	1	0
Unidentified grebe	0	0	0	3	0	0	0	0	0	0	0	0
Loon/Grebe Total	0	0	34	5	6	17	4	1	0	1	1	0
Shorebirds												
Unidentified yellowlegs	0	0	9	23	26	4	0	0	0	0	0	0
Medium shorebird	0	0	0	3	0	0	0	0	0	0	0	0
Small shorebird	0	0	0	17	7	2	0	0	0	0	0	0
Shorebird Total	0	0	9	43	33	6	0	0	0	0	0	0
Gulls/Terns												
Bonaparte's Gull	0	0	0	1	0	0	0	0	0	0	0	0
Mew Gull	0	0	0	3	0	0	0	0	0	0	0	0
Glaucous-winged Gull	0	0	0	0	1	0	0	0	0	0	0	0
Unidentified gull	0	8	0	4	3	0	0	0	0	0	0	3
Arctic Tern	0	0	0	1	3	0	0	0	0	0	0	0
Gull/Tern Total	0	8	0	9	7	0	0	0	0	0	0	3
SUBTOTAL NIKABUNA LAKES	900	1,370	777	1,168	779	2,740	4,733	5,021	2,060	2,495	2,111	3,474

APPENDIX 16.4C

AGE CLASSES OF DUCK BROODS OBSERVED DURING GROUND SURVEYS, MINE STUDY AREA, 2004 AND 2005

APPENDIX 16.4C
Age Classes of Duck Broods Observed during Ground Surveys, Mine Study Area, 2004 and 2005

	Brood Age Class (no. of days)							
Year/ Species	**1A (1-7)**	**1B (8-13)**	**1C (14-18)**	**2A (19-27)**	**2B (28-36)**	**2C (37-42)**	**3 (43-55)**	**Total**
2004								
American Wigeon	1	5	9	1	0	0	1	17
Mallard	0	0	0	1	0	0	0	1
Northern Shoveler	1	0	0	2	1	0	0	4
Northern Pintail	0	0	0	1	3	0	1	5
Green-winged Teal	2	2	0	2	1	3	0	10
Greater Scaup	1	0	0	0	0	0	0	1
Unidentified scaup	5	2	1	0	0	0	0	8
Black Scoter	0	0	2	1	0	0	0	3
Long-tailed Duck	1	0	0	0	0	0	0	1
Common Goldeneye	0	0	1	0	0	0	0	1
Unidentified duck	0	0	0	0	0	0	1	1
TOTAL	11	9	13	8	5	3	3	52
2005								
American Wigeon	2	12	9	7	4	1	0	35
Mallard	1	4	0	2	2	2	0	11
Northern Shoveler	2	0	6	2	2	1	0	13
Northern Pintail	0	1	5	7	4	10	9	36
Green-winged Teal	1	2	4	1	4	2	1	15
Greater Scaup	4	5	0	0	0	0	0	9
Unidentified scaup	4	10	3	0	1	0	0	18
Black Scoter	0	0	0	0	0	0	1	1
Long-tailed Duck	0	3	2	0	0	0	0	5
Unidentified goldeneye	0	0	1	0	0	0	0	1
Red-breasted Merganser	0	0	0	0	1	0	0	1
Unidentified merganser	0	0	2	0	0	0	0	2
Unidentified duck	0	0	0	0	0	1	0	1
TOTAL	14	37	32	19	18	17	11	148

SURVEY AREA Species-Group Species	Spring					Fall						
	Apr 21[a]	Apr 24	May 3	May 14-15	May 21-23	Aug 17-19	Aug 27, 29	Sep 6, 8	Sep 13-14	Sep 30	Oct 7	Oct 12
TOTAL	1,188	1,671	1,330	2,434	2,506	4,191	5,698	6,003	2,926	3,140	2,352	3,810

Notes:

a. Reconnaissance survey conducted by pilot only.

b. Includes lakes and rivers of the headwaters of Upper Talarik Creek and the north and south forks of the Koktuli River (Figure 16.4-2).

c. Includes lakes and rivers south of Sharp Mountain (Figure 16.4-2). No surveys flown from August 27 through September 30. Only Lower Talarik Creek surveyed on October 7 and 12.

d. Includes Nikabuna and Long lakes and a section of the Chulitna River (Figure 16.4-2).

16.5 Breeding Landbirds and Shorebirds—Mine Study Area

16.5.1 Introduction

The results of the 2004 and 2005 surveys for breeding landbirds and shorebirds in the mine study area are presented in this section. This work focuses on assessing the baseline conditions for breeding landbirds and shorebirds in the vicinity of the Pebble Deposit. Only observations of landbirds and shorebirds are reported here. Observations of waterbirds and raptors recorded during the surveys for landbirds and shorebirds in the mine study area are reported in Section 16.4 (waterbirds) and Section 16.3 (raptors). This report summarizes the work conducted during the breeding seasons in 2004 and 2005, documenting the landbird and shorebird species observed, their abundance, and their use of the mapped habitats in the study area. The mapping of wildlife habitats in the mine study area is presented in Section 16.1 (habitat mapping and habitat-value assessments).

16.5.2 Study Objectives

The primary objective of this study was to collect baseline data on breeding landbirds and shorebirds in the mine study area. Researchers recorded all species observed in the field, paying special attention to species of conservation concern. The specific objectives of this study were to:

- Identify the assemblage of landbird and shorebird species that use the study area during the breeding season.
- Quantify the abundance of each species.
- Determine which habitats in the study area are important for breeding landbirds and shorebirds.

16.5.3 Study Area

In 2004, the breeding-bird surveys were conducted within an area of 252 square kilometers, and in 2005, the survey area was expanded to 293 square kilometers. The survey areas in both years (hereafter referred to as the mine study area) encompassed the Pebble Deposit plus a large buffer region surrounding the deposit (Figure 16.5-1).

The mine study area is in an open, glaciated landscape at the headwaters of Upper Talarik Creek and the north and south forks of the Koktuli River and is largely dominated by subalpine and alpine vegetation. Elevations in the study area range from roughly 250 to 800 meters, and the terrain varies from mountainous to flat and gently rolling. Glacial moraine deposits are common at the lower elevations, with scattered kettle lakes and small ponds in depressions in the undulating topography. White spruce (*Picea glauca*) is present in only a few locations, typically occurring only as scattered individual trees. Several isolated stands of balsam poplar (*Populus balsamifera*) also occur in protected locations. These forested patches are anomalous occurrences, however, in a landscape strongly dominated by shrub and herbaceous habitats. The most common breeding-bird habitat in the area is upland dwarf scrub. Dwarf scrub dominates wherever drainage is good, which is common on the upland moraine deposits in the area. Alpine dwarf scrub and alpine barrens occur at the higher elevations. Alternating with the dwarf scrub, in more protected and often wetter locations, are broad patches of lowland low and tall scrub, dominated by willows (*Salix* spp.). Upland low and tall scrub, dominated by willows and Sitka alder (*Alnus sinuata*), often occurs on slopes. Riverine low and tall scrub, again dominated by willows, occurs in the headwaters and floodplains of the larger streams and rivers in the area. The wetter habitats in the area are most often dominated by graminoid vegetation, such as wet sedge and moist graminoid meadows; these habitats occur in lowlands, in riverine areas, and in upland areas with gentle slopes and impeded drainage. Marsh habitats, with standing water, are relatively uncommon in the area and occur most extensively in the wetland complex that is directly north of and contiguous with Frying Pan Lake, and in other low-lying areas along drainages and around lakes and ponds.

16.5.4 Previous Studies

A search of the published and unpublished biological literature for the region surrounding the Pebble Deposit did not reveal any studies of breeding landbirds and shorebirds that apply directly to the mine study area. Baseline biological data for the deposit area collected by Cominco in the early 1990s did not address landbirds or shorebirds. A number of avifaunal studies, however, have been conducted in a broader region surrounding the mine study area (Figure 16.5-2) and provide general information on the relative abundance and distribution of breeding landbirds and shorebirds. Previous studies have been conducted in the Bristol Bay region (Hurley, 1931, 1932); the Iliamna Lake area (Williamson and Peyton, 1962); the northern Alaska Peninsula (Osgood, 1904; Gibson, 1970; Gill et al., 1981); the Katmai region (Cahalane, 1944, 1959); Katmai and Lake Clark national parks (Bennett, 1996a, 1996b; Gill et al., 1999; Gill and Tibbitts, 2003; Ruthrauff et al., 2007); Ugashik Bay (Gibson and Kessel, 1983); the Becharof Lake area (Dewhurst et al., 1996a; Moore and Leeman, 1996); the Mother Goose Lake area (Dewhurst et al., 1996b; Egan and Adler, 2001); or consider birds broadly in southwestern Alaska (Kessel and Gibson, 1978; Bennett, 1996c). None of these studies, however, is directly comparable to surveys conducted in the mine study area because of differences in survey methods, timing of surveys, habitats surveyed, field effort (e.g., number of point-counts conducted), and/or geographical or elevational extent of the surveys. The most important of these factors is variability in the survey coverage of different habitats, which can result in a different set of landbird and shorebird species being recorded in different studies in addition to differences in abundance within species. The conclusions that can be drawn from comparisons of the work done in the mine study area to these other regional studies therefore are limited.

16.5.5 Scope of Work

Surveys for breeding landbirds and shorebirds were conducted in the mine study area during June 2004 and June 2005. Charles T. Schick and Jennifer H. Boisvert, of ABR, Inc., Anchorage, Alaska conducted the study according to the approach described in the *Draft Environmental Baseline Studies, Proposed 2004 Study Plans* (NDM, 2004) and the *Draft Environmental Baseline Studies, 2005 Study Plan* (NDM, 2005). This work included the following activities:

- Allocating point-count sample plots based on aerial photosignature type, which allowed sampling of the important breeding-bird habitats in the mine study area.
- Performing early-morning point-counts at each sample location.
- Recording habitat-use information (when possible) for all species observed at each point-count location.
- Recording observations and habitat-use information for less common species and/or species of conservation concern when in transit between sample locations.

16.5.6 Methods

16.5.6.1 Field Surveys and Habitat-use Analyses

Surveys for breeding landbirds and shorebirds in the mine study area followed the methods outlined in the study plans for 2004 and 2005 (NDM, 2004, 2005). Researchers used variable circular-plot point-count methods (Ralph et al., 1995; Buckland et al., 2001). These survey methods were designed primarily to detect singing male passerine birds defending territories and have become the standard method for surveying breeding landbirds in remote terrain in Alaska (USGS, 2006). The methods also have recently been adopted for inventories of breeding shorebirds in Alaska (Ruthrauff et al., 2007; ASG, 2006).

In 2004, researchers used high-altitude, color-infrared, aerial photographs from the National Aeronautics and Space Administration (late 1970s and early 1980s) to allocate point-count locations for sampling among the available habitats in the mine study area. In 2005, sample points were selected using true-color aerial photography of the mine study area from Eagle Mapping (July 2004). A formal stratified-random sampling of points within each vegetation or habitat type, using a geographic information system (GIS), would have been preferable, but this was not possible given the lack of a fine-scale vegetation or habitat map for the area at the time the surveys were conducted. A completely random allocation of sample points across the survey area also could have been attempted, but this would have resulted in an over-sampling of the most common habitat types and an under-sampling, or omission, of less common habitats. Instead, researchers used the prominent photo signatures on the aerial photography as the sampling strata. Sample points were located in a haphazard fashion within each photosignature (in 2005, by a vegetation ecologist with no knowledge of bird-habitat associations) subject to the restriction of maintaining a minimum distance of 500 meters between sample points. This sampling scheme resulted in a selection of point-count locations that was unbiased with respect to the distribution of birds on the landscape. Sample points were selected to satisfy two criteria:

- To allocate points within all prominent photo signatures evident on the aerial photography.
- To establish an adequate spatial representation of points across the mine study area.

The first criterion was established to help meet one of the primary objectives of this work, which was to assess habitat associations of breeding landbirds and shorebirds. For the second criterion, sample points were spread broadly across the survey area and were replicated within each photosignature to try to capture any spatial variability in habitat use by breeding birds.

Researchers conducted point-counts in the mine study area from June 15 through 23, 2004, and from May 31 through June 15, 2005. Survey timing was selected to coincide with the peak breeding period for landbirds in southwestern Alaska. Many shorebirds start breeding activities earlier in May in southwest Alaska, yet shorebirds were still present and vocal during surveys in 2004 and 2005. Many were agitated and giving alarm vocalizations in the presence of humans and likely were tending broods; thus the habitat-association information acquired for shorebirds in the area will still indicate which habitats are used for breeding (especially brood-rearing).

All point-count surveys were conducted between 0430 and 1600 hours, but most were conducted between 0500 and1400 hours. Point-counts were continued into the afternoon to collect additional data on habitat use and to make the best use of field hours. Although some species, especially landbirds, often reduce their vocal activity after midday, particularly on warm days, this was not an important issue for the primary survey objective because researchers were less interested in the absolute numbers of birds recorded than in collecting data on bird-habitat associations. The survey protocols were not designed for a long-term bird-monitoring program.

Hand-held global positioning system (GPS) receivers were used to locate preselected survey points in the field. Sample points were accessed by helicopter and on foot. All helicopter activity occurred at least 100 meters from any given sample point, and observers waited at least two minutes after arriving at a sample location before starting the count. Point-counts were conducted in standard 10-minute intervals (Ralph et al., 1995). Four categories of observations were made during the point-count survey efforts, and the habitats being used by the bird(s) were recorded whenever possible for each category:

- **Focal observations** were of birds recorded during the point-count period using the habitat that was being sampled by the researchers directly at the point-count location.
- **Nonfocal observations** were of birds recorded during the point-count period but using different habitats, which were typically adjacent to the focal habitat being sampled directly. Focal and nonfocal observations combined were used to assess abundance for landbirds and shorebirds in this study.
- **Incidental observations** were recorded at the point-count location but were not made during the point-count period (birds were either seen before or after the count period). Incidental observations were recorded primarily to collect more data on the less common species. These observations were not systematically made and were not used to assess abundance in this study.
- **In-transit observations** were made as researchers moved between point-count locations. These nonsystematic observations were primarily of less common species and/or observations of nests, defensive behavior indicative of the presence of a nest, or fledglings being tended by an adult(s).

During the point-counts, all species observed either visually or aurally were recorded. Any individual birds counted at multiple points (e.g., birds conducting territorial displays that could be seen or heard from two adjacent point-count locations) were recorded only once at the point where they were initially detected. Habitat types were recorded for as many bird observations as possible. Habitats were categorized in the field using combinations of physiography classes and the Level IV vegetation types of *The Alaska Vegetation Classification* (Viereck et al., 1992).

In 2005, observations were categorized into estimated distance categories (Rosenstock et al., 2002) to allow the possible calculation of bird densities with distance analyses (Laake et al., 1994; Buckland et al., 2001). Distance-estimation training for each field crew member was conducted over a period of two days before the field surveys and laser rangefinders were regularly used in the field to calibrate distance estimates and determine distances when possible.

To assess habitat use by breeding landbirds and shorebirds, each point-count location surveyed in 2004 and 2005 was assigned a wildlife habitat defined by the mapped habitat (map polygon) each point-count location occurred in. This was done in GIS using the habitat map for the mine study area (see Section 16.1); all point-count locations in the mine study area and in that portion of the transportation corridor that occurs in the mine studies region were used. The number of observations of each species using each mapped habitat type during the point-count surveys in 2004 and 2005 (focal observations only) then was summed and divided by the number of point-counts conducted in each habitat to yield average-occurrence figures. The use of average-occurrence data corrects for the different numbers of point-counts conducted in each habitat, effectively standardizing the abundance data across habitats and allowing direct comparisons of relative bird abundance among habitats. Nonfocal observations (recorded in habitats adjacent to the focal habitat of an individual point-count) were not used because those observations can be biased towards more vocal and/or more active species. That is, because the observations in nonfocal habitats typically are made at some distance from the point-count location, the less vocal and less active species may be missed, and inclusion of data from nonfocal habitats may downwardly bias the average-occurrence figures for those species.

16.5.6.2 Species of Conservation Concern

To determine which landbird and shorebird species occurring in the mine study area are considered species of conservation concern, researchers consulted bird-conservation lists from federal and state management agencies, conservation organizations, and bird working-groups that directly address the conservation concerns for Alaskan birds (Table 16.5-1). In general, the goal in preparing these lists is not to identify those species treated formally by the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act, rather it is to identify species that currently may be common but for which there are concerns about the long-term viability of their populations (see below). The bird-conservation lists reviewed were those that considered Alaskan birds specifically and were published as of 2007: the USFWS's *Birds of Conservation Concern* (USFWS, 2002); the Bureau of Land Management's *Alaska Threatened, Endangered, and Sensitive Species List* (BLM, 2005); the U.S. Forest Service's *Alaska Region Sensitive Species List* (USFS, 2002), the Alaska Department of Fish and Game's *Species of Special Concern* (ADF&G, 1998) and *Comprehensive Wildlife Conservation Strategy* (ADF&G, 2006), Audubon Alaska's *Watchlist 2005* (Stenhouse and Senner, 2005), the Alaska Natural Heritage Program's *Birds Tracking List* (AKNHP, 2007), the Boreal Partners in Flight Working Group's *Landbird Conservation Plan for Alaska Biogeographic Regions* (BPIFWG, 1999), and the Alaska Shorebird Group's *Conservation Plan for Alaska Shorebirds* (ASG, 2004). Additional information on bird species of conservation concern in the mine study area is presented in Chapter 17 (Threatened and Endangered Species and Species of Conservation Concern – Bristol Bay Drainages).

The nine bird-conservation lists reviewed here variously considered several criteria related to population persistence in Alaska that included information on population trend, population size, known threats during the breeding and nonbreeding seasons, and range size and dispersion both during breeding and nonbreeding. On some lists (e.g., ADF&G, 2006), additional species-selection criteria were used that included information on known health concerns, the incidence of mortality, endemism (to Alaska), sensitivity to disturbance, the lack of information on population status, questionable taxonomy, representativeness (for habitat use), and international importance for monitoring. Some listing groups similarly considered monitoring concerns, both globally and in the state, when selecting species (BPIFWG, 1999) and others considered specialized habitat requirements (BLM, 2005). Of the nine lists reviewed, eight lists consider landbirds and eight lists consider shorebirds. On some of these lists, species were quantitatively ranked and categorized by conservation class (e.g., high, moderate, or low concern), while on other lists, a single category of conservation concern was used. Alaska stewardship or monitoring concerns also were considered on some lists for those cases in which a large proportion of the global population of the species resides in Alaska. For this study, in an attempt to identify those species for which there is genuine conservation concern, as opposed to stewardship concern or moderate or low conservation concern, researchers selected species of conservation concern using two criteria:

- First, the species had to be listed in the highest conservation category(ies), if applicable, within the classification system used (species of moderate or low concern were not considered). On those lists in which a single conservation class was used, however, all species of conservation concern occurring in the study area were considered.
- Second, the species had to be listed as of conservation concern on at least two of the lists that considered landbirds and shorebirds in Alaska. This criterion helped to eliminate species of moderate or low concern that only occur on a single bird-conservation list.

Additional research reports were reviewed for each species of conservation concern recorded in the mine study area to provide background ecological information on the reasons for conservation concern (see Section 16.5.7).

16.5.7 Results and Discussion

Point-count locations were spread throughout the mine study area during both survey years to adequately sample the spatial variability in habitat types occurring within the study area (Figure 16.5-1).

In 2004, researchers conducted 166 point-counts and recorded 1,794 individual birds in the mine study area. During 2005, researchers conducted 227 point-counts and recorded 2,636 individual birds. In 2005, eight additional point-counts were conducted in the Upper Talarik Creek drainage east of the mine study area (Figure 16.5-1). The information from these eight additional point-counts is presented and discussed separately from the data collected in the mine study area. Researchers recorded 90 individual birds during these eight additional point-counts.

In 2004 and 2005, 253 and 203 birds, respectively, were recorded as incidental and in-transit observations in the mine study area (Appendix 16.5A). During the eight additional point-counts conducted east of the mine study area in 2005, 10 birds were recorded as incidental observations; no in-transit observations were recorded in this area (Appendix 16.5B).

In the two survey years, breeding landbirds and/or shorebirds were recorded in 15 of the 19 habitat types sampled (Table 16.5-2); 25 wildlife habitats were mapped in the mine study area (see Section 16.1), but not all mapped habitats were sampled with point-count surveys. Most of the unsampled habitats were waterbody types (e.g., riverine and aquatic habitats) not targeted for point-count surveys.

The number of bird species (species richness) observed in each sampled habitat ranged from 0 to 16 and the average number of birds recorded per count (focal observations only) in each habitat ranged from 0.0 to 10.2. The most productive breeding habitats, in terms of bird abundance (using focal observations per point count as the measure of abundance), were Lowland Low and Tall Willow Scrub, Riverine Tall Alder or Willow Scrub, and Upland Moist Tall Willow Scrub. In each of these three habitats, more than nine birds were observed per count; in the remaining habitats, seven or fewer birds were recorded per count. One habitat (Riverine Tall Alder or Willow Scrub) supported the highest numbers of breeding-bird species (16), but seven other habitats (Lowland Ericaceous Scrub Bog, Upland Moist Tall Willow Scrub, Upland Moist Tall Alder Scrub, Upland Moist Low Willow Scrub, Lowland Low and Tall Willow Scrub, Riverine Low Willow Scrub, and Lowland Wet Graminoid–Shrub Meadow) supported similar numbers of species

(13 to 15). The remaining habitats supported 10 or fewer species each. Many of the habitat types with the highest species richness also had high bird abundance, as measured by observations per count (Table 16.5-2).

16.5.7.1 Species Richness and Abundance by Species-Group

Including the incidental and in-transit observations recorded outside the point-count periods, researchers identified 42 species of landbirds and shorebirds, combined, in the mine study area in the two years of study (Tables 16.5-3 and 16.5-8). Of these 42 species, 28 were landbirds and 14 were shorebirds. Three additional landbird species (Black-capped Chickadee, White-crowned Sparrow, and White-winged Crossbill) were recorded during survey efforts for the eight point-counts conducted east of the mine study area, though White-winged Crossbill was recorded only incidentally; no additional shorebird species were detected during these additional surveys.

Considering only those 40 species observed systematically during point-count surveys in the mine study area, passerines were clearly the dominant group of landbirds, with 23 species recorded; other landbird species-groups observed included two species of ptarmigan and one corvid (Figure 16.5-3). Fourteeen shorebird species were detected during point-counts in the mine study area over the two survey years.

In terms of abundance, sparrows and allies (including longspurs and buntings) were by far the most abundant birds observed during point-counts in the mine study area (more than 1,800 individuals; Figure 16.5-4). Warblers, thrushes, and finches also were abundant in the area, as were sandpipers, and to a lesser extent, plovers. Ptarmigan, flycatchers, and kinglets were rarely observed during point-count surveys in the mine study area (Figure 16.5-4). It is likely all the abundant and common species were identified during the surveys, although some uncommon or rare species using the area may not have been detected. It is well known that the occurrence and numbers of both landbirds and shorebirds can fluctuate widely among years at any one location. This effect is evident in this study in which several of the less common species were found in the area in only a single year (e.g., Alder Flycatcher, Arctic Warbler) and in which other species (e.g., Wilson’s Warbler, Gray-cheeked Thrush) were present in varying abundances in the two years (Table 16.5-4).

The numbers of landbird and shorebird species observed in the mine study area can be compared to the numbers documented in other studies on the upper Alaska Peninsula and in western Cook Inlet (Figure 16.5-2). To standardize the comparisons, the numbers of species recorded are restricted to only those observations made during point-counts during the breeding season. In the mine study area, 26 landbird species and 14 shorebird species were recorded during point-counts. At Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge, Dewhurst et al. (1996b) and Egan and Adler (2001) recorded 20 landbird and four shorebird species. At Becharof Lake in Becharof National Wildlife Refuge, Moore and Leeman (1996) documented 19 landbird and seven shorebird species during breeding-season point-counts. In Katmai National Park (KNP), Ruthrauff, et al. (2007) also used point-count surveys and recorded 35 landbird and 11 shorebird species during the breeding season, and in Lake Clark National Park (LCNP), the same researchers recorded 46 landbird and 14 shorebird species.

Differences in the number of landbird species observed between the mine study area and these other studies likely is due to variation in extent of study areas and field efforts and differences in the habitat types surveyed. Of the three areas, the habitats surveyed at Becharof Lake were most comparable to the habitats in the mine study area (e.g., dwarf ericaceous scrub and medium-tall willow and alder scrub comprised the dominant vegetation). Many fewer point-counts, however, were conducted over a less extensive geographical area in the Becharof Lake study (99 point-counts versus 393 in the mine study area), which may, in part, explain the lower number of species recorded at Becharof Lake. Similarly the number of point-counts conducted at Mother Goose Lake (141) was lower than in the mine study area and fewer species were recorded. The number of point-counts conducted in KNP and LCNP were greater than, but more similar to the number surveyed in the mine study area (468 and 417 compared to 393, respectively). In KNP and LCNP, the surveys were conducted over a more extensive geographical area and elevational gradient (e.g., lowland, coastal, and forested areas were included). In those cases, it would be expected that a greater number of species would be recorded in the KNP and LCNP surveys, which was the case for landbirds. It is notable, however, that a greater number of shorebird species (14) was recorded in the more localized region of the mine study area than in KNP, where 11 shorebird species were observed in broad-ranging surveys conducted throughout the park. Similarly, the same number of shorebird species (14) was recorded in the mine study area and in broad-ranging surveys conducted in LCNP. The relatively high shorebird species richness in the mine study area is comparable to other headwaters areas on western side of the Alaska Range in LCNP. In particular, all of the 14 shorebird species that have been recorded in LCNP were found in the highlands in the Twin, Turquoise, and Telaquana lakes area (Gill et al., 1999; Ruthrauff et al., 2007). The Twin and Turquoise lakes areas, like the mine study area, are headwaters for tributaries or the main stem of the Mulchatna River; the Telaquana Lake area is the headwaters for a tributary of the Stony River. Similar to the mine study area, these areas are characterized by mountainous terrain with alpine vegetation and lower elevation dwarf-scrub habitats in open, rolling terrain interspersed with lakes and ponds and wetlands, the combination of which provides suitable habitats for a diversity of subarctic-breeding shorebird species.

16.5.7.2 Landbird Occurrence

Researchers observed a total of 26 landbird species during the point-count surveys in 2004 and 2005 (Table 16.5-3) and calculated a mean of 10.2 landbirds observed per point-count over the two seasons. Most landbirds observed were assumed to be nesting in the area, based on actual observations of nests or repeated observations of display activities, territorial behavior, or alarm/skulking reactions typical of nesting landbirds.

The most frequently observed species (those observed in both years and with more than 90 point-count observations in each year) were considered abundant in the area. These nine species were Savannah Sparrow, Golden-crowned Sparrow, Wilson’s Warbler, Orange-crowned Warbler, Common Redpoll, American Tree Sparrow, Gray-cheeked Thrush, Fox Sparrow, and Yellow Warbler (Table 16.5-4). Three of these species (Savannah Sparrow, Golden-crowned Sparrow, and Wilson’s Warbler) were especially abundant and comprised 37 percent of the point-count observations in both years combined. Eight other species were less frequently observed in the mine study area (recorded on point-counts in both years between 10 and 69 times per year) and were considered common in the area. These species were Northern Waterthrush, Lapland Longspur, American Robin, American Pipit, Blackpoll Warbler, Hermit Thrush, Horned Lark, and Snow Bunting. The remaining species (recorded in only one year or less than 10 times on point-counts in any one year) were considered uncommon (Table 16.5-4).

The average occurrences (number of birds per point-count) for most landbird species were roughly similar in both years in the mine study area although there were notable exceptions (e.g., Wilson’s Warbler and Gray-cheeked Thrush increased substantially in abundance in 2005; Table 16.5-4). Average occurrences in

2004 ranged from 0.006 for Rock Ptarmigan and Lincoln's Sparrow to 1.633 for Savannah Sparrow, and in 2005, ranged from 0.004 for Rock Ptarmigan, Common Raven, and Ruby-crowned Kinglet to 1.612 for Savannah Sparrow.

During the eight additional point-counts conducted east of the mine study area in 2005 (Figure 16.5-1), 14 landbird species were recorded (Table 16.5-5). As noted above, three landbird species (Black-capped Chickadee, White-crowned Sparrow, and White-winged Crossbill) recorded in this area were not found in the mine study area. White-winged Crossbill, however, was recorded only as an incidental sighting. Notwithstanding the presence of these three additional species, the species composition and relative abundance of landbirds in this area were similar to those recorded in the mine study area. Average-occurrence values for the 14 landbird species recorded on these eight point-counts (albeit a low sample size) ranged from 0.125 to 1.375.

In Table 16.5-6, landbird abundance in the mine study area is contrasted with landbird abundance found in other similar studies of breeding birds conducted on the upper Alaska Peninsula and in western Cook Inlet. Average-occurrence values were used to standardize abundance data across studies in which different numbers of point-counts were conducted. Point-count-based studies of landbirds were conducted at Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge (Dewhurst et al., 1996b; Egan and Adler, 2001), at Becharof Lake in Becharof National Wildlife Refuge (Moore and Leeman, 1996), and in Katmai and Lake Clark national parks (Ruthrauff et al., 2007) (Figure 16.5-2). Differences among these studies in the sizes of study areas and the habitats surveyed make the comparisons approximate, but with these caveats in mind, the comparisons are still instructive.

Many of the same species categorized as abundant in the mine study area also were commonly recorded in the other studies. For example, the three most abundant species in the mine study area (Savannah Sparrow, Golden-crowned Sparrow, and Wilson's Warbler) also were the three most abundant species recorded at Becharof Lake. Although Golden-crowned Sparrows and Wilson's Warblers had higher average occurrences at Becharof Lake (suggesting more tall- and low-scrub habitats were surveyed), the average occurrence for Savannah Sparrows at Becharof Lake (1.707) was similar to that found in the mine study area (1.629). Similarly, Wilson's Warbler was the most abundant species at Mother Goose Lake, but the average occurrence for Wilson's Warbler at Mother Goose Lake was over twice as high as that found in the mine study area. The next two most abundant species at Mother Goose Lake were Common Redpoll and Hermit Thrush, suggesting that more tall- and low-scrub habitats were surveyed there compared to the mine study area. Overall, the average-occurrence values at Becharof Lake, Mother Goose Lake, and in the mine study area were roughly comparable across all species, with the exception of the very high numbers of Wilson's Warblers found at Mother Goose Lake (Table 16.5-6). Average occurrences ranged from 0.003 to 1.629 in the two years of study in the mine study area, from 0.020 to 1.879 at Becharof Lake, and from 0.007 to 3.057 at Mother Goose Lake. The next highest average-occurrence value at Mother Goose Lake (below the 3.057 for Wilson's Warblers) was 1.723. Differences in the abundance and occurrence of individual species among these three study areas likely are due to differences in habitats surveyed, differences in elevation of the study areas (see below), and other factors related to the distributions of individual species in Alaska. For example, American Tree Sparrows were most common in the mine study area, less common at Becharof Lake, and did not occur further south at Mother Goose Lake (the southern end of this species' breeding range in western Alaska is in the northern portion of the Alaska Peninsula; Naugler, 1993). Similarly, Northern Waterthrushes and Blackpoll Warblers were recorded as abundant and common, respectively, in the mine study area but did not occur at Mother Goose Lake, Becharof Lake, or in KNP (the breeding ranges of these two species in western Alaska extend south only to the northern portion of the Alaska Peninsula; Eaton, 1995; Hunt and Eliason, 1999).

In point-count surveys in LCNP, Ruthrauff et al. (2007) recorded high numbers of four of the scrub-adapted species found to be abundant in the mine study area (American Tree Sparrow, Common Redpoll, Fox Sparrow, and Golden-crowned Sparrow). These were four of the six most common species recorded in LCNP. However, the fourth and fifth most abundant species in LCNP (Dark-eyed Junco and Yellow-rumped Warbler) are forest-dwelling birds and these species were not recorded in the mine study area. This is indicative of the greater elevational range and habitat diversity sampled in LCNP. Ruthrauff et al. (2007) also sampled earlier in the breeding season than was done in the mine study area, and this may explain the greater abundances of some species in LCNP because some early nesting landbird species are more active during the nest-initiation phase. For example, American Pipit, Horned Lark, and Snow Bunting, which use high-elevation habitats similar to those sampled in the mine study area, were found to be more abundant in LCNP. In general, however, the average occurrences of landbird species, and especially the scrub-adapted species, in LCNP were below those recorded in the mine study area (Table 16.5-6). Similar low abundance measurements were recorded for the scrub-adapted species in the LCNP study when compared to the Becharof Lake and Mother Goose Lake studies. Average occurrences across all landbird species at LCNP ranged from 0.002 to 0.628 compared to a range of 0.003 to 1.621 in the mine study area. This reduced abundance across all landbird species in LCNP most likely is a result of the point-count sampling there being conducted over a far greater geographical area and elevational range than in the mine study area. This will cause a “dilution effect” in which the average occurrences calculated for each species in the LCNP study will, in general, be reduced by the inclusion of a larger number of point-counts conducted in habitats, for example, where many scrub-adapted landbird species do not occur (e.g., forests, which essentially do not occur in the mine study area). In contrast, in the mine study area, there is likely a “concentration effect” occurring because many of the same habitats are repeatedly surveyed (by design).

The point-count surveys conducted by Ruthrauff et al. (2007) in KNP, yielded similar results to those from LCNP, but in general the abundances of scrub-adapted species were higher and somewhat more comparable to the abundances of those same species found in the mine study area and at Becharof and Mother Goose lakes. Like the LCNP sampling, the point-count sites at KNP were spread across a large geographical area and elevational range, which will tend to result in lower average-occurrence values for landbirds. Fewer forest species, however, were recorded in KNP compared to LCNP, and overall the average-occurrence values at KNP were higher and somewhat more comparable to those in the mine study area. Average occurrences for landbirds in KNP ranged from 0.002 to 0.868 compared to a range of 0.003 to 1.621 in the mine study area.

Of the two landbird species of conservation concern recorded in the mine study area, Gray-cheeked Thrush and Blackpoll Warbler (see Sections 16.5.7.4 and 16.5.7.8 below for more information on these species), Gray-cheeked Thrushes were roughly twice as abundant in the mine study area compared to Becharof Lake and Mother Goose Lake (Table 16.5-6). Gray-cheeked Thrushes occur throughout southwestern Alaska, but typically occur more commonly as a breeder in scrub habitats at higher elevations in mountainous terrain, as is present in the mine study area. Point-count sampling in the mine study area occurred at elevations from approximately 260 to 790 meters. The sampling at Becharof Lake and Mother Goose Lake occurred at lower elevations than in the mine study area (approximately 10 to 275 meters at Becharof Lake and 30 to 365 meters at Mother Goose Lake). Gray-cheeked Thrushes were not recorded in KNP and were more abundant in the mine study area than in LCNP (over an order of magnitude more abundant) (Table 16.5-6). This greater abundance in the mine study area likely is because scrub habitats were not as intensively sampled at LCNP.

As noted above, the other landbird species of conservation concern recorded in the mine study area, Blackpoll Warbler, did not occur at Mother Goose Lake, Becharof Lake, or KNP (all three areas are south of the range of Blackpoll Warblers on the Alaska Peninsula). Similar to Gray-cheeked Thrushes, Blackpoll Warblers also are commonly found in scrub habitats in western Alaska, and this species was two orders of magnitude more abundant in the mine study area than in LCNP (Table 16.5-6), where scrub habitats were less intensively sampled.

16.5.7.3 Landbird Habitat Associations

Average-occurrence figures (numbers of birds observed per point-count), derived from focal observations only, were used to evaluate habitat use of landbirds in the mine study area. Using an average measure of abundance for each species in each habitat eliminates the bias that occurs in comparing total numbers of birds observed among habitats when unequal numbers of point-counts are conducted in different habitats (see Section 16.5.6.1).

In the mine study area, the greatest numbers of breeding landbird species were recorded in tall- and low-scrub habitats in each of three physiographic types (riverine, lowland, and upland). In each of these six tall- and/or low-scrub habitats, between 13 and 16 landbird species were recorded; which represents 57 to 70 percent of the 23 species recorded as focal observations (Table 16.5-7). No more than seven landbird species were recorded in any other habitat. The three least productive of the 19 sampled habitats for landbird species were Alpine Moist Graminoid–Forb Meadow, Upland Dry Barrens, and Lacustrine Moist Barrens (no landbird species was recorded in any of these habitats, although sample sizes were very low in each habitat). Other habitats, including forests (which are rare in the mine study area), meadows, bogs, dwarf-scrub, and barren areas supported relatively small numbers (two to seven) of breeding landbird species (Table 16.5-7).

The nine most abundant landbird species observed in the mine study area (Savannah Sparrow, Golden-crowned Sparrow, Wilson’s Warbler, Orange-crowned Warbler, Common Redpoll, American Tree Sparrow, Gray-cheeked Thrush, Fox Sparrow, and Yellow Warbler) used the widest array of habitats (six to 13 habitats per species; Table 16.5-7). The eight common species in the study area (Northern Waterthrush, Lapland Longspur, American Robin, American Pipit, Blackpoll Warbler, Hermit Thrush, Horned Lark, and Snow Bunting) used fewer habitats (two to seven) and the remaining uncommon species used a still smaller set of habitats (one to three).

Although the frequency of use varied among species, all the abundant species in the study area regularly used low- and tall-scrub habitats in each of three physiographic areas (riverine, lowland, and upland). These same scrub habitats also were used by many of the common species. Savannah Sparrow, the most abundant species in the mine study area, and four of the common species (Lapland Longspur, American Pipit, Horned Lark, and Snow Bunting) also frequently used dwarf-scrub habitats in alpine and upland areas. Meadow and bog habitats were commonly used by Savannah Sparrows and to a lesser extent by Lapland Longspurs. Barren habitats were regularly used by those relatively few landbird species (Horned Lark, American Pipit, Snow Bunting) which favor rocky and partially vegetated habitats. Large areas of dwarf-, low-, and tall-scrub habitats occur in the mine study area (see Section 16.1) and these habitats are known to be commonly used during the breeding season by many of the abundant and common landbird species recorded in the area (Williamson and Peyton, 1962; Kessel, 1998).

An assessment of the value of all available habitats in the mine study area for a subset of landbird species that are of conservation concern or management concern is presented in Section 16.1.

16.5.7.4 Landbird Species of Conservation Concern

No landbirds that breed in Alaska are listed as federally endangered or threatened, or as proposed or candidate species (USFWS, 2006). A number of landbird species in the state, however, are listed as conservation-priority species by government agencies and non-governmental organizations that consider bird-conservation issues in Alaska and some of these species occur in the mine study area (Table 16.5-1). Using the criteria defined for this study to assess which species are of conservation concern (see Section 16.5.6.2), researchers determined that two (seven percent) of the 28 landbird species recorded in the mine study area are of conservation concern for Alaska (Table 16.5-1, Figure 16.5-3). These two species (Gray-cheeked Thrush and Blackpoll Warbler) were confirmed to nest in the mine study area or were inferred to do so based on behavioral observations. The conservation concerns for these two species are outlined below.

Gray-cheeked Thrush

The Gray-cheeked Thrush is of conservation concern because there are indications, from an analysis of data from the North American Breeding Bird Survey (BBS), that declines in breeding populations in eastern North America occurred from 1978 to 1988 (Sauer and Droege, 1992). A longer-term analysis of BBS data for Canada only, where this species is more common, shows a statistically significant population decline of 8.8 percent per year from 1967 to 2000 (although these results apply to only a small portion of the breeding range; Dunn, 2005). Similar population-trend data for Alaska are not available (Sauer et al., 2005). On its tropical wintering grounds (largely South America east of the Andes), this species is considered vulnerable to deforestation of broadleaf forests (Petit et al., 1993). Because Gray-cheeked Thrushes breed largely in relatively remote and undisturbed boreal forest and arctic environments where population threats are minimal, it is possible that declines in breeding populations may be driven primarily by the effects of tropical deforestation on the wintering grounds. Still, there are concerns that breeding populations in Alaska should be maintained because a large percentage of the species' global breeding range is concentrated in Alaska (BPIFWG, 1999). The Gray-cheeked Thrush is listed as a species of conservation concern for Alaska on four of the eight agency or working group lists that consider landbird conservation issues in the state (Table 16.5-1).

Gray-cheeked Thrushes are known to be common in upland, often mountainous, scrub habitats in Alaska during the breeding season and they were found to be abundant in the mine study area (Table 16.5-4). Gray-cheeked Thrushes occurred most commonly in tall-scrub habitats in upland, lowland, and riverine settings in the study area; the species was less common in low-scrub habitats (Table 16.5-7; see also Section 16.1).

Blackpoll Warbler

An analysis of BBS data for Blackpoll Warblers showed breeding populations across North America declining 9.5 percent per year between 1980 and 2004 (Sauer et al., 2005). Population numbers had increased from 1966 to 1979, but declined thereafter (Sauer et al., 2005). An analysis of data from Alaska also indicated a decline in breeding populations, in this case 3.0 percent per year, between 1980 and 2004 (Sauer et al., 2005). On the wintering grounds in South America, the species is considered highly vulnerable to the removal of tropical forests (Petit et al., 1993, 1995), and there are suggestions that heavy mortality can occur during trans-oceanic fall-migration flights because of tropical storms (Butler, 2000). Because Blackpoll Warblers in Alaska breed largely in relatively remote and undisturbed boreal forest regions (areas with few population threats), the implication is that declines in breeding populations may be driven primarily by the combined effects of mortality during migration and of tropical deforestation on the wintering grounds. Conservation concerns in Alaska are that breeding populations should be maintained because a large percentage of the species' global breeding range is concentrated in Alaska (BPIFWG, 1999). Blackpoll Warbler is listed as a species of conservation concern for Alaska on six of the eight agency or working group lists that consider landbird conservation issues in the state (Table 16.5-1).

Blackpoll Warblers are known to be patchy in their occurrence in appropriate habitat in Alaska, but they were considered to be common in the mine study area (Table 16.5-4), where they were observed most frequently in Riverine Tall Alder or Willow Scrub; the species was less common in low-scrub habitats and in tall-scrub habitats in upland and lowland areas (Table 16.5-7; see also Section 16.1).

16.5.7.5 Shorebird Occurrence

Researchers observed a total of 14 shorebird species in the mine study area during point-count surveys in 2004 and 2005 (Table 16.5-8) and calculated a mean of 1.1 shorebird observations per point-count over the two seasons. Most shorebirds observed were assumed to be nesting in the area, based on observations of nests and/or broods, repeated observations of display activities, or alarm/mobbing reactions typical of nesting shorebirds. Shorebirds were more prevalent in the mine study area than in the transportation-corridor, Bristol Bay drainages study area and in the Cook Inlet drainages study area (Sections 16.11 and 41.5, respectively). Shorebird species richness and abundance both were substantially higher in the mine study area than in these other study areas (14 species compared to seven and two species, respectively, and 1.1 shorebirds per point-count compared to 0.3 birds and 0.1 birds per point-count, respectively). The greater species richness and abundance of shorebirds in the mine study area undoubtedly is because of the much greater predominance there of open graminoid and dwarf-scrub habitats suitable for shorebird breeding.

No shorebird species was considered abundant in the mine study area. The most frequently observed species (those observed in both years and with 14 or more point-count observations in each year) were categorized as common in the area (Table 16.5-9). This set of six species includes Greater Yellowlegs, Wilson's Snipe, Least Sandpiper, Black-bellied Plover, Whimbrel, and American Golden-Plover. Three of these species (Greater Yellowlegs, Wilson's Snipe, and Whimbrel) comprised 54 percent of all point-count observations of shorebirds in both years combined. Eight species (recorded in only one year or recorded less than 10 times in any one year) were considered uncommon (Table 16.5-9).

The average occurrences of shorebird species in the mine study area varied among species and between years. Average occurrences in 2004 ranged from 0.006 for Wandering Tattler and Lesser Yellowlegs to 0.253 for Greater Yellowlegs, and in 2005 ranged from 0.009 for Lesser Yellowlegs and Hudsonian Godwit to 0.264 for Greater Yellowlegs. Based on average-occurrence figures, Wilson's Snipe and Whimbrels were recorded more often in 2005 than 2004, whereas Least Sandpipers, Black-bellied Plovers, and Hudsonian Godwits were recorded more often in 2004 (Table 16.5-9).

During the eight additional point-counts conducted east of the mine study area in 2005 (Figure 16.5-1), six shorebird species were recorded (Table 16.5-10). These six species also were found in the mine study area. The relative abundance of shorebirds in this area was similar to that recorded in the mine study area, although Whimbrels were notably more common in the data from this small number of point-counts conducted east of the mine study area. Average-occurrence values for the six shorebird species recorded on these eight point-counts were higher than the average occurrences in the mine study area (the values undoubtedly being inflated by the low number of points surveyed).

As with the assessment of landbird abundance, the abundance of shorebirds in the mine study area can be compared with shorebird abundance in three areas on the upper Alaska Peninsula and one in western Cook Inlet (Figure 16.5-2). To standardize abundance data across studies in which different numbers of point-counts were conducted, average-occurrence figures are used (Table 16.5-11). Point-count-based studies in which shorebirds were observed were conducted at Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge (Dewhurst et al., 1996b; Egan and Adler, 2001), at Becharof Lake in Becharof National Wildlife Refuge (Moore and Leeman, 1996), and at KNP and LCNP (Ruthrauff et al., 2007). As noted above for the comparisons of landbird abundance, there are differences in the sizes of study areas and the habitats surveyed among these studies that make the comparisons of shorebird abundance approximate. Notwithstanding these caveats, the comparisons are still instructive.

The two most common shorebird species in the mine study area in 2004 and 2005 (Greater Yellowlegs and Wilson's Snipe) also were the two most common species recorded at Mother Goose Lake, Becharof Lake, and KNP (Semipalmated Plover tied with Wilson's Snipe as the second most common species at Becharof Lake). In LCNP, Wilson's Snipe was the second most common species recorded, but Lesser Yellowlegs (instead of Greater Yellowlegs) was the most common shorebird species. Of the five areas studied, Lesser Yellowlegs were recorded only in LCNP and in the mine study area. The range of Lesser Yellowlegs does not extend southward onto the Alaska Peninsula (Tibbitts and Moskoff, 1999), and Lesser Yellowlegs were present in much smaller numbers in the mine study area compared to LCNP.

Shorebird species composition and abundance varied among the different studies, likely due primarily to differences in the habitats surveyed and to variability in the breeding ranges of individual species. For example, the breeding ranges of Whimbrel and Wandering Tattler in western Alaska barely reach south to the northern portions of the Alaska Peninsula (Skeel and Mallory, 1996; Gill et al., 2002), and these two species were not recorded at Becharof Lake or Mother Goose Lake, but were found in both the mine study area and LCNP (Whimbrel, but not Wandering Tattler was recorded at KNP). Similarly, Solitary Sandpiper, a species typical of lower elevation forested regions in Alaska (Moskoff, 1995), was found in LCNP but was not present at the Alaska Peninsula sites or in the mine study area. The average-occurrence values for shorebirds across all species were broadly similar in the mine study area and at Becharof Lake (ranging from 0.020 to 0.374 at Becharof Lake and from 0.003 to 0.260 in the mine study area; Table 16.5-11). The abundances of shorebirds at Mother Goose Lake, KNP, and LCNP were lower (average occurrences ranging from 0.007 to 0.085, 0.002 to 0.147, and from 0.002 to 0.096, respectively). The habitats surveyed at Mother Goose Lake likely are less attractive to breeding shorebirds than that in the mine study area because of the presence of extensive balsam poplar woodlands (Dewhurst et al., 1996b; Egan and Adler, 2001). The lower average occurrences for shorebirds in KNP and LCNP relative to the mine study area likely are at least partially because of a dilution effect, as noted above in the discussion of landbird abundance. This dilution effect occurs because the average occurrences calculated for each species in the KNP and LCNP data sets are reduced by the inclusion of a relatively large number of point-counts conducted in habitats where many shorebird species do not occur (e.g., forested areas).

Three species of shorebirds (Black-bellied Plover, Pacific Golden-Plover, and Hudsonian Godwit) were observed breeding in the mine study area and in KNP but were not detected in the LCNP surveys (Ruthrauff et al., 2007) or at Mother Goose Lake (Dewhurst et al., 1996b; Egan and Adler, 2001). To the researchers' knowledge, these three species have been documented only infrequently as breeders in southwestern Alaska. Black-bellied Plovers were observed in the Iliamna region by Williamson and Peyton (1962) and were thought by locals to be breeding in the area. They were subsequently recorded only as migrants in Katmai (Gibson, 1970) and at Ugashik Bay (Gibson and Kessel, 1983) and were considered by Kessel and Gibson (1978) to be nonbreeders in southwestern Alaska. Moore and Leeman (1996), however, suspected that both Black-bellied Plovers and "Lesser Golden-Plovers" (American and Pacific not separated) may have been breeding at Becharof Lake on the Alaska Peninsula. Recent surveys by Ruthrauff et al. (2007) confirm that both Black-bellied Plovers and Pacific Golden-Plovers occur on the Alaska Peninsula (at KNP).

In the mine study area, researchers recorded 33 Black-bellied Plovers during point-counts in 2004 and 2005, and 25 additional birds as incidental or in-transit observations. Breeding was documented by observations of at least one nest in 2004 and a brood in 2005, as well as observations of territorial nesting behavior by many birds in both years. In a recent study of breeding American and Pacific Golden-Plovers in southwestern Alaska, Bennett (1996c) discovered golden-plovers breeding in interior areas of the region. Bennett documented the two species north of Iliamna Lake in an area that includes the mine study area. Surveys in 2004 and 2005 confirm this finding, as researchers observed 60 golden-plovers (including point-count, incidental, and in-transit observations) within the mine study area. Most of these birds were confirmed or presumed breeders. It is possible that the two golden-plover species breed contiguously in interior regions of southwestern Alaska to the Kuskokwim River, as Bennett (1996c) proposes, but until that is determined, the mine study area and surrounding region is best considered part of a small interior breeding area for *Pluvialis* plovers (black-bellied and golden-plovers) in southwestern Alaska.

The third species recorded in the mine study area and in KNP, but not at the other Alaska Peninsula sites or in LCNP, Hudsonian Godwit, has a patchy and poorly known breeding range in Alaska (see Section 16.5.7.7). To the researchers' knowledge, prior to the surveys by Ruthrauff et al. (2007), this species had not been documented as breeding or suspected of breeding in interior areas of southwestern Alaska or on the Alaska Peninsula. Six Hudsonian Godwits were recorded during point-counts in the mine study area in 2004 and 2005, and eight were recorded in the set of incidental and in-transit observations. These birds all exhibited strong territorial nesting behavior and were presumed to be breeders in the area.

Of the five shorebird species of conservation concern recorded in the mine study area (see Sections 16.5.7.7 and 16.5.7.8 below for more information on these species), one species, Hudsonian Godwit, is discussed above. All of the other four species—American Golden-Plover, Whimbrel, Surfbird, and Short-billed Dowitcher—also were recorded in LCNP but in lower abundances than in the mine study area (Table 16.5-11). Three of those four species (American Golden-Plover, Whimbrel, and Surfbird) also were recorded in KNP on the Alaska Peninsula, where all except Surfbird were recorded in lower abundances than in the mine study area. Short-billed Dowitchers were recorded on the Alaska Peninsula only at Becharof Lake, where they were found to be more abundant than in the mine study area.

16.5.7.6 Shorebird Habitat Associations

Average-occurrence figures (numbers of birds observed per point-count), derived from focal observations only, were used to evaluate habitat use of shorebirds in the mine study area. Using an average measure of abundance for each species in each habitat eliminates the bias that occurs in comparing total numbers of birds observed among habitats when unequal numbers of point-counts are conducted in different habitats (see Section 16.5.6.1).

Shorebirds were found in a variety of habitats throughout the mine study area, but in both years of study, the greatest numbers of shorebird species were concentrated in two habitats: Lowland Ericaceous Scrub Bog and Lowland Wet Graminoid–Shrub Meadow. Both of these habitats supported eight shorebird species (67 percent of the 12 species recorded as focal observations; Table 16.5-12). Five other open habitats (Upland Dry Dwarf Shrub–Lichen Scrub, Upland Moist Dwarf Scrub, Alpine Moist Dwarf Scrub, Alpine Wet Dwarf Shrub–Sedge Scrub, and Riverine Wet Graminoid–Shrub Meadow) also were important for shorebirds and supported between two and four species (17 to 33 percent of the 12 species recorded). All other habitats occupied by shorebirds supported only one shorebird species. The six common shorebird species recorded in the mine study area used the greatest number of habitats (two to six) whereas the other, uncommon species used fewer habitats (one to two; Table 16.5-12).

Hudsonian Godwits were found only in two habitats (Lowland Ericaceous Scrub Bog and Lowland Wet Graminoid–Shrub Meadow) and only in the complex of wetlands and lacustrine waterbodies directly north of Frying Pan Lake. As this species was not previously recorded breeding in the Iliamna Lake region (Williamson and Peyton, 1962) and was not recorded recently in LCNP (Ruthrauff et al., 2007), it appears the mine study area encompasses suitable breeding habitat for Hudsonian Godwits that may not be found abundantly across the Iliamna Lake and Lake Clark region. Several other shorebird species exhibited reasonably specific habitat associations as well. Like Hudsonian Godwits, three other species (Whimbrels, Short-billed Dowitchers, and Red-necked Phalaropes) were found only in Lowland Ericaceous Scrub Bog or Lowland Wet Graminoid–Shrub Meadow (Table 16.5-12), but these species were not restricted to the area north of Frying Pan Lake. Surfbirds were observed exclusively in Alpine Moist Dwarf Scrub and the *Pluvialis* plovers (i.e., black-bellied and golden-plovers) were most commonly observed in dwarf-scrub habitats in upland and alpine areas and in Lowland Ericaceous Scrub Bog or Lowland Wet Graminoid–Shrub Meadow (the latter two habitats being used especially by birds with broods) (Table 16.5-12).

An assessment of the value of all available habitats in the mine study area for a subset of shorebird species of conservation concern is presented in Section 16.1.

16.5.7.7 Shorebird Species of Conservation Concern

No shorebirds that breed in Alaska are listed as federally endangered or threatened, or as proposed or candidate species (USFWS, 2006). Shorebirds are, however, of increasing conservation concern worldwide as many species have relatively low reproductive rates, small effective population sizes, and declining population numbers (IWSG, 2003). Shorebirds also are vulnerable to habitat alteration, especially at migratory staging sites where large numbers of birds congregate (Brown et al., 2001; ASG, 2004). A number of shorebird species in Alaska are listed as species of conservation concern by government agencies and non-governmental organizations that consider bird-conservation issues in the state and several of these species occur in the mine study area (Table 16.5-1). Using the criteria defined for this study to assess which species are of conservation concern (see Section 16.5.6.2), researchers determined that 36 percent (five) of the 14 shorebird species recorded in the mine study area are of conservation concern for Alaska (Table 16.5-1, Figure 16.5-3). These five species—American Golden-Plover, Whimbrel, Hudsonian Godwit, Surfbird, and Short-billed Dowitcher—were confirmed to nest in the mine study area, or were inferred to do so based on behavioral observations. The conservation concerns for these five species are outlined below.

American Golden-Plover

American Golden-Plovers are widely dispersed across arctic regions in Alaska where they defend large territories and breed at low densities. The American Golden-Plover is considered a species of concern for conservation because substantial population declines since the 1970s have been noted on the breeding grounds in the Northwest Territories (Gratto-Trevor et al., 1998). However, analysis of population levels at another Nearctic breeding site did not show population declines, and substantial population declines have not been noted at migration staging areas on the east coast of North America (Morrison et al., 1994). Population threats from habitat loss on the wintering grounds for this species in South America and from alteration of migratory staging habitats and pesticide exposure in the mid-western U.S. during migration are of concern (Johnson, 2003). Because this species breeds in remote and relatively undisturbed arctic regions, population declines generally are suspected to occur from increased mortality during the nonbreeding seasons. Concerns about breeding-population declines in this species are still warranted because little information is known about population trends of this species during breeding. The American Golden-Plover is listed as a species of conservation concern for Alaska on three of the eight agency or working group lists that consider shorebird conservation issues in the state (Table 16.5-1).

American Golden-Plovers were considered common in the mine study area and were frequently observed in both 2004 and 2005 (Table 16.5-9). The species was recorded most commonly in Alpine Moist Dwarf Scrub, Upland Moist Dwarf Scrub, Upland Dry Dwarf Shrub–Lichen Scrub, and Lowland Ericaceous Scrub Bog (Table 16.5-12; see also Section 16.1).

Whimbrel

Substantial population declines in the Hudson Bay race of Whimbrels, *Numenius phaeopus hudsonicus*, (Skeel and Mallory, 1996; Brown et al., 2001) are the primary reason this species is considered of conservation concern. An overall low population size for this species and a restricted breeding distribution in North America also are of concern (ASG, 2004). Over 80 percent of the world population of one subspecies, *N. p. rufiventris*, breeds in Alaska (ASG, 2004). Whimbrels winter along both the Pacific and Atlantic coasts of North, Central, and South America, and loss of intertidal mangrove habitat on wintering grounds on the South American Pacific Coast (Skeel and Mallory, 1996) and at migration stopover sites (ASG, 2004) also has been noted. Because this species breeds in remote and relatively undisturbed arctic regions, it is possible that population declines stem primarily from increased mortality during the nonbreeding seasons. Whimbrels are widely dispersed across tundra regions in Alaska and breed at low densities. Whimbrel is listed as a species of conservation concern for Alaska on two of the eight agency or working group lists that consider shorebird conservation issues in the state (Table 16.5-1).

Whimbrels were considered common in the mine study area and were frequently observed in 2004 and 2005 (Table 16.5-9). During the point-count surveys, they were found only in Lowland Ericaceous Scrub Bog and Lowland Wet Graminoid–Shrub Meadow (Table 16.5-12; see also Section 16.1).

Hudsonian Godwit

The Hudsonian Godwit breeds in small, isolated populations across its range in North America, and there is substantial genetic differentiation among populations (Haig et al., 1997), indicating that individual breeding populations are important reservoirs of genetic variation for the species as a whole. Small, disjunct breeding populations also are more susceptible to local impacts. The breeding range of Hudsonian Godwit in Alaska is poorly known, but is believed to be restricted to northwestern and southcentral Alaska, with a total population size in the state of only approximately 5,000 to 7,500 birds (ASG, 2004). (Note the observations reported in this study of the species breeding in southwestern Alaska.) The specific wintering area(s) of the Alaskan breeding populations are unknown. Because of the combination of small breeding populations, limited breeding and wintering areas (most winter at a few sites in southern South America), and a reliance on relatively few staging sites during migration, the species is considered of conservation concern. Habitat loss on the wintering grounds in southern South America also is of concern (Stenhouse and Senner, 2005). The Hudsonian Godwit is listed as a species of conservation concern for Alaska on five of the eight agency or working group lists that consider shorebird conservation issues in the state (Table 16.5-1).

Hudsonian Godwits were considered uncommon in the mine study area and were only infrequently observed in 2004 and 2005 (Table 16.5-9). They were found only in Lowland Ericaceous Scrub Bog and Lowland Wet Graminoid–Shrub Meadow (Table 16.5-12; see also Section 16.1) and only in the wetlands complex directly north of Frying Pan Lake.

Surfbird

Surfbird is a species of conservation concern because of a suspected population decline (based on Christmas bird-count data; Senner and McCaffery, 1997), a relatively low worldwide population size (approximately 70,000 birds), and a restricted breeding distribution (primarily Alaska and the Yukon; ASG, 2004). Over 75 percent of the global population of Surfbirds breeds in Alaska (ASG, 2004). Surfbirds also tend to congregate in large numbers at traditionally used stopover sites during migration (such as Montague Island in Prince William Sound, Alaska), making them vulnerable to impacts from oil spills during migration (Norton et al., 1990; Senner and McCaffery, 1997; Bishop and Green, 2001). Threats from marine pollution during winter also are of concern because the species forages almost exclusively on rocky coastlines along the west coasts of North, Central, and South America. Surfbird is listed as a species of conservation concern for Alaska on five of the eight agency or working group lists that consider shorebird conservation issues in the state (Table 16.5-1).

Surfbirds were considered uncommon in the mine study area and were only infrequently observed in 2004 and 2005 (Table 16.5-9). During point-count surveys, they were found only in Alpine Moist Dwarf Scrub (Table 16.5-12; see also Section 16.1).

Short-billed Dowitcher

Substantial population declines in the central Canadian race of the Short-billed Dowitcher, *Limnodromus griseus griseus*, have been documented, and declines likely have occurred in the eastern Canadian race, *L. g. hendersoni*, also (Donaldson et al., 2000; Brown et al., 2001; Jehl et al., 2001). Adequate trend data are lacking for the Alaskan subspecies, *L. g. caurinus*, to conduct a formal population-trend analysis, but declining numbers on nonbreeding surveys have researchers concerned that populations of this subspecies as well may have declined over the past decade (ASG, 2004). The world population of *L. g. caurinus* is thought to be relatively low (estimated at approximately 75,000 birds; Morrison et al., 2006), all of which breed in Alaska. Habitat loss on the wintering grounds on the Atlantic and Pacific Coasts of North, Central, and South America, and especially at migration stopover sites, also is of concern (Brown et al., 2001; ABC and NAS, 2007). The Short-billed Dowitcher is listed as a species of conservation concern for Alaska on two of the eight agency or working group lists that consider shorebird conservation issues in the state (Table 16.5-1).

Short-billed Dowitchers were considered uncommon in the mine study area and were only infrequently observed in 2004 and 2005 (Table 16.5-9). During the point-count surveys, they were found only in Lowland Wet Graminoid–Shrub Meadow (Table 16.5-12; see also Section 16.1).

16.5.7.8 Synopsis of Species of Conservation Concern

Based on the species-selection criteria outlined above in Section 16.5.6.2, seven (17 percent) of the 42 landbird and shorebird species recorded during the surveys in the mine study area are considered conservation priority species for Alaska. All of these species were presumed to nest within the mine study area. All seven species occurred more frequently in the mine study area than in recent surveys in LCNP (Ruthrauff et al., 2007). As noted above, however, this result likely is an artifact of the greater geographical extent and greater elevational range surveyed in LCNP. Six of the seven species (all except Short-billed Dowitcher) were detected more frequently in the mine study area than in studies on the upper Alaska Peninsula (Dewhurst et al., 1996a; Moore and Leeman, 1996; Egan and Adler, 2001). American Golden-Plover, Whimbrel, and Hudsonian Godwit also appeared to be more common in the mine study area than they were historically in the broader Iliamna Lake region (Williamson and Peyton, 1962); Whimbrel and Hudsonian Godwit were not recorded by Williamson and Peyton (1962).

16.5.8 Summary

Researchers conducted 166 point-counts and recorded 1,794 individual birds in the mine study area in 2004, and conducted 227 point-counts and recorded 2,636 individual birds in 2005. Including incidental and in-transit observations, researchers identified 28 landbird species and 14 shorebird species in 2004 and 2005. Using point-count survey data, researchers calculated a mean of 10.2 landbirds and 1.1 shorebirds per point-count over both years. Nine landbird species (Savannah Sparrow, Golden-crowned Sparrow, Wilson’s Warbler, Orange-crowned Warbler, Common Redpoll, American Tree Sparrow, Gray-cheeked Thrush, Fox Sparrow, and Yellow Warbler) were considered to be abundant breeders in the mine study area. Three of these species (Savannah Sparrow, Golden-crowned Sparrow, and Wilson’s Warbler) were especially abundant and comprised 37 percent of the point-count observations in both years combined. No shorebird species was considered to be an abundant breeder. A variety of shorebird species were observed in the mine study area, however, and six of the 14 species observed (Greater Yellowlegs, Wilson’s Snipe, Least Sandpiper, Black-bellied Plover, Whimbrel, and American Golden-Plover) were considered common breeders. Of the various landbird and shorebird species-groups observed, sparrows were by far the most abundant breeders, while warblers, thrushes, and finches also were common. Larks, pipits, and swallows were less common, and ptarmigan, flycatchers, corvids, and kinglets were rarely recorded in the area. Sandpipers and plovers were the only shorebird species-groups recorded. Landbird and shorebird abundance in the mine study area often was found to be greater than in other comparable studies conducted elsewhere in southwestern Alaska.

Landbirds were recorded in 15 of the 19 wildlife-habitat types sampled in the study area and shorebirds were recorded in 12. Species richness of landbirds and shorebirds in each of the sampled habitats ranged from 0 to 16, and bird abundance within each habitat ranged from 0.0 to 10.2 birds per point-count. Eight scrub, bog and meadow habitats (Riverine Tall Alder or Willow Scrub, Lowland Ericaceous Scrub Bog, Upland Moist Tall Willow Scrub, Upland Moist Tall Alder Scrub, Upland Moist Low Willow Scrub, Lowland Low and Tall Willow Scrub, Riverine Low Willow Scrub, and Lowland Wet Graminoid–Shrub Meadow) supported the highest numbers of breeding landbird and shorebird species (both groups considered together). The most productive breeding habitats, in terms of bird abundance, were Lowland Low and Tall Willow Scrub, Riverine Tall Alder or Willow Scrub, and Upland Moist Tall Willow Scrub. In these three habitats, more than nine birds were observed per point-count. Most landbirds regularly used tall- and low-scrub habitats, but open habitats (bogs, meadows, dwarf-scrub types, and barrens) were used by those species that favor more open habitats. Shorebirds were found most commonly in open habitats, including bogs, meadows, dwarf-scrub types, and barren habitats.

Seven (17 percent) of the 42 landbird and shorebird species observed during the survey efforts in 2004 and 2005 are considered conservation priority species for Alaska, and all were recorded as nesting or presumed to be nesting within the mine study area. Two of the seven species (Gray-cheeked Thrush and Blackpoll Warbler) are landbird species, and the remainder (American Golden-Plover, Whimbrel, Hudsonian Godwit, Surfbird, and Short-billed Dowitcher) are shorebirds.

16.5.9 References

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16.5.10 Glossary

Avifauna—the set of bird species occurring in a particular geographic region

Corvid—any bird species in the family Corvidae, which includes the jays, crows, and ravens

Graminoid—grass and grass-like plants (including sedges and rushes)

Lacustrine—associated with lakes and ponds, and landscape features derived from the development of lakes and ponds

Nearctic—the arctic, boreal, and temperate climate regions in the New World in which the wildlife species present share many biogeographic and taxonomic affinities

Passerine—collectively, the group of songbirds or perching birds in the taxonomic order Passeriformes

Photosignature—a combination of color and texture on an aerial photo indicative of a particular vegetation or land-cover type

Physiography—in the limited sense used here, a categorization of landforms/topographic regions into classes, which are based largely on the geomorphological forces shaping the landforms in those areas (e.g., alpine, subalpine, upland, lowland, lacustrine [see above], riverine [see below], and coastal)

Riverine—associated with rivers and streams, and landscape features developed from the actions of rivers and streams

TABLES

TABLE 16.5-1
Landbird and Shorebird Species of Conservation Concern[a] For Alaska Observed in the Mine Study Area, 2004 and 2005, and Listing Status

Species	USFWS[b]	BLM[c]	USFS[d]	ADF&G[e]	Audubon[f]	AKNHP[g]	BPIF[h]	ASG[i]
Gray-cheeked Thrush	—[j]	Sensitive species	—	Species of special concern	—	Vulnerable	Priority species for conservation	—
Blackpoll Warbler	Species of conservation concern	Sensitive species	—	Species of special concern and featured species for conservation	Species at risk	—	Priority species for conservation	—
American Golden-Plover	Species of conservation concern	—	—	—	Species at risk	—	—	Species of high conservation concern
Whimbrel	Species of conservation concern	—	—	—	—	—	—	Species of high conservation concern
Hudsonian Godwit	Species of conservation concern	Sensitive species	—	—	Species at risk	Vulnerable	—	Species of high conservation concern
Surfbird	Species of conservation concern	Sensitive species	—	—	Species at risk	Imperiled	—	Species of high conservation concern
Short-billed Dowitcher	Species of conservation concern	—	—	—	—	—	—	Species of high conservation concern

Notes:

a. See Section 16.5.6.2 for definition of species of conservation concern.

b. U.S. Fish and Wildlife Service (USFWS), Birds of Conservation Concern (USFWS, 2002); species shown are listed in either, or both, of two Bird Conservation Regions (BCRs) (western Alaska and northwestern interior forest) because the mine study area is near the border between the two BCRs.

c. Bureau of Land Management (BLM), Alaska Threatened, Endangered, and Sensitive Species List (BLM, 2005).

d. U.S. Forest Service (USFS), Alaska Region Sensitive Species List (USFS, 2002).

e. Alaska Department of Fish and Game (ADF&G), Species of Special Concern (ADG&G, 1998) and Comprehensive Wildlife Conservation Strategy (ADF&G, 2006).

f. Audubon Alaska WatchList 2005 (Stenhouse and Senner, 2005).

g. Alaska Natural Heritage Program (AKNHP), Birds Tracking List (AKNHP, 2007); state listings only; the highest conservation ranking for either the breeding or nonbreeding season is shown; secure and apparently secure rankings (roughly equivalent to low and moderate conservation-concern classes) are not shown.

h. Boreal Partners in Flight Working Group (BPIFWG), Landbird Conservation Plan for Alaska Biogeographic Region (BPIFWG, 1999).

i. Alaska Shorebird Group (ASG), A Conservation Plan for Alaska Shorebirds (ASG, 2004); species of high concern only are listed.

j. A dash indicates the species was not listed by that group or its ranking fell below the conservation-status threshold for inclusion (see notes above).

TABLE 16.5-2
Number of Point-counts, Number of Focal Observations, Focal Observations per Count, and Species Richness Recorded in Mapped Habitat Types[a] during Point-count Surveys for Landbirds and Shorebirds, Mine Study Area, 2004 and 2005

Aggregated Habitat Type	No. of Point-counts	No. of Focal Observations[b]	Focal Observations per Count	Species Richness[c]
Alpine Dry Barrens	7	11	1.6	4
Alpine Moist Dwarf Scrub	52	147	2.8	10
Alpine Moist Graminoid–Forb Meadow	1	0	0.0	0
Alpine Wet Dwarf Shrub–Sedge Scrub	7	10	1.4	4
Upland Dry Barrens	1	0	0.0	0
Upland Dry Dwarf Shrub–Lichen Scrub	38	57	1.5	9
Upland Moist Dwarf Scrub	38	62	1.6	8
Upland Moist Low Willow Scrub	34	167	4.9	15
Upland Moist Tall Alder Scrub	25	156	6.2	15
Upland Moist Tall Willow Scrub	39	365	9.4	15
Upland and Lowland Spruce Forest	0	0	0.0	0
Upland and Lowland Moist Mixed Forest	2	7	3.5	5
Rivers and Streams	0	0	0.0	0
Rivers and Streams (Anadromous)	0	0	0.0	0
Riverine Barrens	0	0	0.0	0
Riverine Wet Graminoid–Shrub Meadow	17	30	1.8	6
Riverine Low Willow Scrub	24	156	6.5	14
Riverine Tall Alder or Willow Scrub	40	389	9.7	16
Riverine Moist Mixed Forest	0	0	0.0	0
Lakes and Ponds	3	0	0.0	0
Lacustrine Moist Barrens	2	0	0.0	0
Lowland Sedge–Forb Marsh	0	0	0.0	0
Lowland Ericaceous Scrub Bog	17	52	3.1	15
Lowland Wet Graminoid–Shrub Meadow	40	94	2.4	13
Lowland Low and Tall Willow Scrub	14	143	10.2	15

Notes:

a. See Section 16.1 for information on wildlife habitat mapping in the mine study area.

b. Focal observations were recorded in the habitat being sampled; observations recorded in adjacent habitats are not shown.

c. Species richness calculated only for focal observations in each habitat.

TABLE 16.5-3
Landbird Species Observed during Point-count Surveys and Incidentally at Point-count Locations[a], Mine Study Area, 2004 and 2005

Avian Group	Common Name	Scientific Name
Grouse & Ptarmigan	Willow Ptarmigan	*Lagopus lagopus*
	Rock Ptarmigan	*Lagopus muta*
Corvids	Black-billed Magpie[b]	*Pica pica*
	Common Raven	*Corvus corax*
Passerines	Alder Flycatcher	*Empidonax alnorum*
	Horned Lark	*Eremophila alpestris*
	Tree Swallow	*Tachycineta bicolor*
	Bank Swallow	*Riparia riparia*
	American Dipper[b]	*Cinclus mexicanus*
	Ruby-crowned Kinglet	*Regulus calendula*
	Arctic Warbler	*Phylloscopus borealis*
	Gray-cheeked Thrush *	*Catharus minimus*
	Hermit Thrush	*Catharus guttatus*
	American Robin	*Turdus migratorius*
	American Pipit	*Anthus rubescens*
	Orange-crowned Warbler	*Vermivora celata*
	Yellow Warbler	*Dendroica petechia*
	Blackpoll Warbler *	*Dendroica striata*
	Northern Waterthrush	*Seiurus noveboracensis*
	Wilson's Warbler	*Wilsonia pusilla*
	American Tree Sparrow	*Spizella arborea*
	Savannah Sparrow	*Passerculus sandwichensis*
	Fox Sparrow	*Passerella iliaca*
	Lincoln's Sparrow	*Melospiza lincolnii*
	Golden-crowned Sparrow	*Zonotrichia atricapilla*
	Lapland Longspur	*Calcarius lapponicus*
	Snow Bunting	*Plectrophenax nivalis*
	Common Redpoll	*Carduelis flammea*

Notes:

a. No additional landbird species were observed in transit between point-count locations.

b. Incidental observations only.

* Denotes a species of conservation concern for Alaska (see Table 16.5-1).

TABLE 16.5-4
Number, Percent of Total Observations, and Average Occurrence of Landbird Species Observed during Point-count Surveys, Mine Study Area, 2004 and 2005

	2004			2005		
Avian Species	**No.**	**%**	**Avg. Occurrence[a] (*n*=166)**	**No.**	**%**	**Avg. Occurrence[a] (*n*=227)**
Savannah Sparrow	271	16.9	1.633	366	15.3	1.612
Golden-crowned Sparrow	213	13.3	1.283	330	13.8	1.454
Wilson's Warbler	143	8.9	0.861	333	13.9	1.467
Orange-crowned Warbler	135	8.4	0.813	172	7.2	0.758
Common Redpoll	123	7.7	0.741	123	5.2	0.542
American Tree Sparrow	122	7.6	0.735	160	6.7	0.705
Gray-cheeked Thrush	116	7.2	0.700	251	10.5	1.106
Fox Sparrow	96	6.0	0.578	159	6.7	0.700
Yellow Warbler	93	5.8	0.560	178	7.5	0.784
Northern Waterthrush	57	3.6	0.343	69	2.9	0.304
Lapland Longspur	57	3.6	0.343	41	1.7	0.181
Bank Swallow	40	2.5	0.241	0	0.0	0.000
American Robin	31	1.9	0.187	38	1.6	0.167
American Pipit	26	1.6	0.157	25	1.0	0.110
Blackpoll Warbler	18	1.1	0.108	34	1.4	0.150
Hermit Thrush	15	0.9	0.090	39	1.6	0.172
Horned Lark	13	0.8	0.078	18	0.8	0.079
Snow Bunting	10	0.6	0.060	11	0.5	0.048
Arctic Warbler	6	0.4	0.036	0	0.0	0.000
Willow Ptarmigan	4	0.2	0.024	17	0.7	0.075
Common Raven	4	0.2	0.024	1	<0.1	0.004
Unidentified swallow	4	0.2	0.024	0	0.0	0.000
Tree Swallow	2	0.1	0.012	2	<0.1	0.009
Unidentified warbler	2	0.1	0.012	0	0.0	0.000
Lincoln's Sparrow	1	<0.1	0.006	6	0.3	0.026
Rock Ptarmigan	1	<0.1	0.006	1	<0.1	0.004
Unidentified finch	1	<0.1	0.006	0	0.0	0.000
Alder Flycatcher	0	0.0	0.000	9	0.4	0.040
Unidentified thrush	0	0.0	0.000	2	<0.1	0.009
Unidentified passerine	0	0.0	0.000	2	<0.1	0.009
Ruby-crowned Kinglet	0	0.0	0.000	1	<0.1	0.004

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

TABLE 16.5-5
Number, Percent of Total Observations, and Average Occurrence of Landbird Species Observed during Eight Additional Point-count Surveys Conducted East of the Mine Study Area[a] in the Bristol Bay Drainages, 2005

Avian Species	**No.**	**%**	**Avg. Occurrence[b] (*n*=8)**
Wilson's Warbler	11	15.1	1.375
Savannah Sparrow	10	13.7	1.250
Orange-crowned Warbler	9	12.3	1.125
American Tree Sparrow	8	11.0	1.000
Northern Waterthrush	7	9.6	0.875
Fox Sparrow	6	8.2	0.750
Golden-crowned Sparrow	6	8.2	0.750
White-crowned Sparrow	5	6.8	0.625
Blackpoll Warbler	4	5.5	0.500
Willow Ptarmigan	2	2.7	0.250
Gray-cheeked Thrush	2	2.7	0.250
Black-capped Chickadee	1	1.4	0.125
Yellow Warbler	1	1.4	0.125
Lapland Longspur	1	1.4	0.125

Notes:

a. See Figure 16.5-1 for point-count locations.

b. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

TABLE 16.5-6
Average Occurrence[a] of Landbird Species Observed in the Mine Study Area, 2004 and 2005, and in other Studies in Southwestern Alaska in which Off-road Point-count Surveys Were Conducted

Landbird Species	**Mother Goose Lake (*n*=141)[b]**	**Becharof Lake (*n*=99)[c]**	**Katmai NP (n=468)[d]**	**Lake Clark NP (*n*=417)[d]**	**This study (*n*=393)**
Savannah Sparrow	0.255	1.707	0.239	0.175	1.621
Golden-crowned Sparrow	0.915	1.879	0.868	0.628	1.382
Wilson's Warbler	3.057	1.808	0.485	0.261	1.211
Gray-cheeked Thrush	0.482	0.414		0.034	0.934
Orange-crowned Warbler	0.993	1.091	0.295	0.077	0.781
American Tree Sparrow		0.182	0.327	0.360	0.718
Yellow Warbler	0.993	0.727	0.051	0.098	0.690
Fox Sparrow	0.603	0.394	0.575	0.374	0.649
Common Redpoll	1.723	1.182	0.222	0.568	0.626
Northern Waterthrush			0.004	0.019	0.321
Lapland Longspur		0.182	0.041	0.043	0.249
American Robin	0.745	0.152	0.291	0.300	0.176
Hermit Thrush	1.589	1.455	0.415	0.297	0.137
Blackpoll Warbler				0.002	0.132
American Pipit		0.141	0.415	0.353	0.130
Bank Swallow	0.021				0.102
Horned Lark			0.085	0.103	0.079
Willow Ptarmigan		0.192	0.135	0.168	0.053
Snow Bunting		0.020	0.122	0.082	0.053
Alder Flycatcher	0.376	0.030			0.023
Lincoln's Sparrow			0.002	0.007	0.018
Arctic Warbler					0.015
Common Raven	0.028		0.058	0.072	0.013
Tree Swallow	0.759	0.071	0.038	0.026	0.010
Rock Ptarmigan			0.135	0.084	0.005
Ruby-crowned Kinglet			0.015	0.170	0.003
White-tailed Ptarmigan			0.004	0.012	
Sandhill Crane			0.019	0.002	
Downy Woodpecker	0.014				
American Three-toed Woodpecker			0.009	0.007	
Olive-sided Flycatcher				0.012	
Say's Phoebe				0.005	
Northern Shrike	0.057	0.020	0.002	0.002	
Gray Jay			0.009	0.034	
Black-billed Magpie	0.007		0.011	0.038	
Violet-green Swallow				0.005	
Black-capped Chickadee	0.064	0.081	0.009	0.007	

Landbird Species	Mother Goose Lake (*n*=141)[b]	Becharof Lake (*n*=99)[c]	Katmai NP (n=468)[d]	Lake Clark NP (*n*=417)[d]	This study (*n*=393)
Boreal Chickadee			0.006	0.017	
Golden-crowned Kinglet				0.002	
Northern Wheatear				0.010	
Swainson's Thrush				0.012	
Varied Thrush			0.041	0.192	
Bohemian Waxwing				0.012	
Yellow-rumped Warbler			0.143	0.362	
White-crowned Sparrow	0.163		0.226	0.288	
Dark-eyed Junco			0.115	0.369	
Rusty Blackbird				0.007	
Gray-crowned Rosy-Finch			0.009	0.005	
Pine Grosbeak	0.170		0.006	0.002	
White-winged Crossbill				0.005	
Pine Siskin				0.002	

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

b. Off-road point-count data collected in 1996 and 2000 at Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge; data were combined from Dewhurst et al. (1996b) and Egan and Adler (2001).

c. Off-road point-count data collected in 1996 at Becharof Lake in the Becharof National Wildlife Refuge (Moore and Leeman, 1996).

d. Off-road point-count data collected in 2004–2006 in Katmai and Lake Clark national parks (Ruthrauff et al., 2007).

TABLE 16.5-7
Average Occurrence Figures[a] for Landbirds in Mapped Wildlife Habitat Types, Mine Study Area, 2004 and 2005

Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Moist Graminoid–Forb Meadow	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
	n=7	*n*=52	*n*=1	*n*=7	*n*=1	*n*=38	*n*=38	*n*=34	*n*=25	*n*=39	*n*=0	*n*=2	*n*=0	*n*=0	*n*=0	*n*=17	*n*=24	*n*=40	*n*=0	*n*=3	*n*=2	*n*=0	*n*=17	*n*=40	*n*=14
Willow Ptarmigan		0.038						0.059																	
Rock Ptarmigan		0.038																							
Alder Flycatcher									0.040	0.051								0.075							
Horned Lark		0.231				0.105	0.105																		
Tree Swallow												1.000													
Arctic Warbler								0.059										0.025							0.071
Gray-cheeked Thrush								0.382	1.040	1.179						0.059	0.500	0.775							0.643
Hermit Thrush								0.029	0.280	0.103							0.042	0.050							0.071
American Robin									0.160	0.103		0.500					0.042	0.100							0.071
American Pipit	0.286	0.481					0.079																		
Orange-crowned Warbler								0.500	0.400	1.026		0.500					0.583	1.150					0.118		1.429
Yellow Warbler								0.235	0.680	1.282						0.059	0.167	1.325							1.071
Blackpoll Warbler								0.029	0.040	0.231		0.500					0.083	0.550							0.214
Northern Waterthrush									0.040	0.128							0.125	0.700							0.214
Wilson's Warbler				0.143				0.824	1.080	1.641							0.833	1.675					0.059	0.025	1.714
American Tree Sparrow						0.053		0.471	0.200	0.590						0.176	1.333	0.700					0.059	0.050	0.714
Savannah Sparrow		0.731		1.000		0.342	0.947	1.118	0.560	0.897						1.000	1.792	0.725					1.176	0.675	1.857
Fox Sparrow								0.206	0.720	0.821							0.292	0.700					0.059		0.786
Lincoln's Sparrow									0.040									0.050							
Golden-crowned Sparrow						0.026	0.053	0.588	0.920	1.128		1.000					0.583	0.850					0.059	0.075	1.071
Lapland Longspur	0.286	0.846				0.263	0.158	0.176															0.176	0.050	
Snow Bunting	0.857	0.212																							
Common Redpoll								0.206	0.040	0.128							0.083	0.225							0.214

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted); only focal observations in each habitat are included (see Section 16.5.6.1, Field Surveys and Habitat-use Analyses)

TABLE 16.5-8
Shorebird Species Observed during Point-count Surveys[a], Mine Study Area, 2004 and 2005

Common Name	Scientific Name
Black-bellied Plover	*Pluvialis squatarola*
American Golden-Plover *	*Pluvialis dominica*
Pacific Golden-Plover	*Pluvialis fulva*
Semipalmated Plover	*Charadrius semipalmatus*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Wandering Tattler	*Heteroscelus incanus*
Whimbrel *	*Numenius phaeopus*
Hudsonian Godwit *	*Limosa haemastica*
Surfbird *	*Aphriza virgata*
Least Sandpiper	*Calidris minutilla*
Short-billed Dowitcher *	*Limnodromus griseus*
Wilson's Snipe	*Gallinago delicata*
Red-necked Phalarope	*Phalaropus lobatus*

Notes:

a. No additional shorebird species were recorded incidentally at point-count locations or in transit between point-count locations.

* Denotes a species of conservation concern for Alaska (see Table 16.5-1).

TABLE 16.5-9
Number, Percent of Total Observations, and Average Occurrence of Shorebird Species Observed during Point-count Surveys, Mine Study Area, 2004 and 2005

	2004			2005		
Shorebird Species	**No.**	**%**	**Avg. Occurrence[a] (*n*=166)**	**No.**	**%**	**Avg. Occurrence[a] (*n*=227)**
Greater Yellowlegs	42	22.1	0.253	60	24.2	0.264
Wilson's Snipe	25	13.2	0.151	52	21.0	0.229
Least Sandpiper	24	12.6	0.145	21	8.5	0.093
Black-bellied Plover	18	9.5	0.108	15	6.0	0.066
Whimbrel	18	9.5	0.108	40	16.1	0.176
American Golden-Plover	16	8.4	0.096	14	5.6	0.062
Red-necked Phalarope	7	3.7	0.042	4	1.6	0.018
Semipalmated Plover	7	3.7	0.042	0	0.0	0.000
Unidentified med. shorebird	7	3.7	0.042	1	0.4	0.004
Pacific Golden-Plover	6	3.2	0.036	6	2.4	0.026
Short-billed Dowitcher	6	3.2	0.036	9	3.6	0.040
Unidentified (*Pluvialis*) Plover	6	3.2	0.036	11	4.4	0.048
Hudsonian Godwit	4	2.1	0.024	2	0.8	0.009
Surfbird	2	1.1	0.012	8	3.2	0.035
Lesser Yellowlegs	1	0.5	0.006	2	0.8	0.009
Unidentified yellowlegs	0	0.0	0.000	2	0.8	0.009
Wandering Tattler	1	0.5	0.006	0	0.0	0.000
Unidentified small sandpiper	0	0.0	0.000	1	0.4	0.004

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

TABLE 16.5-10
Number, Percent of Total Observations, and Average Occurrence of Shorebird Species Observed during Eight Additional Point-count Surveys Conducted East of the Mine Study Area[a] in the Bristol Bay Drainages, 2005

Avian Species	**No.**	**%**	**Avg. Occurrence[b] (*n*=8)**
Whimbrel	10	58.8	1.250
Greater Yellowlegs	2	11.8	0.250
Wilson’s Snipe	2	11.8	0.250
American Golden-Plover	1	5.9	0.125
Pacific Golden-Plover	1	5.9	0.125
Least Sandpiper	1	5.9	0.125

Notes:

a. See Figure 16.5-1 for point-count locations.

b. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

TABLE 16.5-11
Average Occurrence[a] of Shorebird Species Observed in the Mine Study Area, 2004 and 2005, and in other Studies in Southwestern Alaska in which Off-road Point-count Surveys Were Conducted

Landbird Species	**Mother Goose Lake (*n*=141)[b]**	**Becharof Lake (*n*=99)[c]**	**Katmai NP (n=468)[d]**	**Lake Clark NP (*n*=417)[d]**	**This study (*n*=393)**
Greater Yellowlegs	0.014	0.374	0.147	0.031	0.260
Wilson's Snipe	0.085	0.212	0.077	0.091	0.196
Whimbrel			0.073	0.005	0.148
Least Sandpiper		0.081	0.056	0.024	0.115
Black-bellied Plover		0.061	0.011		0.084
American Golden-Plover			0.011	0.055	0.076
Short-billed Dowitcher		0.081		0.002	0.038
Pacific Golden-Plover			0.015		0.031
Red-necked Phalarope				0.034	0.028
Surfbird			0.034	0.017	0.025
Semipalmated Plover	0.007	0.212	0.058	0.022	0.018
Hudsonian Godwit			0.006		0.015
Lesser Yellowlegs				0.096	0.008
Wandering Tattler				0.026	0.003
Solitary Sandpiper				0.005	
Spotted Sandpiper			0.002	0.007	
Western Sandpiper	0.007				
Baird's Sandpiper				0.010	
Rock Sandpiper		0.020			

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

b. Off-road point-count data collected in 1996 and 2000 at Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge; data were combined from Dewhurst et al. (1996b) and Egan and Adler (2001).

c. Off-road point-count data collected in 1996 at Becharof Lake in the Becharof National Wildlife Refuge (Moore and Leeman, 1996).

d. Off-road point-count data collected in 2004–2006 in Katmai and Lake Clark national parks (Ruthrauff et al., 2007).

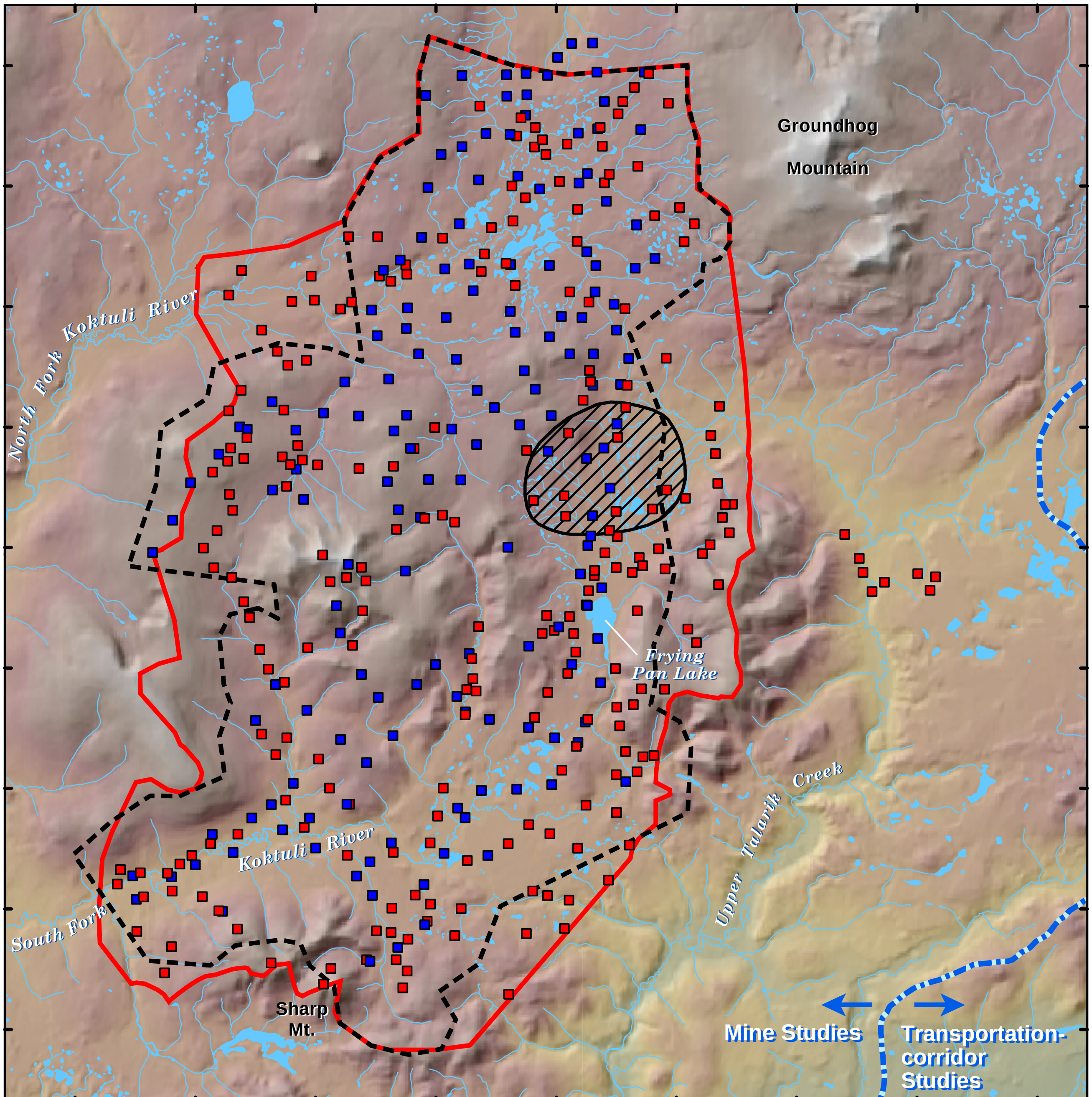
TABLE 16.5-12
Average Occurrence Figures[a] for Shorebirds in Mapped Wildlife Habitat Types, Mine Study Area, 2004 and 2005

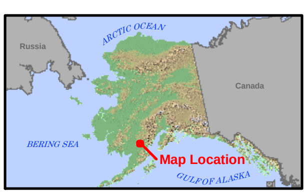
Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Moist Graminoid–Forb Meadow	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
	n=7	*n*=52	*n*=1	*n*=7	*n*=1	*n*=38	*n*=38	*n*=34	*n*=25	*n*=39	*n*=0	*n*=2	*n*=0	*n*=0	*n*=0	*n*=17	*n*=24	*n*=40	*n*=0	*n*=3	*n*=2	*n*=0	*n*=17	*n*=40	*n*=14
Black-bellied Plover						0.368	0.158																	0.050	
American Golden-Plover		0.135				0.079	0.079			0.026													0.118		
Pacific Golden-Plover						0.132		0.029																	
Greater Yellowlegs						0.105	0.026									0.118	0.042						0.059	0.225	
Lesser Yellowlegs																							0.118		
Whimbrel																							0.235	0.275	
Hudsonian Godwit																							0.059	0.050	
Surfbird		0.096																							
Least Sandpiper	0.143	0.019		0.143												0.235							0.235	0.325	
Short-billed Dowitcher																								0.275	
Wilson's Snipe				0.143																			0.294	0.175	0.071
Red-necked Phalarope																							0.235	0.075	

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted); only focal observations in each habitat are included (see Section 16.5.6.1, Field Surveys and Habitat-use Analyses).

FIGURES





Miles 0 1 2 3 4

Kilometers 0 1 2 3 4 5 6

Scale1:160,000

N

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

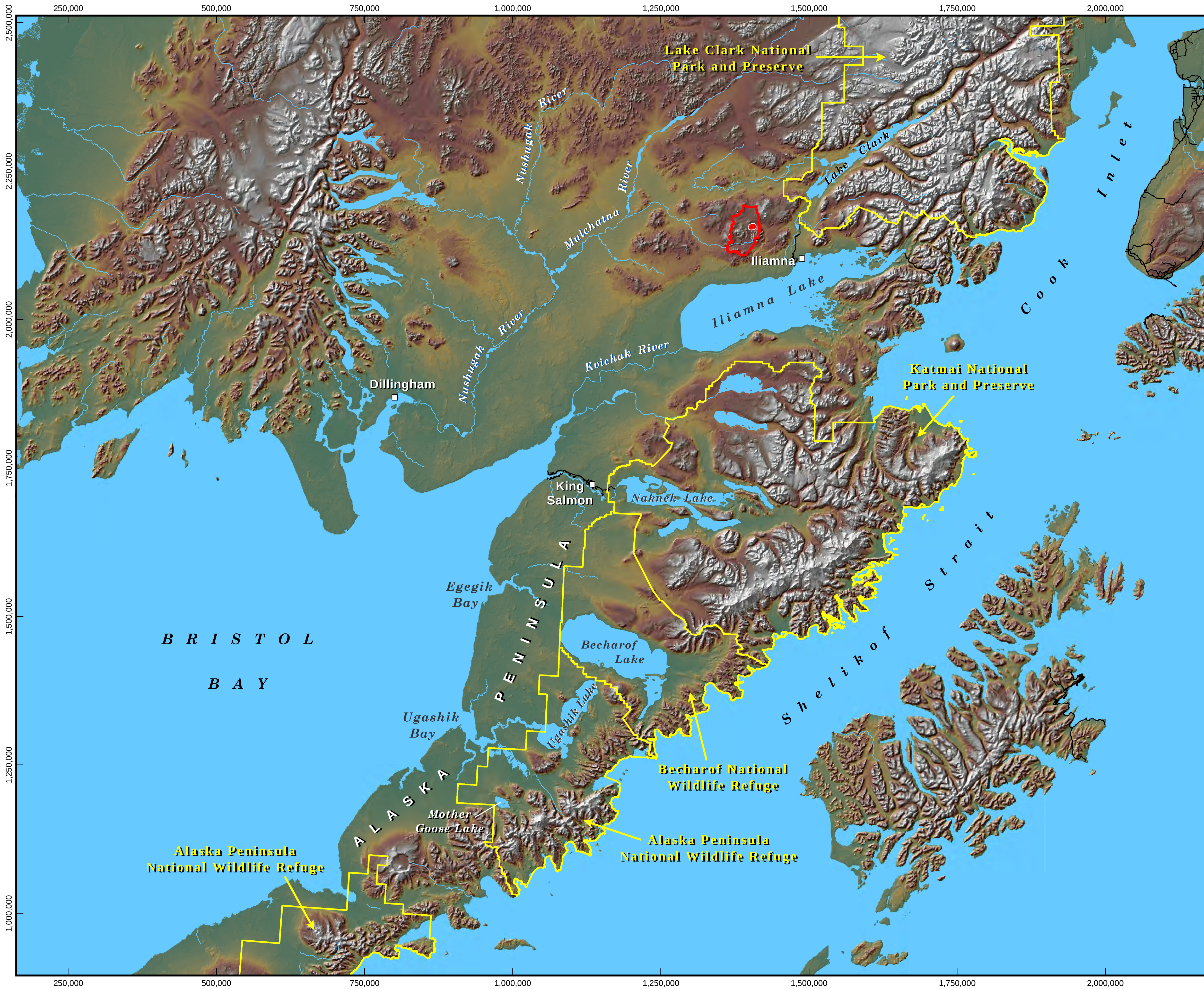
Legend

- 2004 Point-count Location
- 2005 Point-count Location
- 2004 Survey Area
- 2005 Survey Area
- General Deposit Location

THE pebble PARTNERSHIP

Figure 16.5-1
Landbird/Shorebird Point-count Locations and Survey Areas, Mine Study Area, 2004 and 2005

File: 16-5-1_BrBird_Mine_PLP_EBD_v01.mxd	Date: June 16, 2010
Version: 1	Author: ABR-AZC

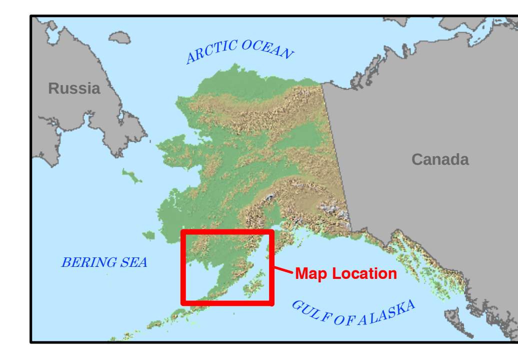


THE pebble PARTNERSHIP

Figure 16.5-2
Region Surrounding the Mine Study Area in which Previous Studies of Landbirds and Shorebirds were Conducted

Legend

- 2005 Mine Study Area
- General Deposit Location
- Existing Road
- Town or Village



Miles: 0 10 20 30 40 50 60

Kilometers: 0 20 40 60 80 100

N

Scale 1:2,000,033

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

File: 16-5-2_BrBird_Previous_PLP_EBD_v01.mxd	Date: June 16, 2010
Version: 1	Author: ABR-AZC

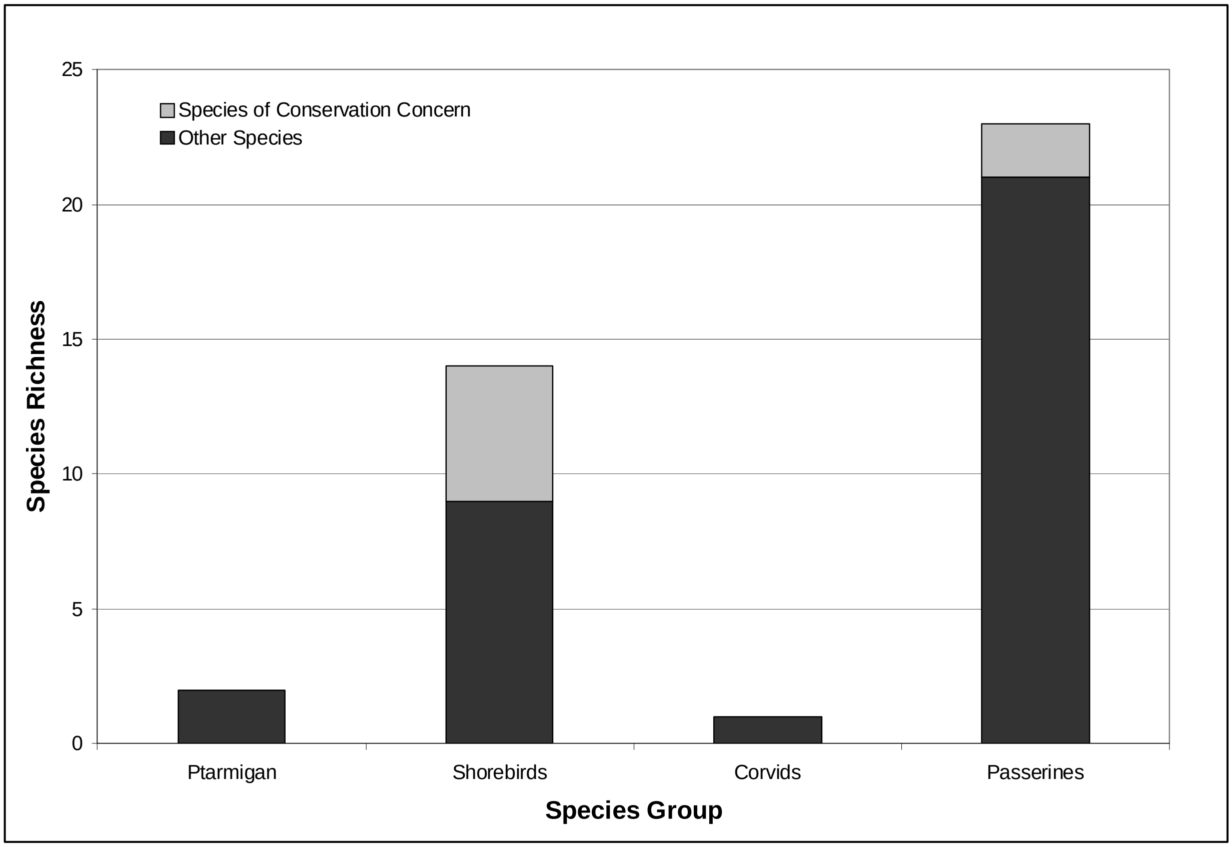


FIGURE 16.5-3
Numbers of Landbird and Shorebird Species (Species Richness) by Species-group Recorded during Point-count Surveys, Mine Study Area, 2004 and 2005

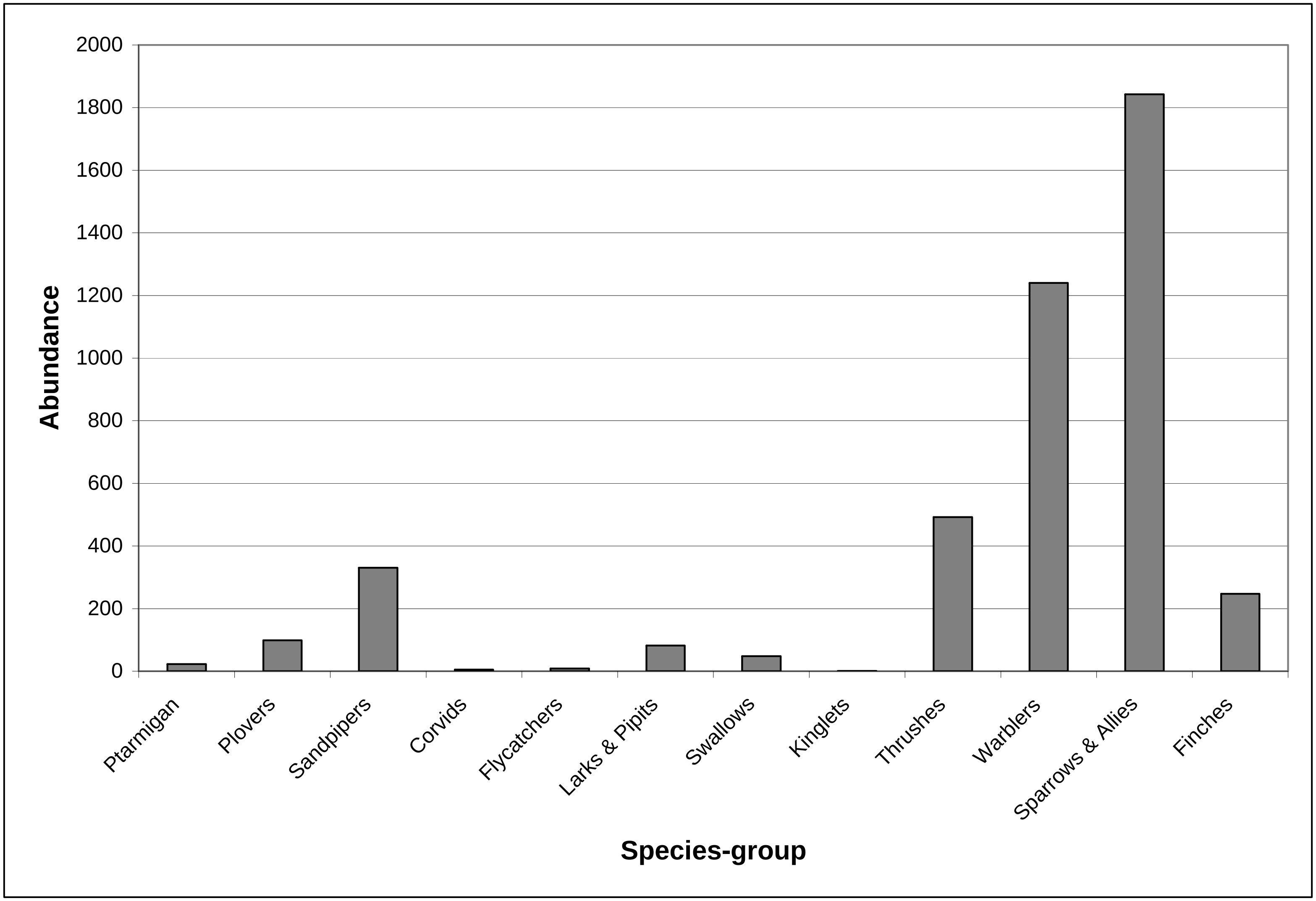


FIGURE 16.5-4
Abundance of Landbirds and Shorebirds by Species-group Recorded during Point-count Surveys, Mine Study Area, 2004 and 2005

APPENDICES

APPENDIX 16.5A

NUMBERS OF LANDBIRDS AND SHOREBIRDS OBSERVED INCIDENTALLY DURING POINT-COUNT SURVEYS AND IN TRANSIT BETWEEN POINT-COUNT LOCATIONS MINE STUDY AREA, 2004 AND 2005

APPENDIX 16.5A

Numbers of Landbirds and Shorebirds Observed Incidentally during Point-count Surveys and In Transit between Point-count Locations, Mine Study Area, 2004 and 2005

	2004		2005	
Avian Species	**No. Incidental[a]**	**No. In Transit[b]**	**No. Incidental[a]**	**No. In Transit[b]**
LANDBIRDS				
American Pipit	6	4	7	1
Horned Lark	5	5	7	7
American Tree Sparrow	5	0	3	12
Common Redpoll	4	0	11	0
Willow Ptarmigan	3	4	2	1
Gray-cheeked Thrush	3	0	2	1
Lapland Longspur	3	1	4	5
Black-billed Magpie	2	0	2	0
Tree Swallow	2	0	1	0
American Robin	2	0	3	0
Blackpoll Warbler	2	0	3	1
Wilson's Warbler	2	0	4	0
Rock Ptarmigan	1	33	1	0
Hermit Thrush	1	1	1	0
Yellow Warbler	1	0	9	0
Northern Waterthrush	1	0	1	0
Savannah Sparrow	1	12	9	13
Lincoln's Sparrow	1	0	0	0
Common Raven	0	6	4	0
Arctic Warbler	0	2	0	0
Golden-crowned Sparrow	0	0	6	0
Fox Sparrow	0	0	10	0
Orange-crowned Warbler	0	0	4	0
Alder Flycatcher	0	0	2	0
American Dipper	0	0	1	0
Snow Bunting	0	0	1	3
SHOREBIRDS				
Least Sandpiper	13	28	8	1
Black-bellied Plover	10	4	3	8
Greater Yellowlegs	8	12	7	0
American Golden-Plover	5	1	1	0
Wilson's Snipe	4	4	4	0

Avian Species	2004 No. Incidental[a]	2004 No. In Transit[b]	2005 No. Incidental[a]	2005 No. In Transit[b]
Unidentified (*Pluvialis*) plover	2	0	4	0
Semipalmated Plover	2	6	0	2
Pacific Golden-Plover	1	5	2	3
Whimbrel	1	7	5	0
Surfbird	1	0	5	1
Hudsonian Godwit	0	6	2	0
Short-billed Dowitcher	0	6	1	0
Red-necked Phalarope	0	14	4	0

Notes:

a. Incidental observations were recorded at point-count locations but not during the count period.

b. In-transit observations recorded while moving on foot between point-count locations are primarily observations of less commonly recorded species and/or observations of nests, defensive behavior indicative of the presence of a nest, or fledglings being tended by adults.

APPENDIX 16.5B

NUMBERS OF LANDBIRDS AND SHOREBIRDS OBSERVED INCIDENTALLY DURING EIGHT ADDITIONAL POINT-COUNT SURVEYS CONDUCTED EAST OF THE MINE STUDY AREA IN THE BRISTOL BAY DRAINAGES, 2005

APPENDIX 16.5B
Numbers of Landbirds and Shorebirds Observed Incidentally[a] during Eight Additional Point-count Surveys Conducted East of the Mine Study Area[b] in the Bristol Bay Drainages, 2005

Avian Species	**No. Incidental[c]**
LANDBIRDS	
Wilson's Warbler	2
Blackpoll Warbler	1
Northern Waterthrush	1
Fox Sparrow	1
White-crowned Sparrow	1
White-winged Crossbill	1
SHOREBIRDS	
Pacific Golden-Plover	3

Notes:

a. No in-transit observations were recorded in this area.

b. See Figure 16.5-1 for point-count locations.

c. Incidental observations were recorded at point-count locations but not during the count period.

16.6 Habitat Mapping and Habitat-value Assessments—Transportation Corridor

16.6.1 Introduction

This chapter section summarizes the wildlife habitat mapping and habitat-value assessment studies for the transportation-corridor, Bristol Bay drainages study area. This work was conducted to provide a baseline inventory of the availability of wildlife habitats in the study area and an assessment of the value of those habitats to a selected set of birds and mammals of concern.

16.6.2 Study Objectives

The primary objectives of the wildlife habitat mapping and habitat-value assessment studies are to provide baseline mapping of wildlife habitats in the transportation-corridor, Bristol Bay drainages study area, quantify the areal coverage of the habitat types present, and identify the importance of those habitats to wildlife species.

16.6.3 Study Area

At its eastern boundary, the transportation-corridor, Bristol Bay drainages study area runs from the Summit Lakes area in the Chigmit Mountains east of Iliamna Lake and then roughly parallels the northern shore of Iliamna Lake to the base of Roadhouse Mountain before heading northwest towards the Pebble Deposit west of the Newhalen River (Figures 16.6-1 and 16.6.2). In 2004, the wildlife habitat mapping field surveys were conducted within a 400-meter-wide study corridor. In 2005, the survey area was changed to an updated 610-meter-wide corridor. Currently, the transportation-corridor, Bristol Bay drainages study area designated for the mapping of wildlife habitats comprises 85 square kilometers within a 610-meter-wide corridor.

The terrain in the transportation-corridor study area is predominantly characterized by gentle slopes, but some steeper mountainous slopes occur in localized areas. Steeper terrain occurs especially along Chinkelyes Creek in the Chigmit Mountains east of Pile Bay and at the base of Knutson and Roadhouse mountains. Upland areas of white-spruce (*Picea glauca*) woodland with dwarf-scrub and graminoid-forb openings are common at the higher elevations, especially to the east towards Cook Inlet. Well-drained areas at higher elevations often are dominated by Upland Moist Dwarf Scrub. Low- and tall-scrub habitats occur in upland, lowland, and riverine areas. Low scrub is typically dominated by willows (*Salix* spp.) and tall scrub by either alder (*Alnus* spp.), willows, or both. Extensive areas of mixed white spruce/Kenai birch (*Betula kenaica*) forest occur throughout the study area and are almost always open forests with a substantial low- and/or tall-scrub understory of alders and willows. Along the floodplains of the larger streams and rivers, which run into Iliamna Lake, open riverine forests of poplar (*Populus balsamifera* and *Populus trichocarpa*) and mixed white spruce/poplar forests occur. Many forest openings are dominated by mesic, lowland low scrub or wetter, lowland scrub-bog habitats, but dwarf-scrub openings also occur at more well-drained sites and higher elevations. West of Roadhouse Mountain, towards the mine study area, extensive areas of white-spruce woodland exist with a low- and dwarf-scrub and lichen-dominated understory.

16.6.4 Previous Studies

Only coarse-scale land-cover mapping has been conducted in the region of the transportation-corridor study area for the Pebble Project. Early mapping of the area was conducted for the Bristol Bay Land Cover Mapping Project (Wibbenmeyer et al., 1982a, 1982b). These data were derived from a classification of Landsat Mulitspectral Scanner satellite imagery. Subsequently, additional coarse-scale land-cover mapping for the State of Alaska was conducted using Advanced Very High Resolution Radiometer satellite data; the land cover classes in this case were developed using a vegetation phenology index from data collected during the 1991 growing season (USGS, 1998). Given the relatively low accuracy of spectral image classifications at fine-scales, and with cell sizes of 50 meters in Wibbenmeyer et al. (1982a) and one square kilometer in USGS (1998), neither of these mapping products will provide the necessary accuracy or resolution to characterize wildlife habitats at a local scale within the transportation-corridor study area. Both of these datasets, however, may be useful in characterizing wildlife habitats on a coarser regional scale.

More recently, a spectral image classification for Lake Clark National Park was conducted using Spot multispectral imagery acquired in 1995; this mapping was augmented with field data, aerial photo interpretation, and other geographic information system (GIS) datasets and is reported to be 83 percent accurate (NPS, 2001). Unfortunately, the mapping resolution is still fairly coarse (cell size of 30 meters) and some portions of the transportation-corridor, Bristol Bay drainages study area are not covered. Additionally, in an initial evaluation of this mapping for the mine study area (see Section 16.1), inaccuracies were found at fine scales, so it is likely these data only will be useful in characterizing wildlife habitats at a coarser regional scale.

16.6.5 Scope of Work

The wildlife habitat mapping study was conducted by Charles T. Schick, Wendy A. Davis, Matthew J. Macander, and Joanna E. Roth, of ABR, Inc. (hereafter ABR). Field surveys to ground-truth the aerial photography for the habitat mapping study were conducted during August and September 2004 and 2005. The field studies were conducted by Sally E. Anderson, Gerald V. Frost, Chandra B. Heaton, Patricia F. Miller, Erik R. Pullman, Joanna E. Roth, and Charles T. Schick according to the approach described in the *Draft Environmental Baseline Studies*, *Proposed 2004 Study Plan* (NDM, 2004) and the *Draft Environmental Baseline Studies*, *2005 Study Plans* (NDM, 2005). Digital habitat mapping was conducted by Wendy A. Davis, Patricia F. Miller, Katherine L. Beattie, Matthew J. Macander, and Charles T. Schick. The wildlife habitat-value assessments were conducted by Brian E. Lawhead and Alexander K. Prichard (mammals), Robert J. Ritchie (raptors), Ann M. Wildman (waterbirds), and Charles T. Schick (landbirds and shorebirds).

The habitat mapping and habitat-value assessment studies include the following tasks:

- Conduct field surveys to ground-truth the aerial photography and determine the photo signatures for vegetation, physiography, and surface forms in the transportation-corridor, Bristol Bay drainages study area.
- In a GIS, add physiographic categories (and landform and surface-form categories, as needed) to the vegetation map polygons prepared by Three Parameters Plus, Inc. (3PP) and HDR Alaska, Inc. (HDR).

- Combine vegetation and physiographic information (and landform and surface-form information, as needed) to develop preliminary multivariate wildlife habitat types.
- Aggregate the preliminary habitat types to develop a final set of habitat types suitable for evaluations of wildlife use in the study area.
- Conduct habitat-value assessments for the mapped habitat types using wildlife survey data specific to the transportation-corridor, Bristol Bay drainages study area and habitat-use information from the scientific literature.

16.6.6 Methods

16.6.6.1 Habitat-mapping Field Surveys and Data Management

Field surveys to ground-truth the aerial photography for the transportation-corridor, Bristol Bay drainages study area were conducted from August 21 through 29, 2004 and from August 13 through September 1, 2005. Field plot locations were selected prior to the field work using either color-infrared or true-color aerial photography depending on the survey year. In 2004, researchers used high-altitude, color-infrared aerial photography from the National Aeronautics and Space Administration to determine ground-truth plot locations; this photography dates from the late 1970s and early 1980s and was reproduced in digital orthophoto format with 0.76-meter pixels by Aero-Metric, Inc. In 2005, sample plots to the west of the Newhalen River were selected using true-color aerial photography of the transportation-corridor study area acquired in July 2004 (digital orthophotos with 0.46-meter pixels produced by Koidak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc.). To the east of the Newhalen River in 2005, sample plots were selected using true-color aerial photography acquired in early October 2004 (digital orthophotos with 0.46-meter pixels produced by Aero-Metric, Inc., with additional processing by Resource Data, Inc.).

One-hundred fifty-seven habitat-mapping field plots were sampled in 2004 and 160 plots in 2005. Considering both years combined, 317 field plots were sampled within the transportation-corridor, Bristol Bay drainages study area. Field surveys and data-management activities for the habitat mapping efforts in the transportation-corridor study area were conducted following the same methods used in the mine study area (see Section 16.1.6.1).

16.6.6.2 Mapping and Classification of Habitat Types

The first step in mapping wildlife habitats in the transportation-corridor, Bristol Bay drainages study area was the mapping of vegetation for the area (completed by 3PP and HDR). Two different sources of vegetation mapping were used. West of the Newhalen River, the vegetation mapping was completed for a corridor that included portions of five 3PP map sections. East of the Newhalen River, the vegetation mapping was performed for the full extent of six HDR map sections, and for a portion of a seventh HDR map section that also covered part of the Cook Inlet drainages study area. The 22 map tiles displayed on Figure 16.6-2 were created to display the completed wildlife habitat mapping at a scale at which map polygons are discernable and do not represent the vegetation map sections used during the mapping process.

With completed vegetation map polygons in a GIS, researchers at ABR then assigned physiographic attributes (alpine, upland, lowland, lacustrine, and riverine) to each of the vegetation polygons. Non-water and water types were treated separately (see Section 16.1.6.2). For the transportation corridor west of the

Newhalen River, a generalized physiography map covering the mine studies region was generated by ABR biologists based on photo-interpretation of landforms and surface forms, and elevation data. The generalized physiography map then was overlaid on the non-water vegetation polygons and each polygon was assigned a preliminary physiographic type based on the generalized physiographic type with the largest overlapping area. For the transportation-corridor study area east of the Newhalen River, preliminary physiographic types were assigned manually to each non-water polygon based on photo-interpretation. The aerial photography used in the mapping of physiographic types to the west of the Newhalen River was acquired in July 2004 (described above), and to the east of the Newhalen River aerial photography from October 2004 (described above) and September 2008 was used. Like the October 2004 photography, the aerial photography from September 2008 was true-color and was produced in digital orthophoto format with 0.46-meter pixels by Aero-Metric, Inc., with additional processing by Resource Data, Inc. The remainder of the development of wildlife habitat types for the transportation-corridor study area followed the same methods used for the mine study area (see Section 16.1.6.2).

16.6.6.3 Habitat-value Assessments

A subset of 45 species was assessed for wildlife habitat values from the full set of bird and mammal species known or expected to occur in the transportation-corridor, Bristol Bay drainages study area (Table 16.6-1). The 45 species assessed for habitat values included 13 mammals, four tree-nesting raptors, three cliff-nesting raptors, nine waterbirds, seven shorebirds, and nine landbirds. For each bird and mammal species recorded or expected to occur in the transportation-corridor study area, habitat values in each mapped habitat type were categorized into one of four value classes: high, moderate, low, or negligible value (Table 16.6-2). The selection of species and the habitat-value assessments for the transportation-corridor study area were conducted following the same methods used in the mine study area (see Section 16.1.6.3), with the exceptions noted below.

For mammals, black bears were added to the species evaluated in the transportation-corridor study area because they are more common in the forested habitats there than in the more open habitats in the mine study area (Section 16.7). Caribou, however, were not evaluated in the transportation corridor because they have only occurred sporadically in small numbers east of the Pebble Deposit in recent years (see Section 16.2).

The same raptor species evaluated in the mine study area also were evaluated in the transportation-corridor study area. Field data and, in particular, nest locations specific to the mine study area and the transportation-corridor study area (see Sections 16.3 and 16.9) were used in the raptor habitat evaluations.

For waterbirds, Trumpeter Swans were added to the species evaluated in the transportation-corridor study area because they were found to occur in the far eastern portion of the study area. Field data and, in particular, nest, brood, and migrant-flock locations specific to the mine study area and the transportation-corridor study area (see Sections 16.4 and 16.10) were used in the waterbird habitat evaluations.

For shorebirds, one additional species (Solitary Sandpiper) was added to the species evaluated in the transportation-corridor study area because this boreal-forest shorebird was found during field surveys in the study area. For landbirds, five additional species (Spruce Grouse, Black-backed Woodpecker, Olive-sided Flycatcher, Varied Thrush, and Rusty Blackbird) were added to the species evaluated in the transportation-corridor study area because these forest-dwelling species were found during field surveys in the study area. Field data and, in particular, average-occurrence figures derived from point-count surveys in the mine study area and the transportation-corridor study area (see Sections 16.5 and 16.11) were used in the shorebird and landbird habitat evaluations. In this process, emphasis was placed, as much as possible, on the average-occurrence figures calculated for the shorebird and landbird observations that occurred in each mapped habitat in the transportation-corridor study area (Appendix 16.6A; see also Section 16.1.6.3). However, because there were few observations of some uncommon landbird species (e.g., Black-backed Woodpecker and Rusty Blackbird) and similarly few observations of shorebirds, ptarmigan, and Spruce Grouse in the transportation-corridor study area, habitat evaluations for these species were based largely on habitat-use information from the published and unpublished literature. Information from the literature was supplemented, when necessary, by professional judgment based on observations of habitat use by these species elsewhere in southwestern and southcentral Alaska.

16.6.7 Results and Discussion

16.6.7.1 Wildlife Habitat Availability

The transportation-corridor, Bristol Bay drainages study area designated for wildlife habitat mapping encompasses 85.1 square kilometers. The study area spans the region between the un-forested, quaternary moraine deposits common in the mine study area in the west and the forested, mountainous terrain dominated by colluvial and riverine deposits in the east along the northern shore of Illiamna Lake. The majority of the study area is dominated by forest habitats. Twenty-five wildlife habitat types were mapped in the study area (Figures 16.6-1 and 16.6-2). The habitat types are described in Appendix 16.6B, and summaries of the areal coverage of each habitat type are presented in Table 16.6-3.

The most commonly occurring habitat in the transportation-corridor, Bristol Bay drainages study area is Upland and Lowland Moist Mixed Forest, which accounts for 34.1 square kilometers (40.0 percent) of the mapped area. Combined with Upland and Lowland Spruce Forest (19.2 square kilometers), Riverine Moist Mixed Forest (2.1 square kilometers), and Riverine Moist White Spruce Forest (0.2 square kilometers), forested habitats comprise 65.3 percent of the area. The upland and lowland forest types commonly occur along mountain toe slopes and along the borders of riverine corridors; riverine forests occur within the active floodplains of streams and rivers. Six low- and/or tall-scrub habitats (Upland Moist Low Willow Scrub, Upland Moist Tall Alder Scrub, Upland Moist Tall Willow Scrub, Riverine Low Willow Scrub, Riverine Tall Alder or Willow Scrub, and Lowland Low and Tall Willow Scrub) are relatively common in the study area, together comprising 13.1 kilometers (15.4 percent of the area). Four open dwarf-scrub habitats (Alpine Moist Dwarf Scrub, Alpine Wet Dwarf Shrub–Sedge Scrub, Upland Dry Dwarf Shrub–Lichen Scrub, and Upland Moist Dwarf Scrub) are less common (9.0 kilometers; 10.6 percent of the area), and the remaining habitats are relatively uncommon in the study area.

Four relatively open habitats in upland areas (Upland Dry Barrens, Upland Dry Dwarf Shrub–Lichen Scrub, Upland Moist Dwarf Scrub, and Upland Moist Low Willow Scrub) are most prevalent between Roadhouse Mountain and the Newhalen River and then again near the boundary of the mine study area. Forested habitats, and especially Upland and Lowland Spruce Forest, predominate to the west of the Newhalen River, and forested habitats in general are strongly dominant from the base of Roadhouse Mountain eastward throughout the rest of the study area. Upland tall-scrub habitats are most common in the eastern portion of the study area on steep, middle and upper mountain slopes near Summit Lakes.

Riverine habitats (excluding actual river channels, see below) occur throughout the study area, which crosses at least six major river corridors. Riverine Moist Mixed Forest (2.1 square kilometers) is the most common riverine habitat type and occurs in association with Riverine Moist White Spruce Forest, Riverine Tall Alder or Willow Scrub, Riverine Low Willow Scrub, and the more poorly drained Riverine Wet Graminoid–Shrub Meadow. These vegetated riverine habitats comprise 3.6 square kilometers or 4.2 percent of the study area.

Poorly-drained lowland habitats in the study area include Lowland Low and Tall Willow Scrub, Lowland Ericaceous Scrub Bog, Lowland Wet Graminoid–Shrub Meadow, and Lowland Sedge–Forb Marsh. The combined area for these lowland habitat types is 4.5 square kilometers or 5.3 percent of the study area. In general, these habitats are scattered throughout the study area in small pockets in kettle depressions or on poorly drained portions of toe slopes. The most concentrated area of wet lowland habitats occurs along mountain toe slopes in the Summit Lakes area.

Aquatic habitats in the study area include Lakes and Ponds, Rivers and Streams, and Rivers and Streams (Anadromous). Lakes and Ponds generally form in kettle depressions as they do in the mine site study area, but in the transportation-corridor, Bristol Bay drainages study area they tend to be larger, averaging 9,800 square meters in area. The smaller lacustrine habitats mapped in the study area often are portions of larger features that extend beyond the transportation-corridor study area boundaries. Lakes and Ponds are dispersed throughout the study area, accounting for 1.7 square kilometers or 2.0 percent of the area. Rivers and Streams (both anadromous and non-anadromous types considered together) account for 0.96 square kilometers (1.1 percent of the area). The streams in the study area generally are relatively high-gradient, upper perennial features. Riverine Barrens and Lacustrine Moist Barrens also occur in small amounts in association with riverine and lacustrine waterbodies. These uncommon habitat types represent relatively ephemeral features subject to seasonal and annual fluctuations in water levels.

Three alpine habitat types (Alpine Dry Barrens, Alpine Moist Dwarf Scrub, and Alpine Wet Dwarf Shrub–Sedge Scrub) occur in small amounts, primarily in the mountainous region near Summit Lakes in the eastern portion of the study area. These habitats are not prominent features in the study area (comprising 0.2 square kilometers or 0.2 percent of the area).

16.6.7.2 Habitat-value Assessments

Habitat values for 45 bird and mammal species of concern were assessed for each of the 25 habitats mapped in the transportation-corridor, Bristol Bay drainages study area; 32 bird species and 13 mammal species were evaluated (Appendix 16.6C). Using this set of 45 species, researchers assessed the overall wildlife value of each of the mapped habitats in the transportation-corridor study area by determining the number of species (species richness) of birds and mammals with moderate- or high-value rankings in each habitat (Figures 16.6-3 and 16.6-4). This analysis of species richness by habitat indicates that the four forested habitats (Upland and Lowland Moist Mixed Forest, Upland and Lowland Spruce Forest, Riverine Moist Mixed Forest, Riverine Moist White Spruce Forest) and one open wetland habitat (Lowland Ericaceous Scrub Bog) have the highest numbers of bird and mammal species of concern with moderate- or high-value habitat rankings (20–24 species; Figure 16.6-3). The species-rich forest habitats are concentrated in the westernmost portion of the study area to the west of the Newhalen River and again from the base of Roadhouse Mountain east to where the transportation corridor runs along Chinkelyes Creek up to Summit Lakes (Figure 16.6-4). The species-rich lowland-bog habitats are scattered throughout the study area, occurring in small patches in poorly drained areas. A set of seven other habitats has relatively high numbers of bird and mammal species with moderate or high habitat rankings (16–19 species); these habitats include Rivers and Streams (Anadromous), Lakes and Ponds, and five other low- and tall-scrub and meadow habitats in riverine and lowland areas. Another set of nine habitats has lower numbers of species with moderate or high habitat rankings (nine–13 species); these habitats include Rivers and Streams, Lowland Sedge–Forb Marsh, and seven other dwarf-, low-, and tall-scrub habitats in upland and alpine settings. A small set of barren habitats in alpine, upland, riverine, and lacustrine areas has the fewest numbers of bird and mammal species with moderate or high habitat rankings (three–six species).

In the sections below, the habitat-value assessments for each of the 45 individual bird and mammal species of concern in the transportation-corridor, Bristol Bay drainages study area, are described.

Mammals

Wolf. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of wolf habitat use in boreal forest regions.

Wolves feed on a variety of prey including large and small mammals, birds, and salmon, and their use of habitats is largely dependent on the presence of prey in suitable numbers. Most of the habitat in the region of the Pebble Project is moderate-value wolf habitat and supports one or more prey species favored by wolves. Alpine and open upland areas support caribou, arctic ground squirrels, and ptarmigan; tall-scrub habitats in upland areas support moose in the fall and early winter; and riverine and lower elevation forested areas are used during winter by moose. Wolves also may feed on salmon in anadromous streams in the area.

Because the wolf is a generalist species and can use a wide variety of habitats, no individual habitat in the transportation-corridor, Bristol Bay drainages study area was considered to be of high value and neither was any habitat considered to be of negligible value. A set of 18 habitats was considered to be of moderate value for wolves and the remaining seven habitats were categorized as low value (Appendix 16.6C).

Red Fox. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of red fox habitat use in boreal forest regions.

Like wolves, red foxes occur in a wide variety of habitats as long as suitable prey are available. In the region of the Pebble Project, red foxes are expected to be present in most habitats that provide adequate vegetation cover and potential prey. Given the presence of coyotes, however, which prey on foxes, they are less likely to frequent open areas. Small-mammal prey and berries are present in many different habitats, hares occur in riverine scrub and forested areas, waterfowl near lakes, ponds, and wetlands, and moose carcasses may be most available in riverine areas during winter.

Because the red fox, like the wolf, is a generalist predator and can use a diversity of habitats, no individual habitat in the transportation-corridor, Bristol Bay drainages study area was considered to be of high value and neither was any habitat considered to be of negligible value. A set of 14 habitats was considered to be of moderate value for red foxes and the remaining 11 habitats were categorized as low value (Appendix 16.6C).

River Otter. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of river otter habitat use in boreal forest regions.

River otters occur most commonly in productive aquatic habitats where they feed heavily on fishes. River otters occur primarily in aquatic habitats and adjacent, associated habitat types with adequate vegetation cover. Lakes, ponds, and rivers are used for foraging, and nearby areas are used for travel, cover, and denning.

In the transportation-corridor, Bristol Bay drainages study area, three habitats (Rivers and Streams, Rivers and Streams [Anadromous], and Lakes and Ponds) were considered to be of high value for river otters (Appendix 16.6C). A set of seven associated riverine and lacustrine habitats was considered to be of moderate value. The remaining habitats were considered to be of either low or negligible value.

Wolverine. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of wolverine habitat use in boreal forest regions.

Wolverines are expected to use virtually all of the habitats in the region of the Pebble Project. Alpine and upland areas with large numbers of arctic ground squirrels may be important in the summer, and lower elevation forested and riverine areas may be more important in the winter when moose carcasses are present.

Because the wolverine is a generalist predator known to use many different habitats, no individual habitat in the transportation-corridor, Bristol Bay drainages study area, was considered to be of high value and neither was any habitat considered to be of negligible value. A set of 19 habitats was considered to be of moderate value for wolverines and the remaining six habitats were categorized as low value (Appendix 16.6C).

Black Bear. Black bears are known to avoid open habitats and occur more commonly in closed forest and shrub habitats (Holm et al., 1999). In the transportation-corridor, Bristol Bay drainages study area, black bears occur primarily in forested areas or in alder scrub (see Section 16.7). In areas where brown bears also occur, black bears typically avoid habitats used consistently by brown bears, such as salmon-spawning streams; in such areas, there is an inverse relationship between brown bear density and the proportion of salmon in black bear diets (Belant et al., 2006), and hence, black bears are largely herbivorous and frugivorous when they occur sympatrically with brown bears (Jacoby et al., 1999; Belant et al., 2006; Fortin et al., 2007).

After emergence from dens in spring, black bears seek newly emerging green vegetation such as horsetails (*Equisetum* spp.), grasses, and sedges (*Carex* spp.), which are high in protein and easily digestible. Overwintered berries from the preceding fall are eaten where available. Animal foods are sought at any time of year, but the carcasses of winter-killed animals and the newborn calves of ungulates can be particularly important supplemental foods in spring. The nutrient quality of green vegetation decreases as it matures in summer, causing bears to switch to other plant species such as claspleaf twistedstalk (*Streptopus amplexifolius*), rusty menziesia (*Menziesia ferruginea*), and common cowparsnip (*Heracleum maximum*), as well as insects (ants, wasps, beetles), and salmon when spawning runs begin (if brown bears are not present). Bears begin to eat berries and fruit as they begin to ripen in mid-summer and continue feeding heavily on berries and fruit throughout the fall to store up energy for winter dormancy.

In the region of the Pebble Project, black bears are most numerous east of Iliamna Lake and in some areas near Cook Inlet; they have been observed rarely in the region of the Pebble Deposit (see Sections 16.2 and 16.7). They often are found in high elevation alder patches and mixed forest where there is abundant cover and forage in small clearings. Given the high densities of brown bears in the Pebble area, it is likely that black bears are largely excluded from salmon streams in late summer and from open areas away from escape cover during all seasons. Black bears may use coastal areas and feed in intertidal zones when brown bears are not present (Carlton and Hodder, 2003).

In the transportation-corridor, Bristol Bay drainages study area, six habitats (Upland and Lowland Moist Mixed Forest, Riverine Moist White Spruce Forest, Riverine Moist Mixed Forest, Upland Moist Tall Alder Scrub, Riverine Tall Alder or Willow Scrub, and Lowland Low and Tall Willow Scrub) were considered to be of high value for black bears (Appendix 16.6C). A set of eight other forest, scrub, scrub-bog, meadow, marsh, and lacustrine habitats, and Rivers and Streams (Anadromous) was considered to be of moderate value. The remaining habitats were considered to be of either low or negligible value. In the transportation-corridor, Bristol Bay drainages study area, high- and moderate-value habitats for black bears are common and widespread (Figure 16.6-5).

Brown Bear. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of brown bear habitat use in boreal forest regions.

The brown bear density around Iliamna Lake is moderately high (47.7 bears per 1,000 km^2; Becker, 2010). Bears in the area use a variety of different seasonal resources. In the spring and early summer, large concentrations of bears are found in sedge meadows along the coast foraging on vegetation. During the summer and early fall, brown bears concentrate along salmon streams. Bears also feed on ground squirrels, moose and caribou calves, and berries when available. In late fall and early winter, bears excavate winter dens.

Brown bears in the region of the Pebble Project use different habitats at different times of year. They den most frequently at high elevations and often feed on arctic ground squirrels in high-elevation habitats in the spring. Riverine and forested areas also may be used for travel corridors and for hunting moose calves. Coastal sedge meadows and mudflats can support very high densities of bears in early summer. In mid- and late summer, brown bears congregate at salmon-spawning streams throughout the region.

In the transportation-corridor, Bristol Bay drainages study area, only one habitat (Rivers and Streams [Anadromous]) was considered to be of high value for brown bears because of the concentrated foraging that can occur along salmon streams in mid- and late summer (Appendix 16.6C). Because brown bears are known to use a wide variety of habitats for foraging and denning, another 20 habitats in the study area were considered to be of moderate value. The remaining four habitats were considered to be of low value; no habitats were considered to be of negligible value for brown bears. In the transportation-corridor, Bristol Bay drainages study area, high- and moderate-value habitats for brown bears are common and widespread (Figure 16.6-5).

Moose. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of moose habitat use in boreal forest regions.

Moose distribution in the region of the Pebble Project is heavily influenced by snow cover and elevation. Moose calve in riverine and forested areas in the spring and may use lakes and ponds for early emergent vegetation and nutrients. Higher elevation tall-scrub habitats are used in the fall and during the rut, and then moose move to lower elevations when snow depth becomes too high at higher elevations. Riverine willows are especially important for moose during winter. In the transportation-corridor study area, the highest densities of wintering moose were observed in the Chekok Creek and Pile River valleys (see Section 16.7).

In the transportation-corridor, Bristol Bay drainages study area, four low and/or tall willow-scrub habitats in upland, lowland, and riverine settings, the two riverine forest types, and Lakes and Ponds were considered to be of high value for moose (Appendix 16.6C), primarily for forage. Another eight scrub, scrub-bog, forest, meadow, marsh, and lacustrine habitats were considered to be of moderate value, also for forage. All other habitats were considered to be of low or negligible value. The high-value moose habitats in the study area tend to be concentrated in stream drainage systems, whereas moderate-value habitats are common and widespread throughout the study area (Figure 16.6-6).

Arctic Ground Squirrel. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of arctic ground squirrel habitat use in boreal forest regions.

Arctic ground squirrels in the region of the Pebble Project occur most frequently in open alpine and upland habitats with well-drained soils and good visibility. They also make use of riverbanks and lakeshores.

In the transportation-corridor, Bristol Bay drainages study area, a single habitat (Upland Dry Dwarf Shrub–Lichen Scrub) was considered to be of high value for arctic ground squirrels (Appendix 16.6C). A set of four other open upland and alpine habitats was considered to be of moderate value. All other habitats were considered to be of low or negligible value.

Red Squirrel. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of red squirrel habitat use in boreal forest regions.

Within the region of the Pebble Project, red squirrels occur in forested areas, predominantly using dense spruce forests, with lower densities occurring in mixed forests and open spruce forests. Open forests, both mixed and spruce-dominated, are the most common forest types in the transportation-corridor, Bristol Bay drainages study area.

In the transportation-corridor study area, three forest habitats (Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, and Riverine Moist White Spruce Forest) were considered to be of high value for red squirrels (Appendix 16.6C). A fourth forest habitat (Riverine Moist Mixed Forest) was considered to be of moderate value. All other habitats were considered to be of low or negligible value.

Beaver. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of beaver habitat use in boreal forest regions.

In the region of the Pebble Project, beavers occur in rivers, lakes, and ponds, and in adjacent forest and tall-scrub habitats. The only aquatic habitats unsuitable for beavers are fast-moving streams and rivers and those with widely varying levels of water flow. Beavers build dams, lodges, and food caches in waterbodies, and travel short distances to gather aspen (*Populus tremuloides*), balsam poplar, willow, and occasionally alder. Other areas may be used for travel to preferred areas or for dispersal of young beavers to new areas. Beavers are common along the larger rivers and creeks in the transportation-corridor, Bristol Bay drainages study area (see Section 16.7).

In the transportation-corridor study area, four habitats (Rivers and Streams, Rivers and Streams [Anadromous], Lakes and Ponds, and Riverine Moist Mixed Forest) were considered to be of high value for beavers (Appendix 16.6C). Three other riverine forest and scrub habitats and Upland and Lowland Moist Mixed Forest were considered to be of moderate value. All other habitats were considered to be of low or negligible value.

Northern Red-Backed Vole. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of northern red-backed vole habitat use in boreal forest regions.

In the region of the Pebble Project, northern red-backed voles are likely to be widely distributed in a variety of forest and scrub habitats. Densities are probably highest in mixed forest and spruce forest habitats. These habitats are common in the transportation-corridor, Bristol Bay drainages study area.

In the transportation-corridor study area, four forest habitats (Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, Riverine Moist White Spruce Forest, and Riverine Moist Mixed Forest) were considered to be of high value for northern red-backed voles (Appendix 16.6C). Six other scrub and scrub-bog habitats were considered to be of moderate value and the remaining habitats were categorized as low or negligible value.

Tundra Vole. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of tundra vole habitat use in boreal forest regions.

Tundra voles (also known as root voles) in the region of the Pebble Project are expected to occur most commonly in wet, open habitats dominated by graminoid vegetation (i.e., wet meadow habitats).

In the transportation-corridor, Bristol Bay drainages study area, two habitats (Riverine Wet Graminoid–Shrub Meadow and Lowland Wet Graminoid–Shrub Meadow) were considered to be of high value for tundra voles (Appendix 16.6C). Nine other scrub, scrub-bog, and marsh habitats were considered to be of moderate value and the remaining habitats were categorized as low or negligible value.

Snowshoe Hare. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of snowshoe hare habitat use in boreal forest regions.

In the region of the Pebble Project, snowshoe hares are most likely to be found in dense cover in forest and in tall willow-scrub habitats. They are not likely to occur in alpine or coastal areas.

In the transportation-corridor, Bristol Bay drainages study area, three habitats (Upland and Lowland Spruce Forest, Riverine Tall Alder or Willow Scrub, and Lowland Low and Tall Willow Scrub) were considered to be of high value for snowshoe hares (Appendix 16.6C). Seven other scrub and forest habitats were considered to be of moderate value and the remaining habitats were categorized as low or negligible value.

Tree-nesting Raptors

Habitat availability in the transportation-corridor, Bristol Bay drainages study area, for the four tree-nesting raptors species of concern addressed in this study was assessed spatially in map form (Figure 16.6-7). This figure displays the suitability of habitats (moderate or high habitat-value rankings) for both nesting and foraging tree-nesting raptors considered as a group. Four forest habitats (Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, Riverine Moist White Spruce Forest, and Riverine Moist Mixed Forest) were considered suitable for three to four tree-nesting raptor species for nesting and/or foraging (Appendix 16.6C). These habitats are common and widespread in the study area. Other forest, scrub, meadow, and barren habitats, and Lakes and Ponds were considered suitable for fewer species; these habitats are less common, but similarly are widespread throughout the study area. Overall, in contrast to the mine study area (which is largely open and where suitable habitats for tree-nesting raptors are uncommon), in the transportation-corridor study area, suitable habitats for nesting and foraging tree-nesting raptors are common and widespread.

Bald Eagle. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Bald Eagle habitat use in Alaska.

Suitable nesting habitat for Bald Eagles in the transportation-corridor, Bristol Bay drainages study area is common and occurs primarily in forests along streams and lake shores, including Riverine Moist White Spruce Forest, Riverine Moist Mixed Forest, and Upland and Lowland Moist Mixed Forest; these habitats were considered to be of either high or moderate value (Appendix 16.6C). High-value foraging habitats include Rivers and Streams (Anadromous). Moderate-value foraging habitats include Rivers and Streams, and Lake and Ponds. Low-value habitats include most of the open, upland forest and scrub habitats, riverine scrub habitats, and open meadows, scrub-bogs, and marshes in lowland areas; however, because Bald Eagles range widely, they will use most of these open habitats at least infrequently. Use of tall-scrub habitats is probably negligible for Bald Eagles.

Northern Goshawk. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Northern Goshawk habitat use in Alaska.

Northern Goshawks occur in forest habitats in southwestern Alaska as far south as the Iliamna Lake area (south of Iliamna Lake on the Alaska Peninsula forest habitats become patchy). However, no Northern Goshawk nests were located in the transportation-corridor, Bristol Bay drainages study area during baseline raptor surveys (see Section 16.9) and they may not be common in the area.

All four forest types (Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, Riverine Moist White Spruce Forest, and Riverine Moist Mixed Forest) could be used by nesting and foraging goshawks and these habitats were considered to be of either high or moderate value (Appendix 16.6C). However, goshawks forage in a larger suite of habitats within and adjacent to these forested habitats, so at least some open habitats in lowland and upland areas would be of low value.

Merlin. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Merlin habitat use in Alaska.

Merlins probably nest near the edges of the four forest types in the transportation-corridor, Bristol Bay drainages study area (Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, Riverine Moist White Spruce Forest, and Riverine Moist Mixed Forest) and in Lowland Low and Tall Scrub; these habitats were considered to be of moderate value for nesting Merlins (Appendix 16.6C). They also probably range widely through the study area while foraging during breeding and migration. Moderate-value foraging habitats for Merlins in the study area would include Rivers and Streams, Rivers and Streams (Anadromous), Lakes and Ponds, and any of the forested habitats.

Great Horned Owl. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Great Horned Owl habitat use in Alaska.

High-value breeding habitats in the transportation-corridor, Bristol Bay drainages study area for Great Horned Owls include Riverine Moist Mixed Forest and Riverine Moist White Spruce Forest. Two other forest types (Upland and Lowland Moist Mixed Forest and Upland and Lowland Spruce Forest) were considered to be of moderate-value breeding habitat for this species (Appendix 16.6C). Because Great Horned Owls forage in habitats closely associated with forests, some other adjacent habitats (e.g., meadows and low-scrub habitats in riverine and lowland settings) were considered to be of moderate value, while most other habitats in the study area probably are of low to negligible value.

Cliff-nesting Raptors

The suitability of habitats (moderate or high habitat-value rankings) for both nesting and foraging cliff-nesting raptors in the transportation-corridor, Bristol Bay drainages study area, was assessed spatially in map form (Figure 16.6-8). This figure displays the overall habitat availability for the three cliff-nesting raptors species of concern addressed in this study. Two open alpine and upland habitats (Alpine Moist Dwarf Scrub and Alpine Wet Dwarf Shrub–Sedge Scrub) were considered suitable for all three cliff-nesting raptor species for foraging and/or nesting (nesting only in situations where cliffs are present) (Appendix 16.6C). These habitats, however, are uncommon in the study area; concentrations occur at the eastern end of the study area near Summit Lakes. Rivers and Streams and Rivers and Streams (Anadromous), in areas where cliffs are present, were considered suitable for nesting for two species. Other barren, forest, scrub, scrub-bog, meadow, marsh, and lacustrine habitats were considered suitable for one to two species, largely for foraging. Overall, the habitats preferred for foraging by cliff-nesting raptors in the study area are relatively common and widespread, but nesting habitats are uncommon.

Golden Eagle. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Golden Eagle habitat use in Alaska.

Golden Eagles nest primarily on cliffs in alpine, upland, and riparian areas in and near the transportation-corridor, Bristol Bay drainages study area. Golden Eagles probably range widely throughout upland habitats in the study area, feeding primarily on ground squirrels, hares, marmots, and ptarmigan, but also feeding on caribou calves, waterfowl, and carrion. High-value habitats for nesting include all cliff areas, primarily in Alpine Dry Barrens. Moderate-value nesting habitats occur along Rivers and Streams and Rivers and Streams (Anadromous), in areas where cliffs are present (Appendix 16.6C). Moderate-value habitats for foraging include all the barren, dwarf-, and low-scrub types in alpine and upland areas.

Gyrfalcon. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Gyrfalcon habitat use in Alaska.

Gyrfalcons nest in tundra habitats and they were uncommon in the region of the transportation-corridor, Bristol Bay drainages study area. All nests found in the region were on cliffs in Alpine Dry Barrens and along Rivers and Streams or Rivers and Streams (Anadromous), but were located outside the study area for habitat mapping. Moderate-value foraging habitats include all the barren, dwarf-, and low-scrub types in alpine and upland areas (Appendix 16.6C).

Peregrine Falcon. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Peregrine Falcon habitat use in Alaska.

A few Peregrine Falcon nests have been located in the region of the transportation-corridor, Bristol Bay drainages study area, but were located outside the study area for habitat mapping. Suitable nesting habitat, however, occurs wherever cliffs occur. Cliff habitats, particularly along Rivers and Streams and Rivers and Streams (Anadromous) (e.g., Newhalen and Iliamna rivers) are potential high-value breeding habitats (Appendix 16.6C). High-value foraging habitats for Peregrine Falcons in the study area include Rivers and Streams, Rivers and Streams (Anadromous), Riverine Moist Mixed Forest, and Lakes and Ponds. Several dwarf-scrub habitats in alpine areas, open forests, and barren, low-scrub, scrub-bog, meadow, and marsh habitats in riverine and lowland areas were considered to be of moderate value for foraging.

Waterbirds

All nine waterbird species assessed for habitat values (Trumpeter Swan, Tundra Swan, Harlequin Duck, Surf Scoter, Black Scoter, Long-tailed Duck, Red-throated Loon, Common Loon, and Arctic Tern) are dependent on one or more types of waterbody/wetland habitat during the breeding and/or migration seasons (Appendix 16.6C). Lakes and Ponds and Lowland Wet Graminoid–Shrub Meadow were considered to be moderate- or high-value habitats for eight of the nine species. Stable water levels, irregular shorelines, emergent vegetation, organic content, and water clarity, acidity, and depth are some of the important features that determine whether a lake or pond is used by waterbirds for foraging, nesting, and/or brood-rearing (Palmer 1976a, 1976b). Rivers and Streams (Anadromous) was considered to be a high-value habitat for Harlequin Ducks and Arctic Terns, and a moderate-value habitat for Red-throated and Common loons. The value and use of habitats for nesting by waterbirds depends on their proximity to a waterbody that serves as foraging and/or brood-rearing habitat. Distance of a nest from water depends on each species' habitat preferences and requirements sometimes can vary widely within a species. Meadow- and shrub-edge habitats adjacent to waterbodies most frequently are used for nesting and for protective cover during brood-rearing.

In the transportation-corridor, Bristol Bay drainages study area, waterbirds were associated with 18 of the 25 mapped habitats during breeding and migration (Appendix 16.6C). Six habitats were considered to be of high value for one to two species, which includes three meadow/marsh types (Riverine Wet Graminoid–Shrub Meadow, Lowland Sedge–Forb Marsh, and Lowland Wet Graminoid–Shrub Meadow), two waterbody types (Lakes and Ponds, and Rivers and Streams [Anadromous]), and one shrub type (Riverine Low Willow Scrub). Ten habitats, mostly scrub and forest, ranked no higher than moderate value and two habitat types ranked no higher than low value. The value of seven habitats (mostly alpine and tall-scrub types) was considered to be negligible for waterbirds.

The overall habitat availability in the transportation-corridor, Bristol Bay drainages study area, for the nine waterbird species of concern addressed in this study was assessed spatially in map form (Figure 16.6-9). This figure displays the suitability of habitats (moderate or high habitat-value rankings) for breeding and migrant waterbirds considered as a group. Two habitats (Lakes and Ponds, and Lowland Wet Graminoid–Shrub Meadow) were considered suitable for the largest number of waterbird species (Appendix 16.6C). Suitable habitats for fewer species include various scrub-bog, meadow, marsh, and dwarf-scrub habitats, and Rivers and Streams (Anadromous). Other forest and low- and/or tall-scrub habitats were considered suitable for the fewest number of waterbird species. Suitable habitats for waterbirds are relatively common and widespread in the transportation-corridor study area, but as noted above, these habitats have a higher likelihood of use when in association with aquatic habitats, especially lacustrine waterbodies.

Trumpeter Swan. For breeding, Trumpeter Swans prefer waterbodies with irregular shorelines, emergent vegetation, abundant and diverse communities of aquatic plants, early ice-off, a depth less than 1.2 meters, and multiple available nest sites (Mitchell and Elchholz, 2010). Trumpeter Swans build high nest-mounds near lake margins, on islands, or even on top of beaver dams, and return to the same breeding territory each year, sometimes reusing the same nest site (Mitchell and Elchholz, 2010). The Iliamna Lake area is on the western edge the Trumpeters Swan’s breeding distribution in Alaska (Conant et al., 2002).

In 2006, nesting by Trumpeter Swans near the Pile River was suspected because a brood of that species was identified near a swan nest (see Section 16.10). The nest was located in Lowland Wet Graminoid–Shrub Meadow near a pond classified as Lakes and Ponds. Swan broods observed in the study area near the Pile River in 2005 and 2006 were recorded in Lakes and Ponds. Both of these habitat types were considered to be of high value for nesting and foraging Trumpeter Swans in the transportation-corridor, Bristol Bay drainages study area (Appendix 16.6C). Riverine Wet Graminoid–Shrub Meadow, Riverine Low Willow Scrub, and Lowland Ericaeous Scrub Bog were considered to be moderate-value habitats and are relatively abundant near the recorded nesting and brood-rearing locations; these habitats can provide escape and resting habitat for swans.

Tundra Swan. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Tundra Swan habitat use in Alaska.

The Iliamna Lake area is near the southeastern limits of the Tundra Swan breeding distribution in Alaska. No Tundra Swans nests or broods were found during surveys in 2004 and 2005 in the transportation-corridor, Bristol Bay drainages study area, but breeding habitat similar to that used in the mine study area does occur in the transportation-corridor study area. Six different habitat types were considered to be of moderate value for breeding: Upland Dry Dwarf Shrub–Lichen Scrub, Upland Dwarf Moist Scrub, Riverine Wet Graminoid–Shrub Meadow, Lakes and Ponds, Lowland Wet Graminoid–Shrub Meadow, and Lowland Ericaceous Scrub Bog (Appendix 16.6C). These six habitats not only have the requirements needed for a nest site, but also provide escape, resting, and/or foraging habitat. Both types of Rivers and Streams and four low willow-scrub habitats were considered to be low-value habitats because although they provide potential foraging, escape, and resting areas, these habitats are not common in the transportation-corridor study area.

Harlequin Duck. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Harlequin Duck habitat use in Alaska.

Harlequin Ducks are a common breeder along rivers in the Iliamna Lake area, including those in the transportation-corridor, Bristol Bay drainages study area. Pre-nesting and brood-rearing Harlequin Ducks were found during surveys in 2004 and 2005 in those sections of the Newhalen and Iliamna rivers that occur in the transportation-corridor study area. Both rivers are classified as Rivers and Streams (Anadromous) and were considered to be high-value habitats for Harlequin Ducks because they are used for pair bonding and mating during pre-nesting, and for foraging during nesting and brood-rearing (Appendix 16.6C). Riverine Wet Graminoid–Shrub Meadow and Riverine Low Willow Scrub, found on islands and along the shorelines of Rivers and Streams (Anadromous), were considered to be high-value nesting habitats. These two habitats also provide escape and resting habitat for Harlequin Ducks. Riverine Tall Alder or Willow Scrub, Riverine Moist White Spruce Forest, and Riverine Moist Mixed Forest were considered to be moderate-value habitats that provide potential nesting habitat.

Surf Scoter. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Surf Scoter habitat use in Alaska.

Surf Scoters were observed in small staging flocks on one lake in the transportation-corridor, Bristol Bay drainages study area during spring and fall migration surveys in 2004 and 2005. Surf Scoters also were found on many lakes in areas adjacent to the transportation-corridor study area. No evidence of breeding by Surf Scoters was found in the study area. Lakes and Ponds was considered to be a moderate-value habitat because it is used by staging birds during both spring and fall migration (Appendix 16.6C). Two upland forest types were considered to be of moderate value because they provide potential nesting habitat. Three lowland habitats were considered to be of moderate value because they occur along the shorelines of Lakes and Ponds and provide escape and resting areas for broods.

Black Scoter. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Black Scoter habitat use in Alaska.

Black Scoters were recorded using large lakes and ponds near the transportation-corridor, Bristol Bay drainages study area during spring and fall migration surveys in 2004 and 2005, but were not found in the study area proper. Breeding habitat similar to that used in the mine study area, however, does occur in the transportation-corridor study area. Lakes and Ponds and the surrounding habitats that are preferred by Black Scoters for nesting (Upland Moist Dwarf Scrub, Lowland Sedge–Forb Marsh, Lowland Ericaceous Scrub Bog, and Lowland Wet Graminoid–Shrub Meadow) were considered to be of moderate value because they provide nesting, foraging, brood-rearing, and escape areas (Appendix 16.6C).

Long-tailed Duck. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Long-tailed Duck habitat use in Alaska.

Long-tailed Ducks were observed using large lakes and ponds near the transportation-corridor, Bristol Bay drainages study area during spring and fall migration surveys in 2004 and 2005, but were not found in the study area proper. Breeding habitat similar to that used in the mine study area, however, does occur in the transportation-corridor study area. Lakes and Ponds and the surrounding habitats that are preferred by Long-tailed Ducks for nesting (Upland Moist Dwarf Scrub, Upland Moist Low Willow Scrub, Lowland Sedge–Forb Marsh, Lowland Ericaceous Scrub Bog, and Lowland Wet Graminoid–Shrub Meadow) were considered to be of moderate value because they provide nesting, foraging, brood-rearing, and escape areas (Appendix 16.6C).

Red-throated Loon. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Red-throated Loon habitat use in Alaska.

Red-Throated Loons were not recorded breeding in the transportation-corridor, Bristol Bay drainages study area during surveys in 2004 and 2005, but one loon was observed on the Newhalen River during a fall migration survey in 2005. This observation was outside the transportation-corridor study area, but Red-throated Loons could occur anywhere on large rivers such as the Newhalen and the Iliamna. Rivers and Streams (Anadromous) was considered to be of moderate value because this habitat is used for foraging by Red-throated Loons. Lakes and Ponds was considered to be of moderate value because it provides staging habitat and potential nesting habitat (Appendix 16.6C). Preferred nesting habitats of Red-throated Loons (Lowland Sedge–Forb Marsh and Lowland Wet Graminoid–Shrub Meadow) occur along the shorelines of Lakes and Ponds in the transportation-corridor study area and these types were considered to be of moderate value.

Common Loon. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Common Loon habitat use in Alaska.

The Iliamna Lake area is located on the eastern edge of the nesting grounds for Common Loons in the Bristol Bay region. During surveys in 2004 and 2005, Common Loons were found on six different lakes in the transportation-corridor, Bristol Bay drainages study area, and broods were located on three of the six lakes. Lakes and Ponds greater than 15 hectares in size were considered to be of high value for foraging, nesting, and brood-rearing. Lowland Sedge–Forb Marsh and Lowland Wet Graminoid–Shrub Meadow that occur on the shores of large lakes in the study area were considered to be of high value for nesting and resting (Appendix 16.6C). Rivers and Streams (Anadromous) provide potential staging areas and this habitat was considered to be of moderate value. Lowland Ericaceous Scrub Bog sometimes occurs along the shores of large lakes and may provide potential nesting habitat, but this habitat was considered to be of low value.

Arctic Tern. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Arctic Tern habitat use in Alaska.

Arctic Terns were observed using some lakes and rivers (the Newhalen and Iliamna) for foraging during spring migration surveys in the transportation-corridor, Bristol Bay drainages study area in 2004 and 2005. Observations ranged from individuals to large flocks. Rivers and Streams (Anadromous) was considered to be a high-value foraging habitat and Lakes and Ponds a moderate-value habitat. No nesting Arctic Terns were found during surveys in the transportation-corridor study area in 2004 and 2005, but potential nesting habitat occurs in Riverine Barrens, Riverine Wet Graminoid–Shrub Meadow, Lowland Ericaceous Scrub Bog, and Lowland Wet Graminoid–Shrub Meadow, all of which were considered to be low- to moderate-value habitats.

Shorebirds

The seven breeding shorebird species of concern evaluated in this study regularly are associated with a wide variety of habitat types during the nesting and brood-rearing periods. In the transportation-corridor, Bristol Bay drainages study area, two species (Surfbird and American Golden-Plover) may use higher elevation alpine and upland habitats, with Surfbirds focusing on barren and dwarf-scrub habitats in alpine areas, and American Golden-Plovers using alpine and upland dwarf-scrub habitats as well as lowland scrub-bog and meadow types. Five other species (Solitary Sandpiper, Lesser Yellowlegs, Whimbrel, Hudsonian Godwit, and Short-billed Dowitcher) all regularly are associated with open, wet, lowland and riverine habitats (meadows, scrub-bogs, marshes) as well as the shorelines of lacustrine waterbodies.

Lesser Yellowlegs and Solitary Sandpipers also can use poorly drained spruce woodland and tall-scrub habitats.

The overall habitat availability in the transportation-corridor, Bristol Bay drainages study area for these seven shorebird species was assessed spatially in map form (Figure 16.1-10). This figure displays the suitability of habitats (moderate or high habitat-value rankings) for breeding shorebirds considered as a group. One habitat (Lowland Ericaceous Scrub Bog) was found suitable for the largest number of species (Appendix 16.6C). A diverse set of nine other habitats including dwarf-scrub, tall-scrub, forest, stream, meadow, marsh, and lacustrine waterbody types are suitable for a smaller number of shorebird species. Suitable habitats for the fewest number of species include various barren, dwarf-scrub, and meadow types. As a group, these suitable shorebird habitats are widely scattered throughout the transportation-corridor study area with no obvious areas of concentration.

American Golden-Plover. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of habitat use by breeding American Golden-Plovers in Alaska.

Montane tundra habitats suitable for breeding American Golden-Plovers are common in the transportation-corridor, Bristol Bay drainages study area, but the species was recorded only rarely during the point-count surveys in 2005. Habitats categorized as high value for American Golden-Plovers were Alpine Moist Dwarf Scrub, Upland Moist Dwarf Scrub, Upland Dry Dwarf Shrub–Lichen Scrub, Lowland Ericaceous Scrub Bog, and Lowland Wet Graminoid–Shrub Meadow, the latter two types probably only used by brood-rearing birds (Appendix 16.6C). Alpine Wet Dwarf Shrub–Sedge Scrub was considered to be of moderate value and all other mapped habitats were categorized as low or negligible value.

Solitary Sandpiper. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of habitat use by breeding Solitary Sandpipers in Alaska.

Forest openings and bog habitats with lakes and ponds suitable for breeding Solitary Sandpipers are common in the transportation-corridor, Bristol Bay drainages study area. The species, however, was recorded only rarely during the point-count surveys in 2005. Habitats categorized as high value for Solitary Sandpipers were Lowland Sedge–Forb Marsh and Lakes and Ponds (Appendix 16.6C). Habitats considered to be of moderate value were Lowland Ericaceous Scrub Bog, the tall-scrub types in lowland and riverine areas, Upland and Lowland Spruce Forest, and both types of Rivers and Streams. All other mapped habitats were categorized as low or negligible value.

Lesser Yellowlegs. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of habitat use by breeding Lesser Yellowlegs in Alaska.

Suitable forest, scrub, and wetland habitats for breeding Lesser Yellowlegs are common in the transportation-corridor, Bristol Bay drainages study area. The species, however, was recorded uncommonly during the point-count surveys in 2005. Habitats categorized as high value for Lesser Yellowlegs were Lowland Ericaceous Scrub Bog, Lowland Wet Graminoid–Shrub Meadow, Lowland Sedge–Forb Marsh, and Lakes and Ponds (Appendix 16.6C). Moderate-value habitats were the tall-scrub types in lowland and riverine areas, Upland and Lowland Spruce Forest, Riverine Wet Graminoid–Shrub Meadow, and both types of Rivers and Streams. All other mapped habitats were categorized as low or negligible value.

Whimbrel. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of habitat use by breeding Whimbrels in Alaska.

Alpine tundra and wetland habitats suitable for breeding Whimbrels are fairly common in the transportation-corridor, Bristol Bay drainages study area. Many of these habitats, however, were not adequately sampled (less than 10 point-counts) during the point-count surveys in 2005, and the species was not recorded in the area. Because the quality of the available habitats was considered to be low for this species and the species was not observed in the study area, but has the potential to occur there, all mapped habitats were considered to be of low or negligible value for Whimbrels (Appendix 16.6C).

Hudsonian Godwit. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of habitat use by breeding Hudsonian Godwits in Alaska.

Complexes of forest and wetland habitats suitable for breeding Hudsonian Godwits are fairly common in the transportation-corridor, Bristol Bay drainages study area. Many of these habitats, however, were not adequately sampled (less than 10 point-counts) during the point-count surveys in 2005, and the species was not recorded in the area. Because the quality of the available habitats was considered to be low for this species and the species was not observed in the study area, but has the potential to occur there, all mapped habitats were considered to be of low or negligible value for Hudsonian Godwits (Appendix 16.6C).

Surfbird. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of habitat use by breeding Surfbirds in Alaska.

Rocky alpine habitats suitable for breeding Surfbirds are relatively uncommon in the transportation-corridor, Bristol Bay drainages study area. These habitats were not sampled, however, during the point-count surveys in 2005, and the species was not recorded in the area. Because the species was not observed in the study area but has the potential to occur there, Alpine Dry Barrens and Alpine Moist Dwarf Scrub were considered to be of moderate value for Surfbirds (Appendix 16.6C). All other mapped habitats were categorized as low or negligible value.

Short-billed Dowitcher. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of habitat use by breeding Short-billed Dowitchers in Alaska.

Woodland bog habitats suitable for breeding Short-billed Dowitchers are fairly common in the transportation-corridor, Bristol Bay drainages study area. Many of these habitats, however, were not adequately sampled (less than 10 point-counts) during the point-count surveys in 2005, and the species was not recorded in the area. Because the quality of the available habitats was considered to be low for this species and the species was not observed in the study area, but has the potential to occur there, all mapped habitats were considered to be of low or negligible value for Short-billed Dowitchers (Appendix 16.6C).

Landbirds

The nine landbird species of concern evaluated in this study regularly are associated with several different habitats including barren alpine and upland areas (Rock Ptarmigan); dwarf-scrub habitats in alpine and upland areas (Rock and Willow Ptarmigan); low- and/or tall-scrub habitats in upland, lowland, and riverine settings (Willow Ptarmigan, Gray-cheeked Thrush, Varied Thrush, Blackpoll Warbler); and forests in upland, lowland, and riverine areas (Spruce Grouse, Black-backed Woodpecker, Olive-sided Flycatcher, Gray-cheeked Thrush, Varied Thrush, Blackpoll Warbler, Rusty Blackbird).

The overall habitat availability in the transportation-corridor, Bristol Bay drainages study area, for these nine landbird species was assessed spatially in map form (Figure 16.1-11). Forest habitats in upland, lowland, and riverine areas provide suitable breeding habitat (moderate or high habitat-value rankings) for the largest number of landbird species (Appendix 16.6C). These forest habitats are concentrated largely in two areas: from the base of Roadhouse Mountain east to where the transportation corridor runs along Chinkelyes Creek up to Summit Lakes and in the westernmost portion of the study area to the west of the Newhalen River. Suitable habitats for a decreasing number of species include tall-scrub and scrub-bog types, which have two areas of concentration: in the Pile/Iliamna river and Chinkelyes Creek drainages. Suitable habitats for the fewest number of landbird species include low-scrub, dwarf-scrub, and barren types in a variety of physiographic settings.

Spruce Grouse. Spruce Grouse are found exclusively in forested habitats. During the breeding season they only occur in forests where conifer trees are dominant or co-dominant (Boag and Schroeder, 1992). Spruce Grouse are resident in Alaska, and during the nonbreeding seasons they can sometimes be found in deciduous forests.

Forested habitats suitable for Spruce Grouse are abundant in the transportation-corridor, Bristol Bay drainages study area. Spruce Grouse, however, were recorded only rarely during the point-count surveys in 2005. Habitats categorized as high value for Spruce Grouse were Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, Riverine Moist White Spruce Forest, and Riverine Moist Mixed Forest (Appendix 16.6C). All other mapped habitats were categorized as negligible value.

Willow Ptarmigan. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Willow Ptarmigan habitat use in Alaska.

Suitable alpine and upland habitats for Willow Ptarmigan are common in the transportation-corridor, Bristol Bay drainages study area, although the species was recorded only rarely during the point-count surveys in 2005. Habitats categorized as high value for Willow Ptarmigan were the alpine and upland forms of moist dwarf scrub and all the low- and tall-scrub habitats in upland and lowland areas (Appendix 16.6C). Habitats categorized as moderate value were the low- and tall-scrub types in riverine areas and Lowland Ericaceous Scrub Bog. All other mapped habitats were categorized as low or negligible value.

Rock Ptarmigan. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of Rock Ptarmigan habitat use in Alaska.

Dwarf scrub and alpine barrens habitats suitable for Rock Ptarmigan are relatively uncommon in the transportation-corridor, Bristol Bay drainages study area, and the species was recorded rarely during the point-count surveys in 2005. Alpine Dry Barrens and Alpine Moist Dwarf Scrub were categorized as high value for Rock Ptarmigan, and Upland Dry Barrens, Upland Dry Dwarf Shrub–Lichen Scrub, and Upland Moist Dwarf Scrub were considered to be of moderate value (Appendix 16.6C). All other mapped habitats were categorized as low or negligible value.

Black-backed Woodpecker. Throughout their range, Black-backed Woodpeckers are found exclusively in forested habitats, especially coniferous forests or mixed forests with a strong coniferous tree component; in Alaska, the species is notably more abundant in areas with dead or dying trees and often selects smaller diameter, dead trees (coniferous or deciduous) for its nest sites (BPIFWG, 1999; Dixon and Saab, 2000). Black-backed Woodpeckers are resident in Alaska, and during the nonbreeding seasons they are found in the same habitats that are used during breeding.

Forested habitats suitable for Black-backed Woodpeckers are abundant in the transportation-corridor, Bristol Bay drainages study area. Black-backed Woodpeckers, however, were recorded only rarely during the point-count surveys in 2005. Habitats categorized as high value for Black-backed Woodpeckers were Riverine Moist White Spruce Forest and Riverine Moist Mixed Forest (Appendix 16.6C). Upland and Lowland Spruce Forest and Upland and Lowland Moist Mixed Forest were categorized as moderate value. All other mapped habitats were categorized as negligible value.

Olive-sided Flycatcher. Olive-sided Flycatchers breed primarily in montane and northern coniferous and mixed forests (BPIFWG, 1999; Altman and Sallabanks, 2000). They are more commonly found in open forests and make heavy use of forest openings (e.g., streams, ponds, lakeshores, bogs, meadows, burns, and other disturbances), where high perches along the forest edge are used for foraging and singing. Without forest openings, uneven canopies are preferred, which provide prominent perches above the canopy below. Wetter sites often are selected for their greater insect productivity.

Open-forest habitats suitable for Olive-sided Flycatchers are abundant in the transportation-corridor, Bristol Bay drainages study area, and the species was commonly recorded during the point-count surveys in 2005. Habitats categorized as high value for Olive-sided Flycatchers were Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, Riverine Moist White Spruce Forest, and Riverine Moist Mixed Forest (Appendix 16.6C). One habitat (Lowland Ericaceous Scrub Bog) was classified as moderate value. All other mapped habitats were categorized as negligible value.

Gray-cheeked Thrush. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of habitat use by breeding Gray-cheeked Thrushes in Alaska.

Tall-scrub habitats suitable for Gray-cheeked Thrushes are abundant in the transportation-corridor, Bristol Bay drainages study area, and the species was recorded frequently during the point-count surveys in 2005. Two habitats (Upland Moist Tall Willow Scrub and Upland Moist Tall Alder Scrub) were categorized as high value for Gray-cheeked Thrushes (Appendix 16.6C). Habitats considered to be of moderate value were Riverine Moist Mixed Forest, Riverine Tall Alder or Willow Scrub, Riverine Low Willow Scrub, Lowland Low and Tall Willow Scrub, and Upland Moist Low Willow Scrub. All other mapped habitats were categorized as low or negligible value.

Varied Thrush. Across their range, Varied Thrushes breed in wet coastal forests and in dense forests in interior areas; coniferous, deciduous, and mixed forests are all used (BPIFWG, 1999; George, 2000). In western Alaska, Varied Thrushes are occasionally found in tall-scrub thickets.

Suitable wet forest habitats for Varied Thrushes are common in the transportation-corridor, Bristol Bay drainages study area, and the species was recorded frequently during the point-count surveys in 2005. The habitats categorized as high value for Varied Thrushes were Riverine Moist Mixed Forest and Riverine Moist White Spruce Forest (Appendix 16.6C). Habitats considered to be of moderate value were Upland

and Lowland Moist Mixed Forest, Upland and Lowland Spruce Forest, Riverine Tall Alder or Willow Scrub, Lowland Low and Tall Willow Scrub, Upland Moist Tall Alder Scrub, and Upland Moist Tall Willow Scrub. All other mapped habitats were categorized as negligible value.

Blackpoll Warbler. See Section 16.1.7.2 (habitat-value assessments—mine study area) for a synopsis of habitat use by breeding Blackpoll Warblers in Alaska.

In the transportation-corridor, Bristol Bay drainages study area, forest and riverine tall-scrub habitats suitable for Blackpoll Warblers are common, and the species was recorded frequently during the point-count surveys in 2005. Habitats categorized as high value for Blackpoll Warblers were Riverine Moist Mixed Forest, Riverine Moist White Spruce Forest, and Riverine Tall Alder or Willow Scrub (Appendix 16.6C). Habitats considered to be of moderate value were the tall-scrub habitats in upland and lowland areas, Upland and Lowland Moist Mixed Forest, and Upland and Lowland Spruce Forest. All other mapped habitats were categorized as low or negligible value.

Rusty Blackbird. A bird of boreal forests, Rusty Blackbirds breed in wet coniferous and mixed forests where they use openings at scrub bogs, fens, and the marshy shores of lakes and ponds (Avery, 1995; BPIFWG, 1999). They prefer a tall-scrub or sapling-tree component in forest openings.

Wet, scrubby, forest openings suitable for Rusty Blackbirds are common in the transportation-corridor, Bristol Bay drainages study area, but the species was recorded only rarely during the point-count surveys in 2005. Habitats categorized as high value for Rusty Blackbirds were Upland and Lowland Moist Mixed Forest, Upland and Lowland Spruce Forest, and Lowland Ericaceous Scrub Bog (Appendix 16.6C). Habitats considered to be of moderate value were Riverine Moist Mixed Forest and Riverine Moist White Spruce Forest. All other mapped habitats were categorized as low or negligible value.

16.6.8 Summary

The transportation-corridor, Bristol Bay drainages study area designated for wildlife habitat mapping is 85 square kilometers in size and extends from the Summit Lakes area in the Chigmit Mountains east of Iliamna Lake and then roughly parallels the northern shore of Iliamna Lake to the base of Roadhouse Mountain before heading northwest towards the Pebble Deposit west of the Newhalen River. Twenty-five wildlife habitat types in the transportation-corridor, Bristol Bay drainages study area were mapped from aerial photography taken in July and October 2004 and September 2008. Habitat types were defined primarily by two variables (vegetation structure and physiographic setting). Forest habitats strongly dominate in the study area. Four forest types in upland, lowland, and riverine settings (Upland and Lowland Spruce Forest, Upland and Lowland Moist Mixed Forest, Riverine Moist White Spruce Forest, and Riverine Moist Mixed Forest) cover 65 percent of the study area. Low- and tall-scrub habitats dominated by willow and alder, also occurring in upland, lowland, and riverine areas, are relatively common and comprise 15 percent of the study area. Open dwarf-scrub and barren habitats in upland and alpine areas are less common and cover 11 percent of the study area.

Lacustrine waterbodies, wet graminoid-dominated meadows, and shrub-dominated bog habitats are relatively uncommon (seven percent of the study area) and occur primarily in lowland and riverine physiographic settings. Marsh habitats are rare and occur along the margins of lakes and ponds. A large number of riverine corridors occur in the area and support numerous stream channels and associated riverine forest, scrub, and meadow vegetation. Prominent streams in the study area, all of which drain into

Iliamna Lake, include, from east to west, Chinkelyes Creek; Iliamna and Pile rivers; Knutson, Canyon, and Chekok creeks; and the Newhalen River. Many of the streams in the study area support anadromous fish populations and provide foraging opportunities for wildlife.

Habitat-value assessments were made for 45 bird and mammal species of concern (32 birds and 13 mammals) that have been recorded or are strongly expected to occur in the transportation-corridor study area. These 45 species were selected because of their protected status, conservation concern, sensitive/indicator status, management concern, and/or ecological importance. Habitat values were ranked for the 45 birds and mammals for each of the 25 mapped wildlife habitat types. Habitat values were categorically ranked into four classes (high, moderate, low, and negligible value) based upon project-specific field data whenever possible. When project-specific data were lacking, habitat values were determined by referencing habitat-use information in the scientific literature and/or using professional judgment based on field experience with the species in question in Alaska.

The most species-rich habitats in the transportation-corridor study area are the forest types, which have the greatest number of bird and mammal species with moderate- or high-value rankings (20–24 of the 45 species assessed). A diverse set of other habitats including Rivers and Streams (Anadromous), lacustrine waterbodies, and low- and tall-scrub and meadow habitats in riverine and lowland areas has relatively high numbers of species with moderate- or high-value rankings (16–19 species). Another set of habitats has lower numbers of species with moderate or high habitat rankings (nine–13 species); these habitats include Rivers and Streams, marshes, and dwarf-, low-, and tall-scrub habitats in upland and alpine settings. A small set of barren habitats in alpine, upland, riverine, and lacustrine areas has the fewest numbers of bird and mammal species with moderate or high habitat rankings (three–six species).

The transportation-corridor, Bristol Bay drainages study area provides at least some suitable habitat (moderate and/or high habitat-value rankings) for a set of 13 mammal species (wolf, red fox, river otter, wolverine, black bear, brown bear, moose, arctic ground squirrel, red squirrel, beaver, northern red-backed vole, tundra vole, and snowshoe hare). Black bears favor habitats that provide cover, and in the transportation-corridor study area most forest and tall-scrub habitats were considered to be of high value for black bears. Other forest, scrub, scrub-bog, meadow, marsh, and lacustrine habitats, and those rivers and streams supporting anadromous fishes were considered to be of moderate value for black bears. In contrast, brown bears are known to use a broader array of habitats than black bears, and 20 habitats in the study area were considered to be of moderate value for brown bears. One habitat (Rivers and Streams [Anadromous]) was considered to be of high value for brown bears because salmon streams are heavily used by foraging brown bears in late summer. Habitats suitable for both black and brown bears are common and widespread in the study area. For moose, low and/or tall willow-scrub habitats, riverine forests, and Lakes and Ponds were considered to be of high value, primarily for forage. The high-value moose habitats in the study area tend to be concentrated in stream drainage systems. Other scrub, scrub-bog, forest, meadow, marsh, and lacustrine habitats were considered to be of moderate value for moose, also for forage.

For birds, the transportation-corridor, Bristol Bay drainages study area provides at least some suitable habitat (moderate and/or high habitat-value rankings) for a set of four tree-nesting raptor species (Bald Eagle, Northern Goshawk, Merlin, Great Horned Owl), three cliff-nesting raptor species (Golden Eagle, Gyrfalcon, Peregrine Falcon), nine waterbird species (Trumpeter Swan, Tundra Swan, Harlequin Duck, Surf Scoter, Black Scoter, Long-tailed Duck, Red-throated Loon, Common Loon, Arctic Tern), four shorebird species (American Golden-Plover, Solitary Sandpiper, Lesser Yellowlegs, Surfbird), and nine landbird species (Spruce Grouse, Willow Ptarmigan, Rock Ptarmigan, Black-backed Woodpecker, Olive-sided Flycatcher, Gray-cheeked Thrush, Varied Thrush, Blackpoll Warbler, and Rusty Blackbird).

Habitats considered suitable for nesting and/or foraging tree-nesting raptors (forests, some scrub and barren habitats, meadows, lacustrine and riverine waterbodies) are common and widespread in the study area. For cliff-nesting raptors, a set of higher elevation, open dwarf-scrub and barren habitats, and some forest, scrub, scrub-bog, meadow, marsh, and aquatic habitats were considered suitable for nesting and/or foraging. The habitats preferred for foraging by cliff-nesting raptors in the study area are relatively common and widespread, but nesting habitats (cliffs) are uncommon.

For breeding and migrant waterbirds, lacustrine waterbodies and associated wet meadow habitats were considered to be of high value. Scrub-bogs, marshes, anadromous streams, and some forest and dwarf-, low- and tall-scrub habitats were considered to be of moderate value. Suitable habitats for breeding and migrant waterbirds are relatively common and widespread in the transportation-corridor study area, but these habitats have a higher likelihood of use when in association with aquatic habitats, especially lacustrine waterbodies. Suitable habitats for breeding shorebirds include open wetland types such as Lowland Ericaceous Scrub Bog and a diverse set of nine other habitats including barrens, dwarf-scrub, tall-scrub, forests, streams (both anadromous and non-anadromous types), meadows, marshes, and the shorelines of lacustrine waterbodies. The suitable habitats for breeding shorebirds are widely scattered throughout the transportation-corridor study area. Habitats suitable for breeding landbirds include forests, tall-scrub and scrub-bog, low-scrub, dwarf-scrub, and barren types in a variety of physiographic settings. Suitable habitats for breeding landbirds are common and widespread across the study area.

16.6.9 References

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16.6.10 Glossary

Frugivorous—refers to animal species that eat fruits, either entirely or as part of their diet

Graminoid—grass and grass-like plants (including sedges and rushes)

Lacustrine—associated with lakes and ponds and landscape features derived from the development of lakes and ponds

Orthophoto—a digital image of an aerial photo in which corrections have been to account for the camera angle and curvature of the earth so as to accurately represent the area displayed on a flat plane (i.e., computer screen)

Phenology—the study of recurring biological phenomena in plant and animal species due to changing weather conditions (e.g., seasonal changes in plant growth)

Photosignature—in the limited sense used here, a combination of color and texture on an aerial photo indicative of a particular vegetation, physiographic, or surface-form type

Physiography—in the limited sense used here, a categorization of landforms/topographic regions into classes, which are based largely on the geomorphological forces shaping the landforms in those areas (e.g., alpine, upland, lowland, lacustrine [see above], and riverine [see below])

Riverine—associated with rivers and streams and landscape features developed from the actions of rivers and streams

Sympatric—typically in reference to two species, often similar species, occurring together in the same geographic region

Ungulate—a hoofed mammal species (e.g., moose, caribou)

TABLES

TABLE 16.6-1
Criteria for the Selection of Bird and Mammal Species for Habitat-value Assessments, Transportation-corridor, Bristol Bay Drainages Study Area, 2010

Common Name	Scientific Name	Protected Species [a]	Conserv. Concern [b]	Sensitive Species [c]	Manage. Concern [d]	Ecol. Important [e]
Birds						
Trumpeter Swan	*Cygnus buccinator*			X		
Tundra Swan	*Cygnus columbianus*			X		
Harlequin Duck	*Histrionicus histrionicus*			X		
Surf Scoter	*Melanitta perspicillata*		X		X	
Black Scoter	*Melanitta nigra*		X		X	
Long-tailed Duck	*Clangula hyemalis*		X		X	
Spruce Grouse	*Falcipennis canadensis*				X	
Willow Ptarmigan	*Lagopus lagopus*				X	
Rock Ptarmigan	*Lagopus muta*				X	
Red-throated Loon	*Gavia stellata*		X			
Common Loon	*Gavia immer*			X		
Bald Eagle	*Haliaeetus leucocephalus*	X				
Northern Goshawk	*Accipiter gentilis*					X
Golden Eagle	*Aquila chrysaetos*	X				
Merlin	*Falco columbarius*					X
Gyrfalcon	*Falco rusticolus*		X			
Peregrine Falcon	*Falco peregrinus*		X			
American Golden-Plover	*Pluvialis dominica*		X			
Solitary Sandpiper	*Tringa solitaria*		X			
Lesser Yellowlegs	*Tringa flavipes*		X			
Whimbrel	*Numenius phaeopus*		X			
Hudsonian Godwit	*Limosa haemastica*		X			
Surfbird	*Aphriza virgata*		X			
Short-billed Dowitcher	*Limnodromus griseus*		X			

Common Name	Scientific Name	Protected Species [a]	Conserv. Concern [b]	Sensitive Species [c]	Manage. Concern [d]	Ecol. Important [e]
Arctic Tern	*Sterna paradisaea*		X			
Great Horned Owl	*Bubo virginianus*					X
Black-backed Woodpecker	*Picoides arcticus*		X			
Olive-sided Flycatcher	*Contopus cooperi*		X			
Gray-cheeked Thrush	*Catharus minimus*		X			
Varied Thrush	*Ixoreus naevius*		X			
Blackpoll Warbler	*Dendroica striata*		X			
Rusty Blackbird	*Euphagus carolinus*		X			
Mammals						
Wolf	*Canis lupus*				X	X
Red fox	*Vulpes vulpes*					X
River otter	*Lontra canadensis*				X	
Wolverine	*Gulo gulo*				X	
Black bear	*Ursus americanus*				X	
Brown bear	*Ursus arctos*				X	X
Moose	*Alces alces*				X	X
Arctic ground squirrel	*Spermophilus parryii*				X	X
Red squirrel	*Tamiasciurus hudsonicus*					X
Beaver	*Castor canadensis*				X	X
Northern red-backed vole	*Myodes rutilus*					X
Root vole	*Microtus oeconomus*					X
Snowshoe hare	*Lepus americanus*				X	X

Notes:

a. Legally protected under the Bald and Golden Eagle Protection Act.

b. Species is of conservation concern (see Chapter 17 for more information).

c. Species is sensitive to human disturbance and development in freshwater habitats and serves as an indicator of environmental health.

d. Species is of management concern for subsistence and/or sport hunting/trapping.

e. Ecologically important as predator or prey (not otherwise represented by another species under one of the other criteria above) or because of other prominent ecosystem effects.

TABLE 16.6-2
Wildlife Habitat-value Categories, Transportation-corridor, Bristol Bay Drainages Study Area, 2010

Wildlife Group	Value Class	Ranking Score	Description
Birds	High value	3	Known to be frequently used for nesting and/or foraging during the breeding season; these habitats are also often used during migration
	Moderate value	2	Moderate-value habitats would be regularly used during the breeding and/or migration seasons but less so than high-value habitats
	Low value	1	Low-value habitats would see little use by the species under consideration
	Negligible value	0	The species is not expected to occur, or will occur very rarely, in negligible-value habitats
Mammals	High value	3	Known to be frequently used for breeding, calving, denning, etc., and/or foraging during critical seasons
	Moderate value	2	Moderate-value habitats would be regularly used (e.g., especially for foraging) but less so than high-value habitats
	Low value	1	Low-value habitats would see little use by the species under consideration
	Negligible value	0	The species is not expected to occur, or will occur very rarely, in negligible-value habitats

TABLE 16.6-3
Areas (Square Kilometers) and Relative Abundance (Percent of Study Area) for Mapped Wildlife Habitat Types, Transportation-corridor, Bristol Bay Drainages Study Area, 2010

Habitat Type	**Area (Square Kilometers)**	**Percent of Study Area**
Alpine Dry Barrens	<0.01	0.01
Alpine Moist Dwarf Scrub	0.18	0.21
Alpine Wet Dwarf Shrub–Sedge Scrub	0.01	0.02
Upland Dry Barrens	0.31	0.37
Upland Dry Dwarf Shrub-Lichen Scrub	0.34	0.40
Upland Moist Dwarf Scrub	8.47	9.96
Upland Moist Low Willow Scrub	0.60	0.71
Upland Moist Tall Alder Scrub	6.77	7.96
Upland Moist Tall Willow Scrub	4.18	4.92
Upland and Lowland Spruce Forest	19.24	22.61
Upland and Lowland Moist Mixed Forest	34.07	40.04
Rivers and Streams	0.37	0.44
Rivers and Streams (Anadromous)	0.59	0.69
Riverine Barrens	0.09	0.10
Riverine Wet Graminoid–Shrub Meadow	0.36	0.43
Riverine Low Willow Scrub	0.51	0.60
Riverine Tall Alder or Willow Scrub	0.41	0.48
Riverine Moist White Spruce Forest	0.18	0.21
Riverine Moist Mixed Forest	2.10	2.47
Lakes and Ponds	1.70	2.00
Lacustrine Moist Barrens	0.06	0.07
Lowland Sedge–Forb Marsh	0.11	0.13
Lowland Ericaceous Scrub Bog	1.91	2.24
Lowland Wet Graminoid–Shrub Meadow	1.88	2.21
Lowland Low and Tall Willow Scrub	0.64	0.75
TOTAL	**85.10**	**100.00**

FIGURES

Figure 16.6-1
Overview of Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

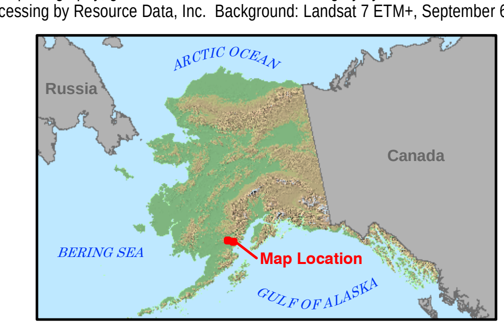
Legend

Wildlife Habitats

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area — Existing Road — Community

Color orthophotography for the mine mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.



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

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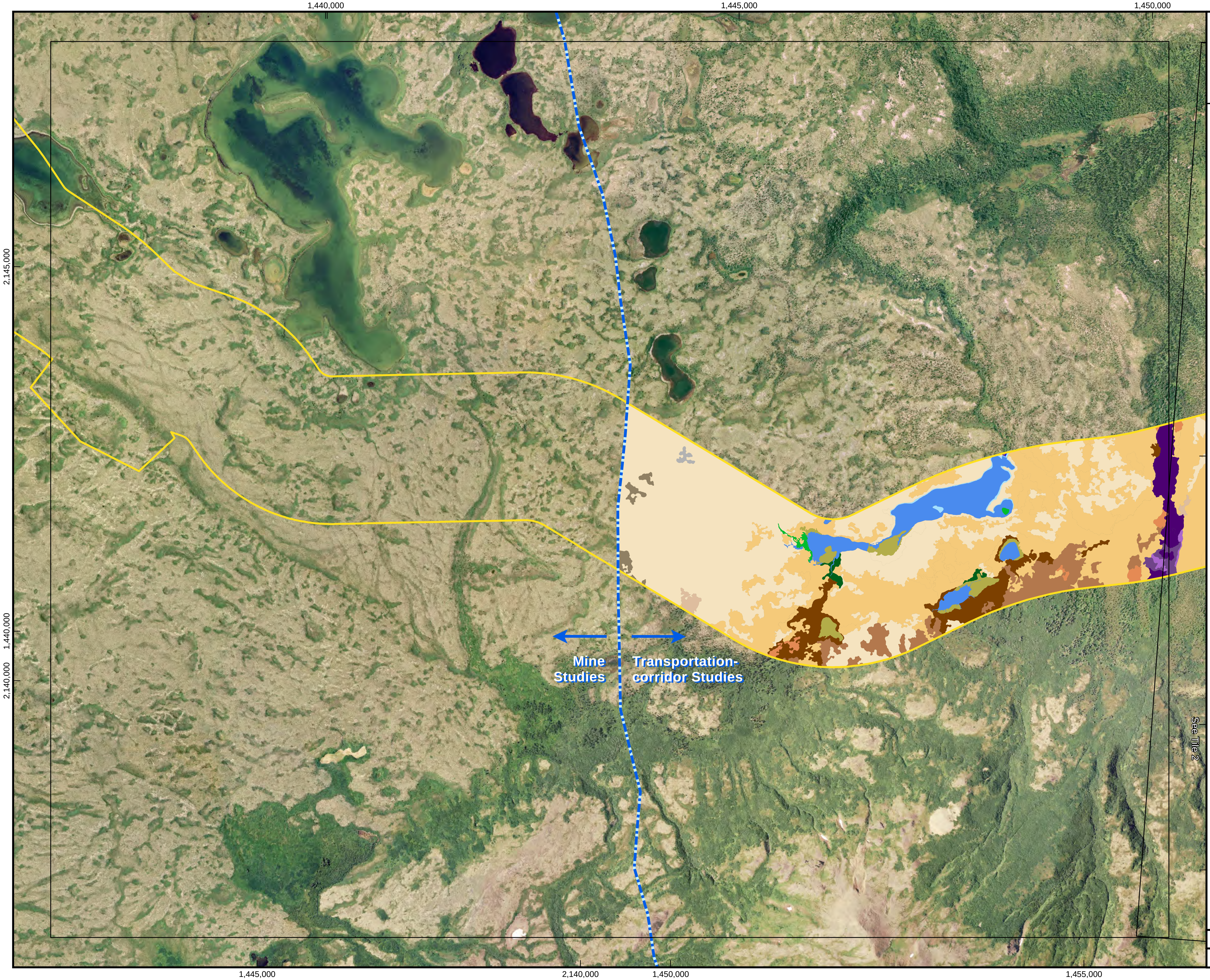
Version: 3	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.6-2a
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

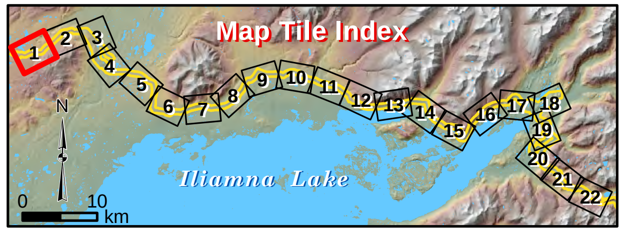
Wildlife Habitats – Tile 1

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Scale 1:16,000

0 500 1,000 1,500 2,000 Feet

0 200 400 600 Meters

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC

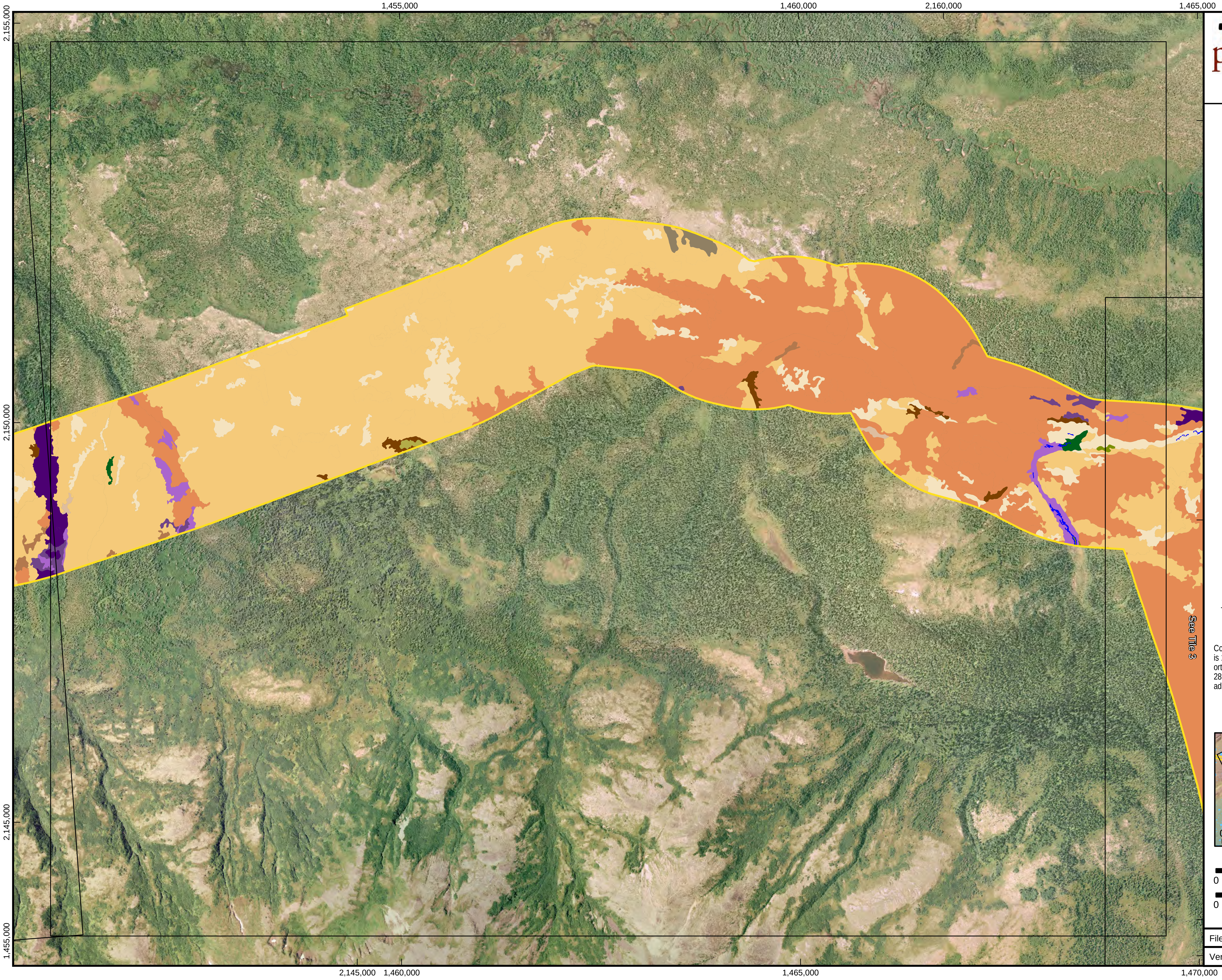


Figure 16.6-2b
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP

Legend

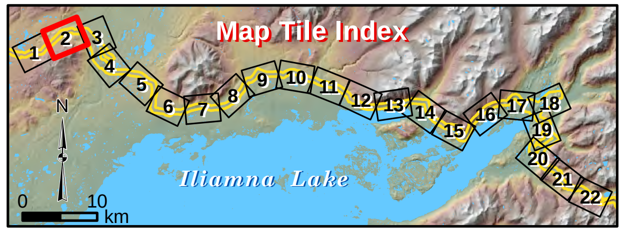
Wildlife Habitats – Tile 2

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

N

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

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Version: 2	Author: ABR-AZC

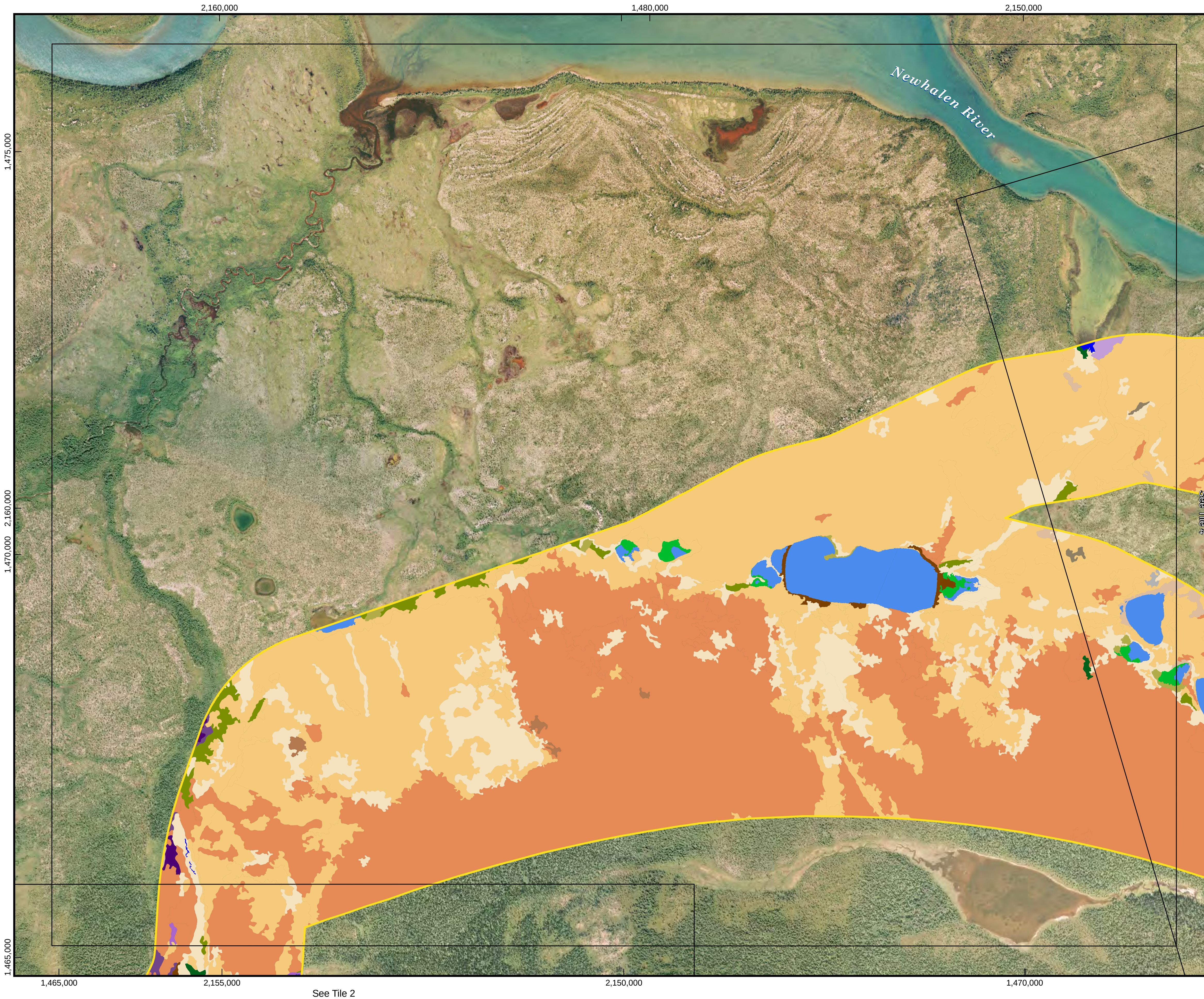

Figure 16.6-2c
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats – Tile 3

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

0 500 1,000 1,500 2,000 Feet

0 200 400 600 Meters

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

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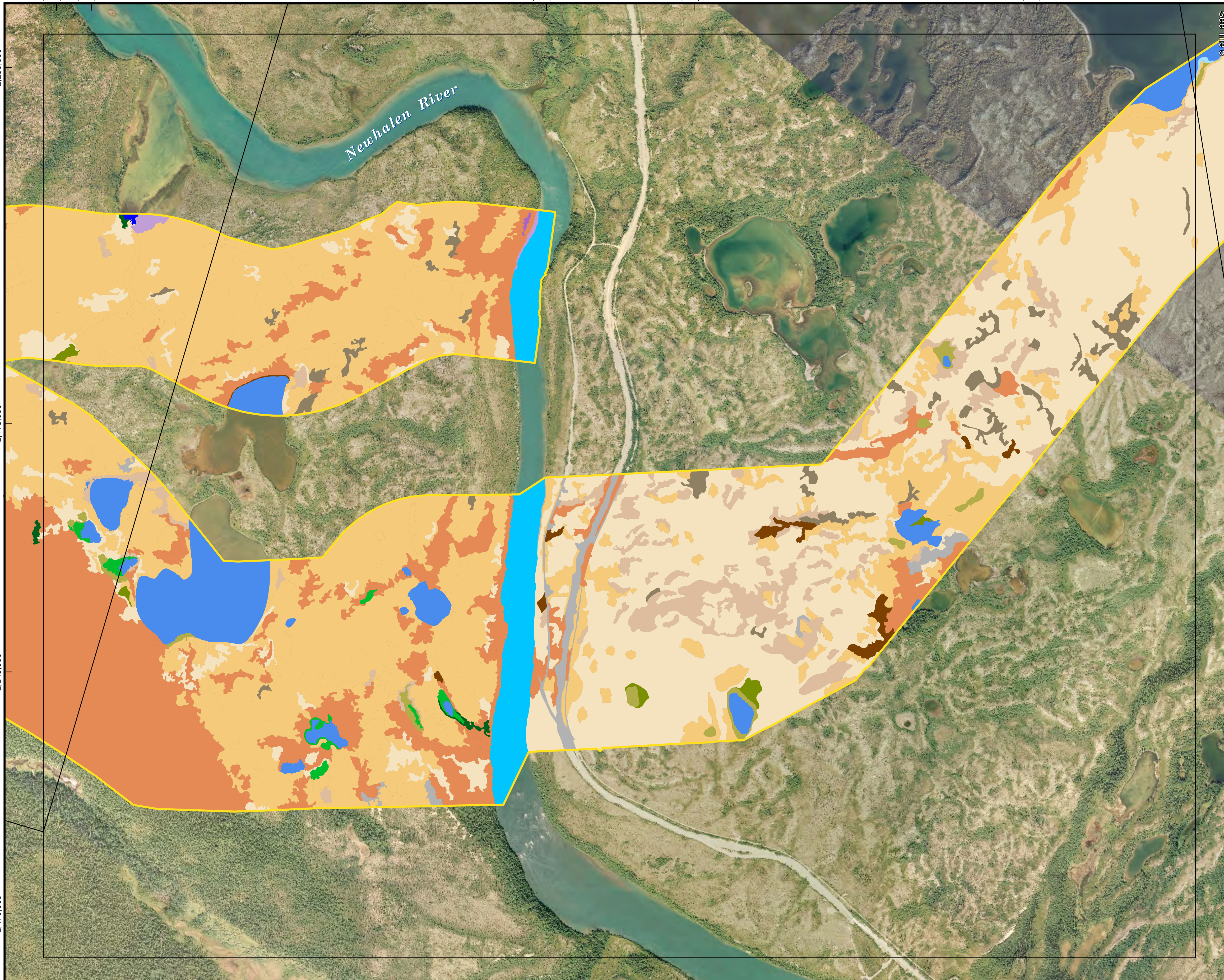
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.6-2d
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Wildlife Habitats – Tile 4

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC

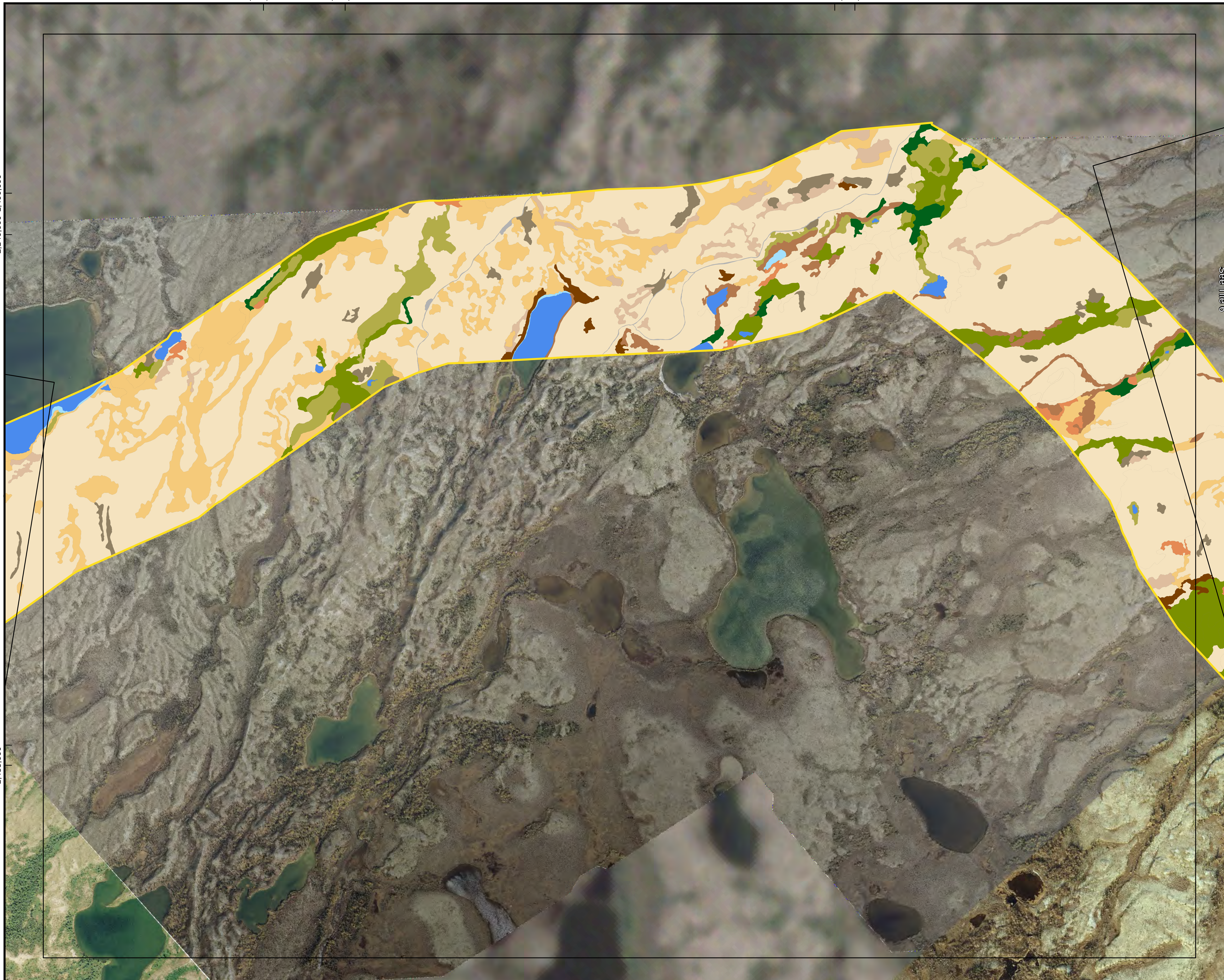


Figure 16.6-2e
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Wildlife Habitats – Tile 5

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

Feet: 0 | 500 | 1,000 | 1,500 | 2,000

Meters: 0 | 200 | 400 | 600

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC

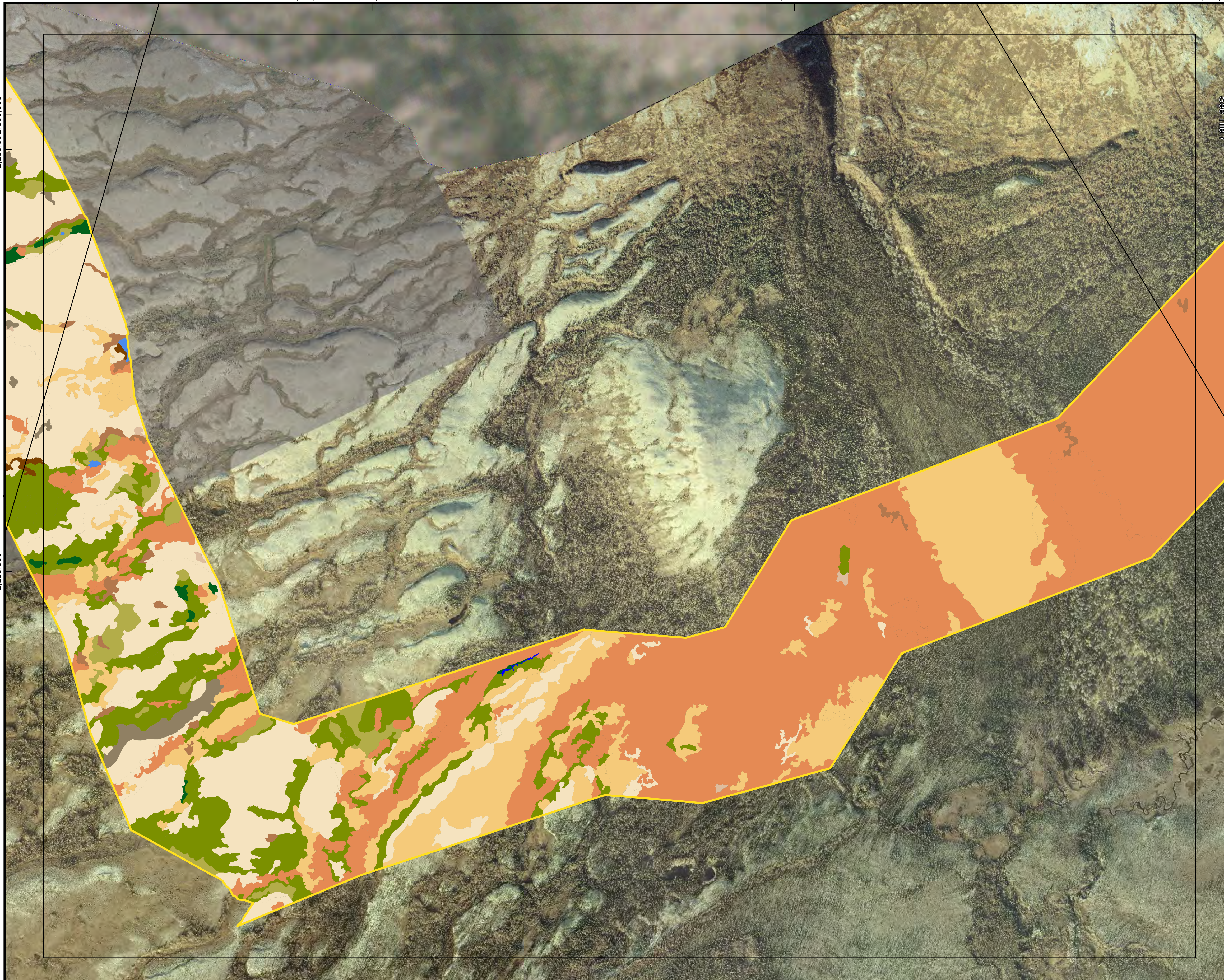


Figure 16.6-2f
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Wildlife Habitats – Tile 6

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

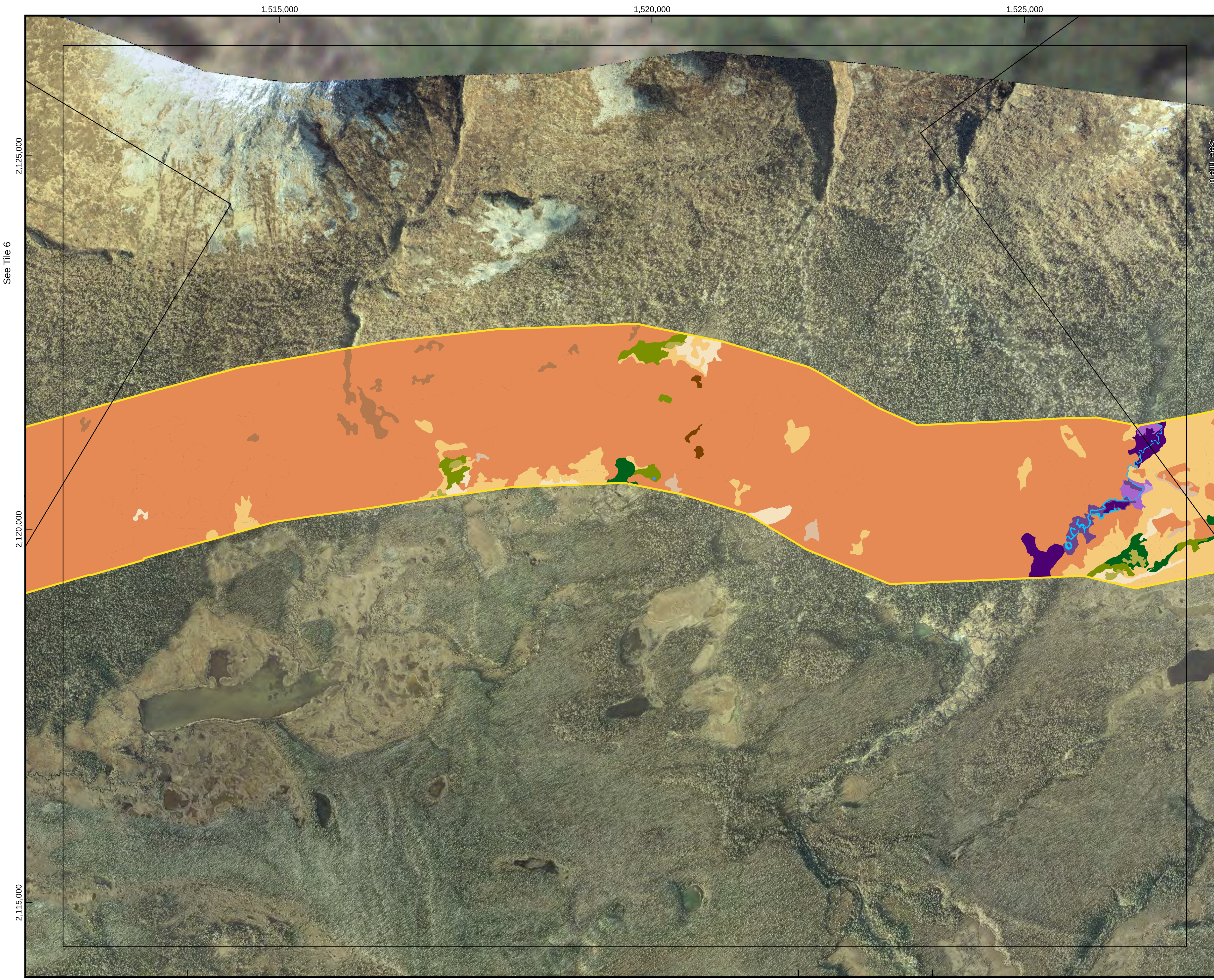
Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.6-2g
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Wildlife Habitats – Tile 7

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   ● Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC

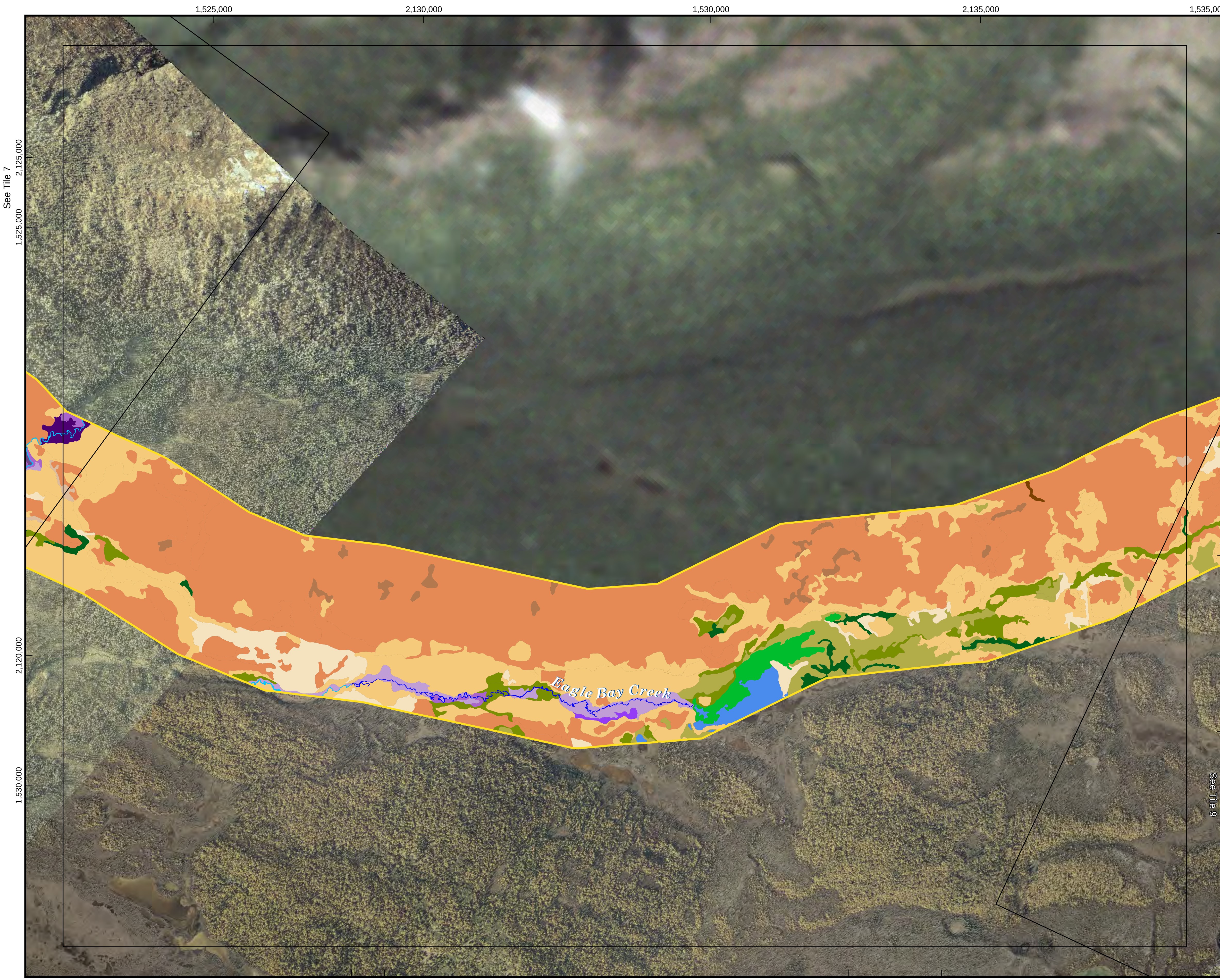


Figure 16.6-2h
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

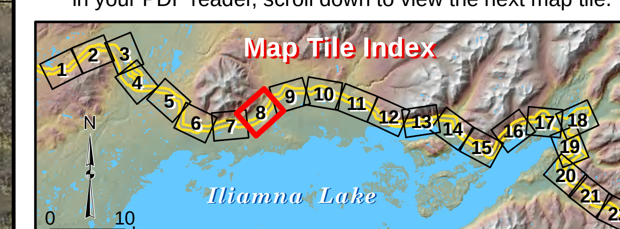
Wildlife Habitats – Tile 8

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Scale 1:16,000

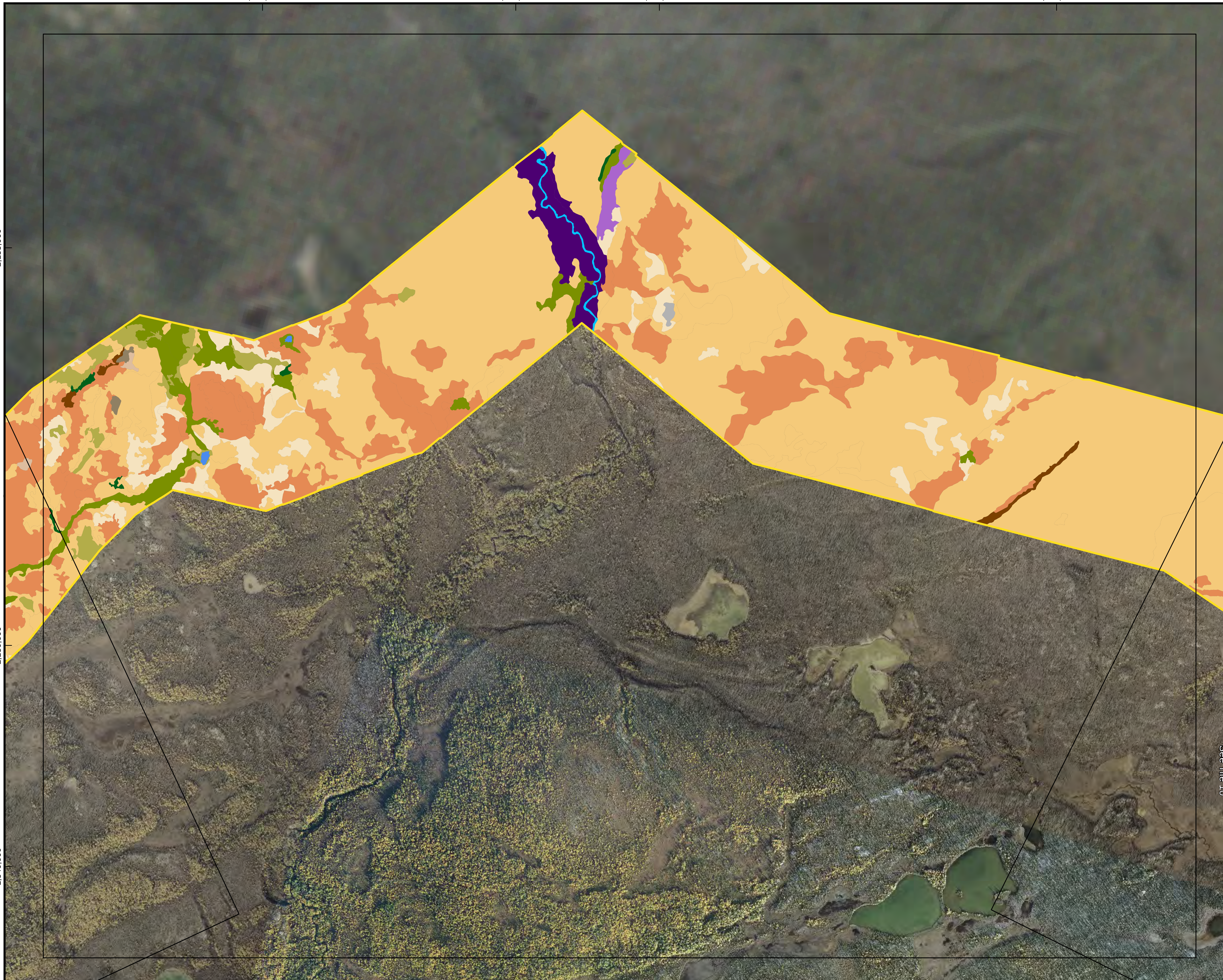
Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.6-2i
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

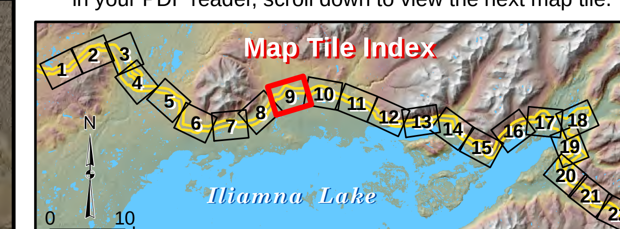
Wildlife Habitats – Tile 9

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Scale 1:16,000

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
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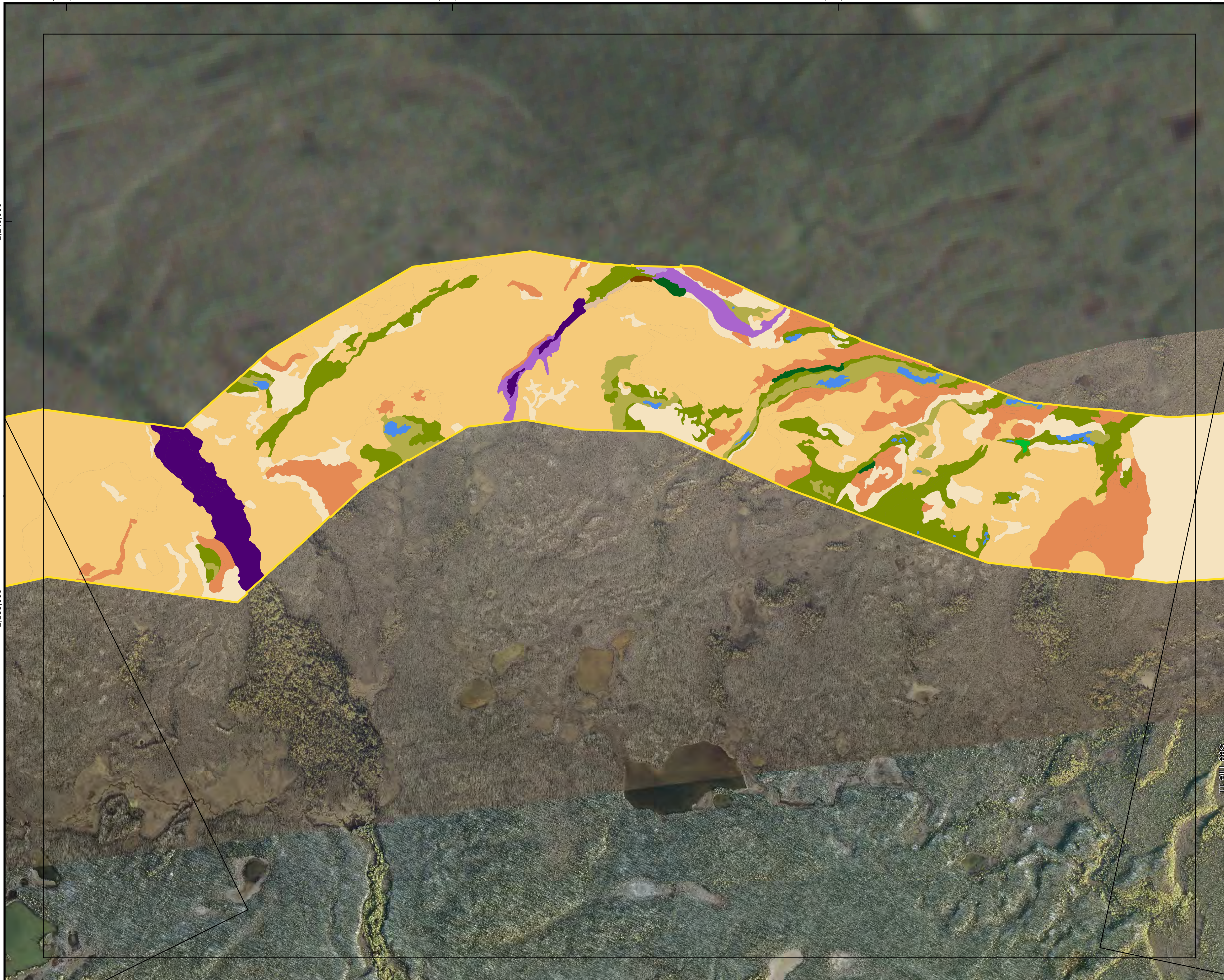

Figure 16.6-2j
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats – Tile 10

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

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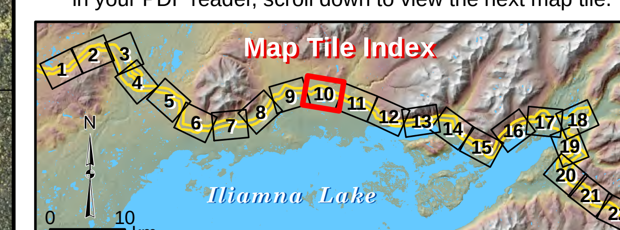

Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
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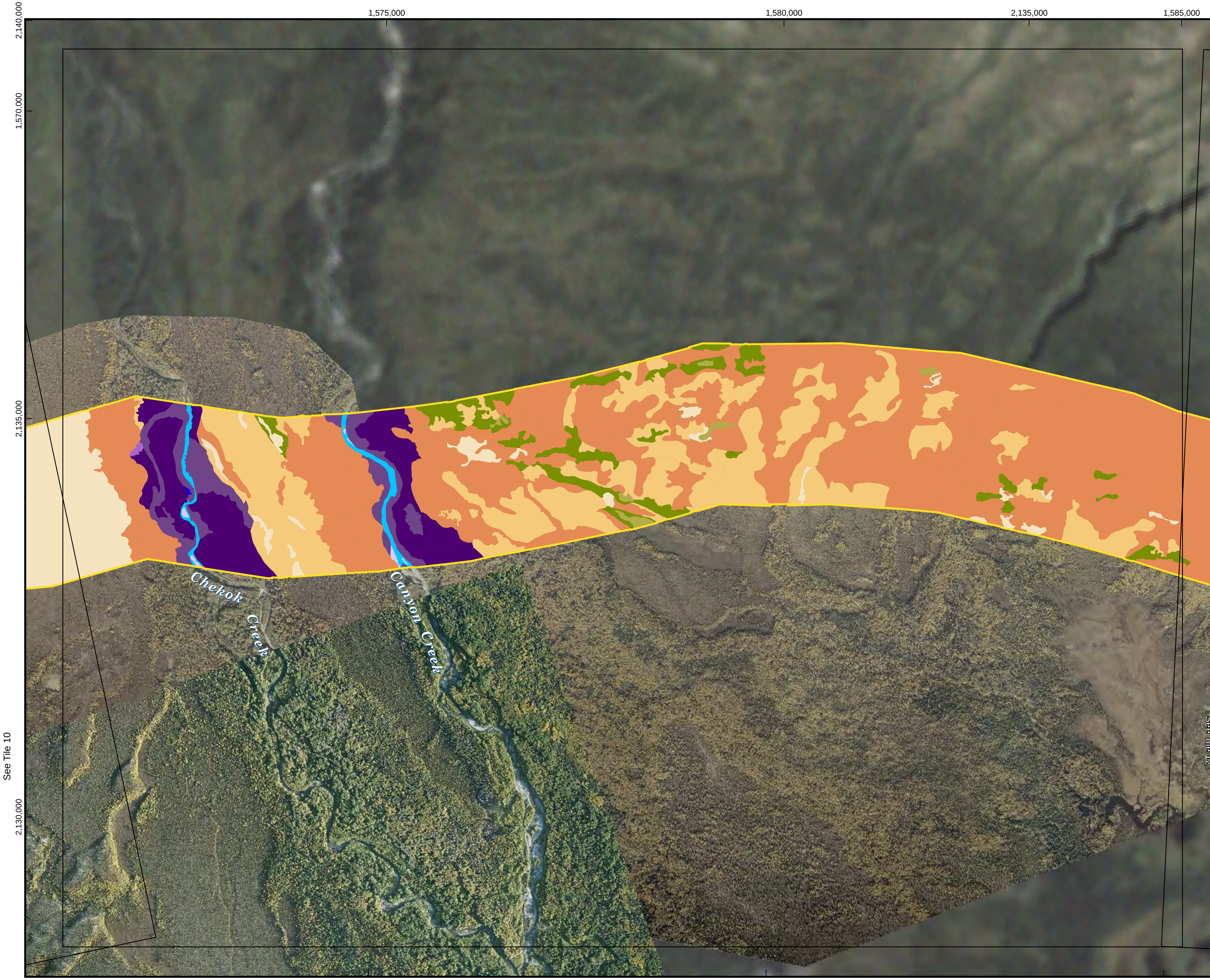
Figure 16.6-2k
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP



Legend

Wildlife Habitats – Tile 11

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

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Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

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

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Figure 16.6-2l
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Wildlife Habitats – Tile 12

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

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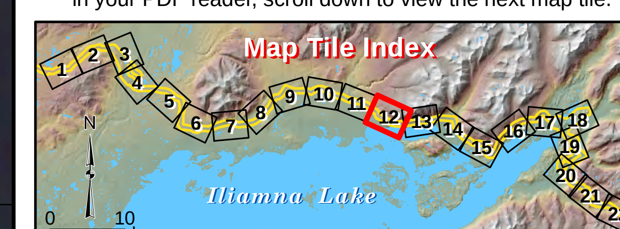

Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC

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Figure 16.6-2m
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Wildlife Habitats – Tile 13

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

0 500 1,000 1,500 2,000 Feet

0 200 400 600 Meters

N

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

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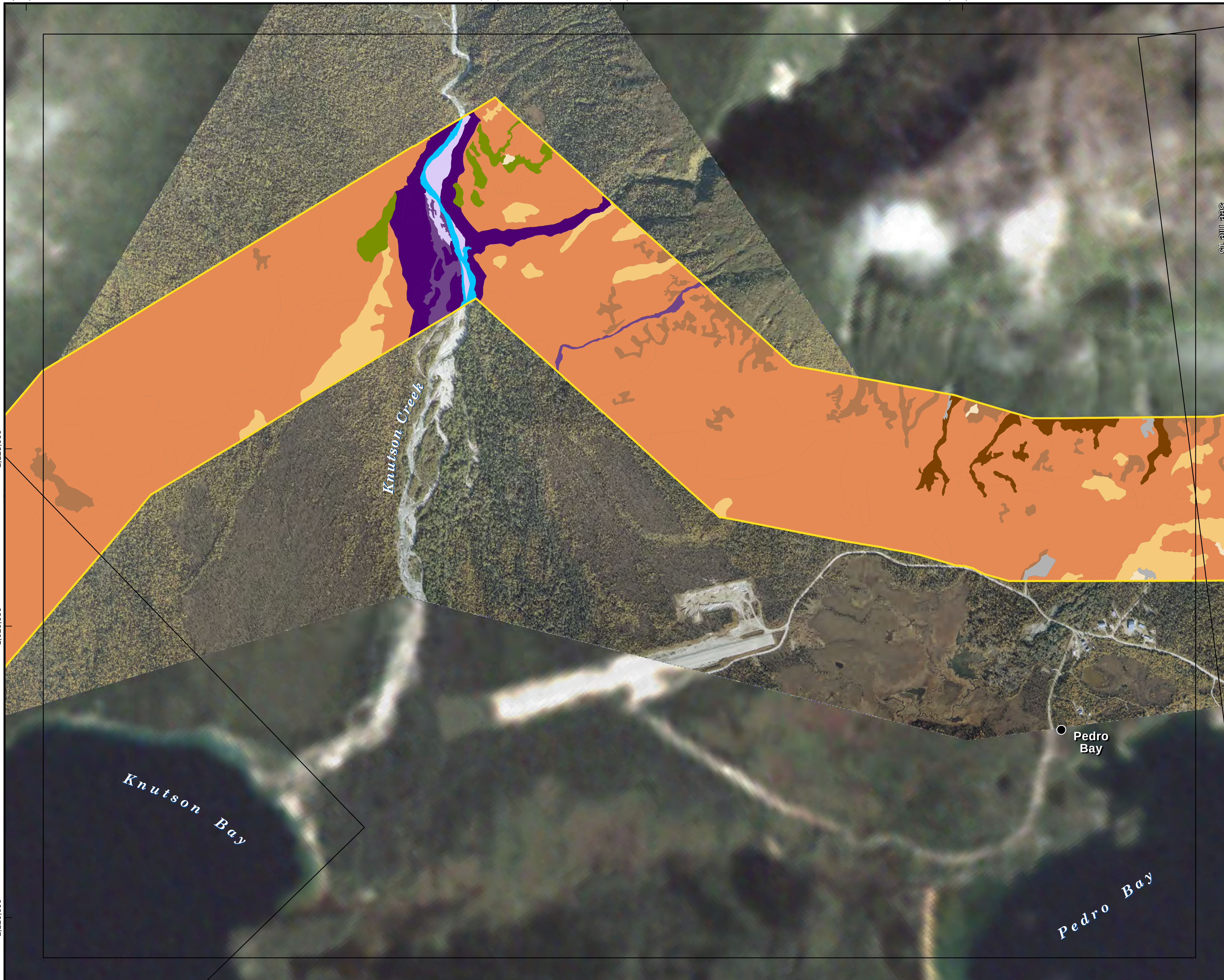
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.6-2n
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Wildlife Habitats – Tile 14

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC

Figure 16.6-2o
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats – Tile 15

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

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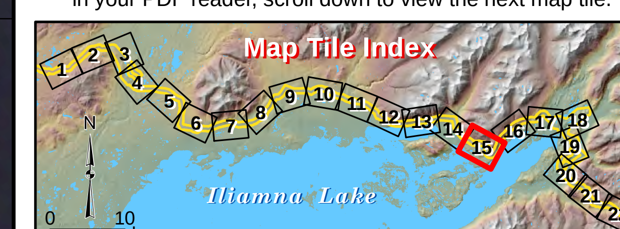

Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC

Figure 16.6-2p
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats – Tile 16

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

N

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

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Version: 2	Author: ABR-AZC

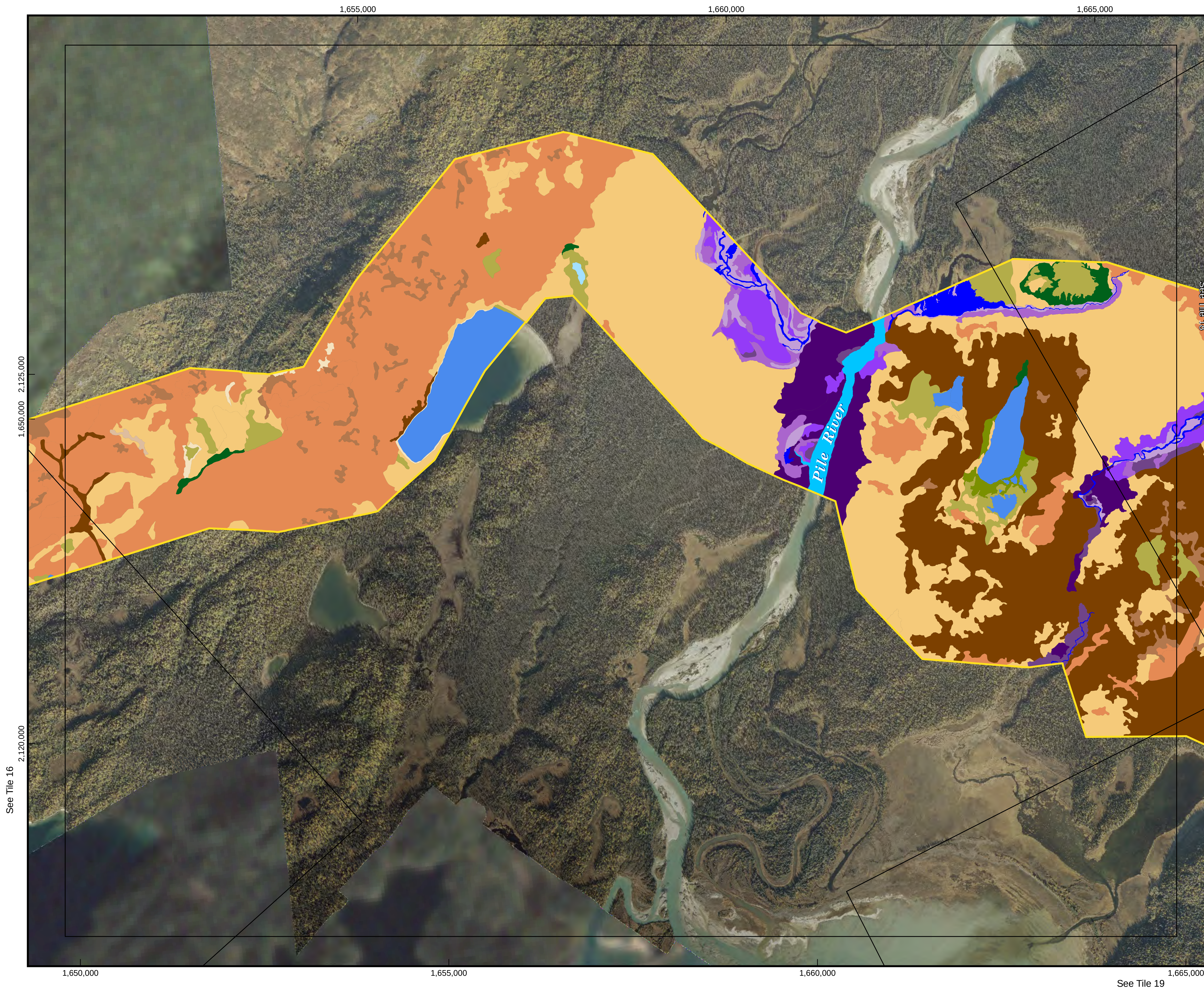


Figure 16.6-2q
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP

Legend

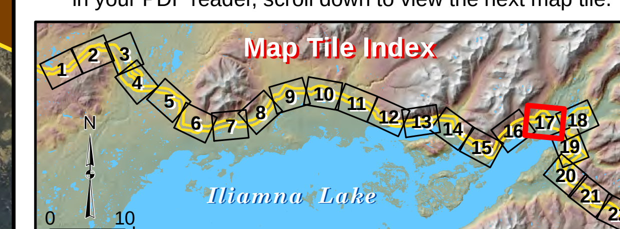
Wildlife Habitats – Tile 17

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area — Map Tile — Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.



Scale 1:16,000

0 500 1,000 1,500 2,000 Feet

0 200 400 600 Meters

N

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

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Version: 2	Author: ABR-AZC

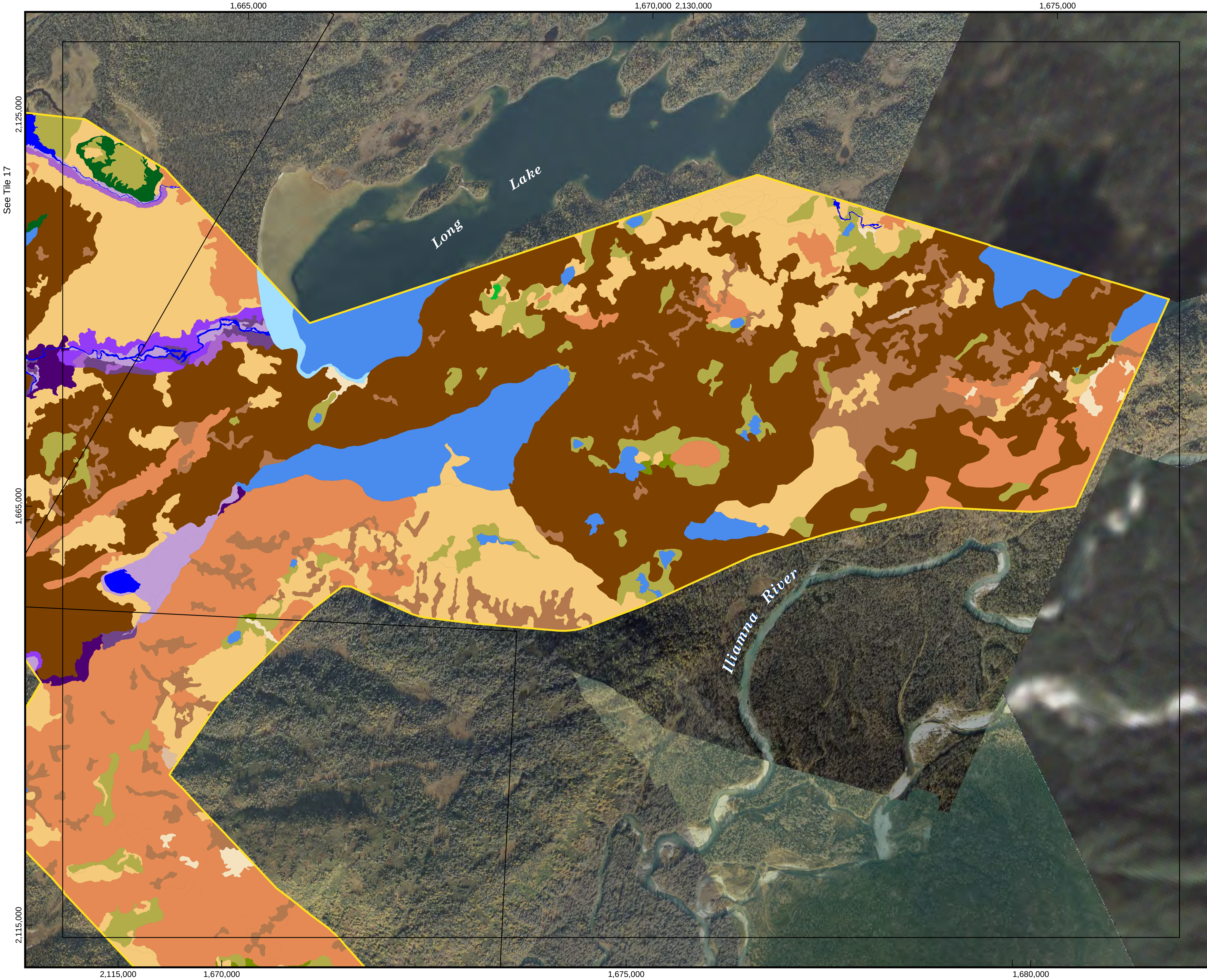


Figure 16.6-2s
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats – Tile 18

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

N

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC

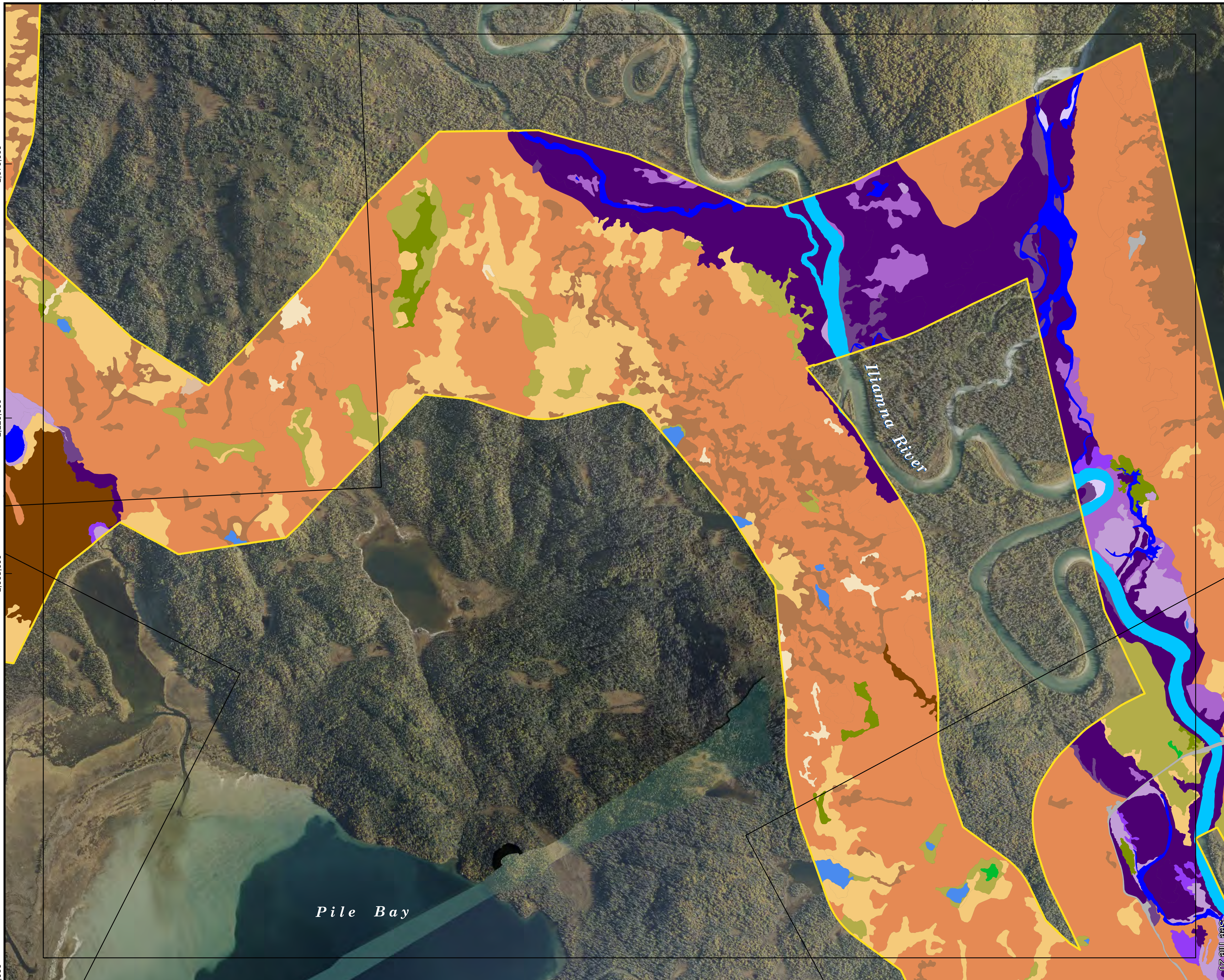


Figure 16.6-2r
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Wildlife Habitats – Tile 19

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

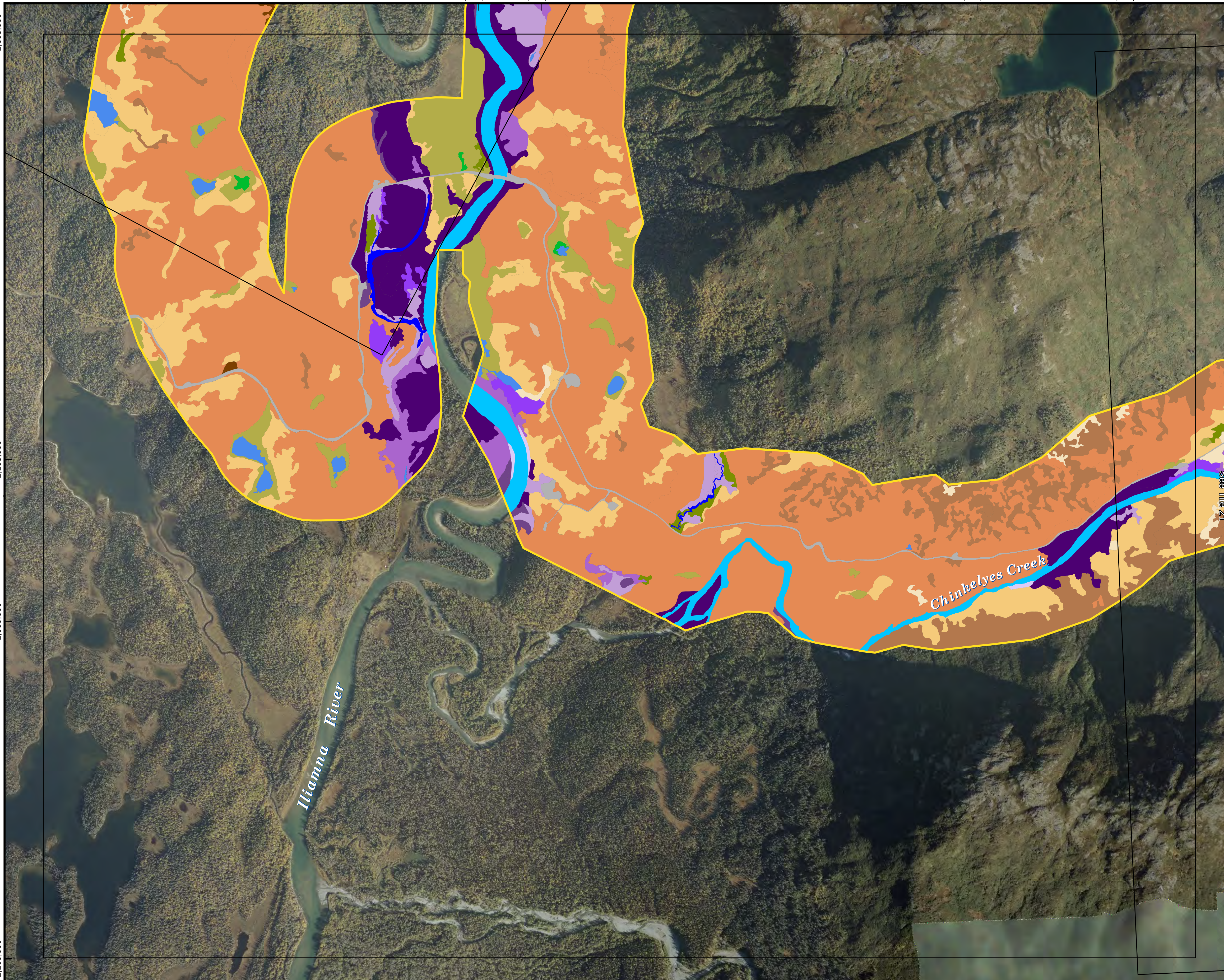
Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

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

File: 16-6-2_HabTiles_TC_PLP_EBD_v02.mxd	Date: March 15, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.6-2t
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Wildlife Habitats – Tile 20

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area   Map Tile   Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

Feet: 0, 500, 1,000, 1,500, 2,000

Meters: 0, 200, 400, 600

N

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

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Version: 2	Author: ABR-AZC

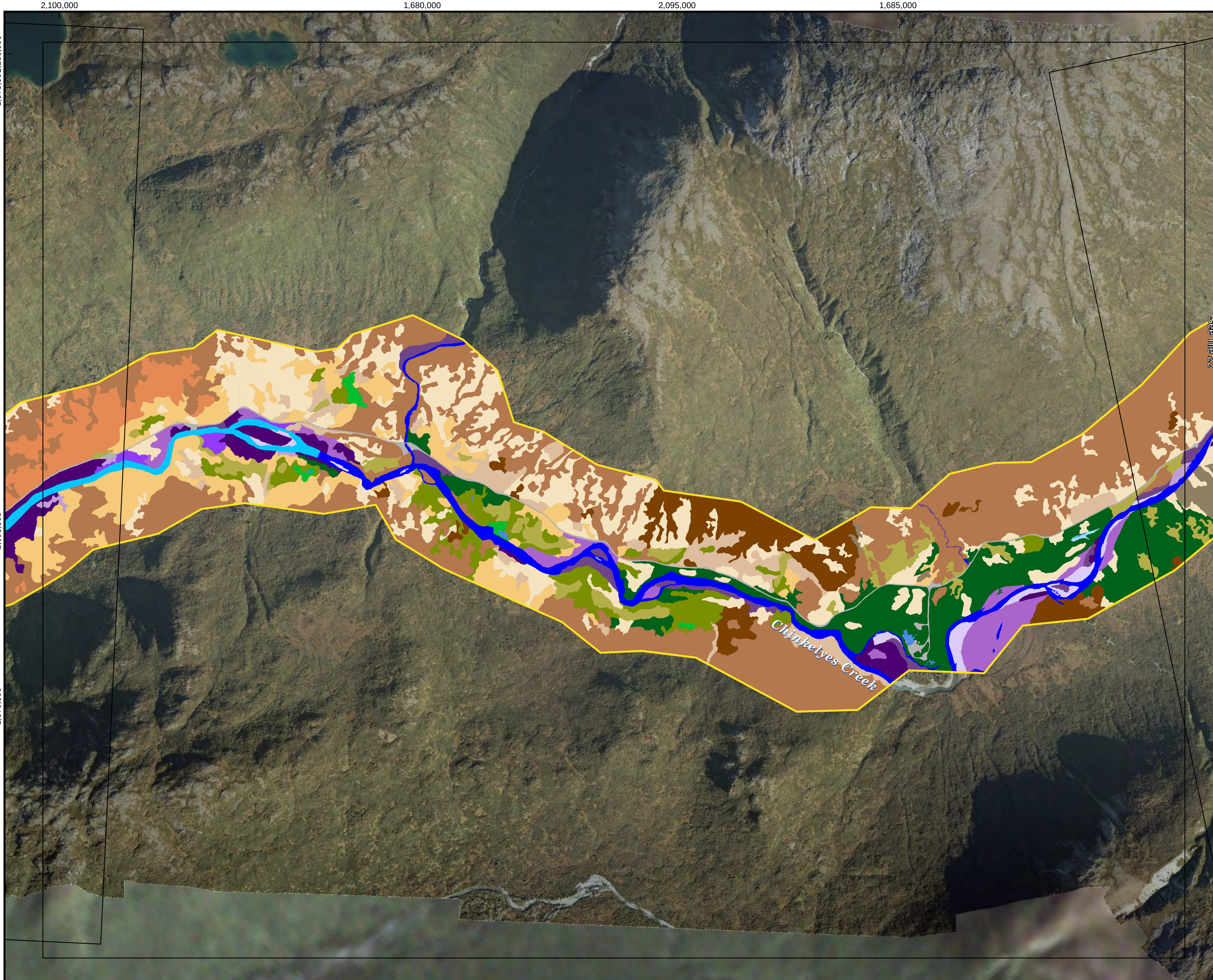

Figure 16.6-2u
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP

Legend

Wildlife Habitats – Tile 21

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area · Map Tile · Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

N

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

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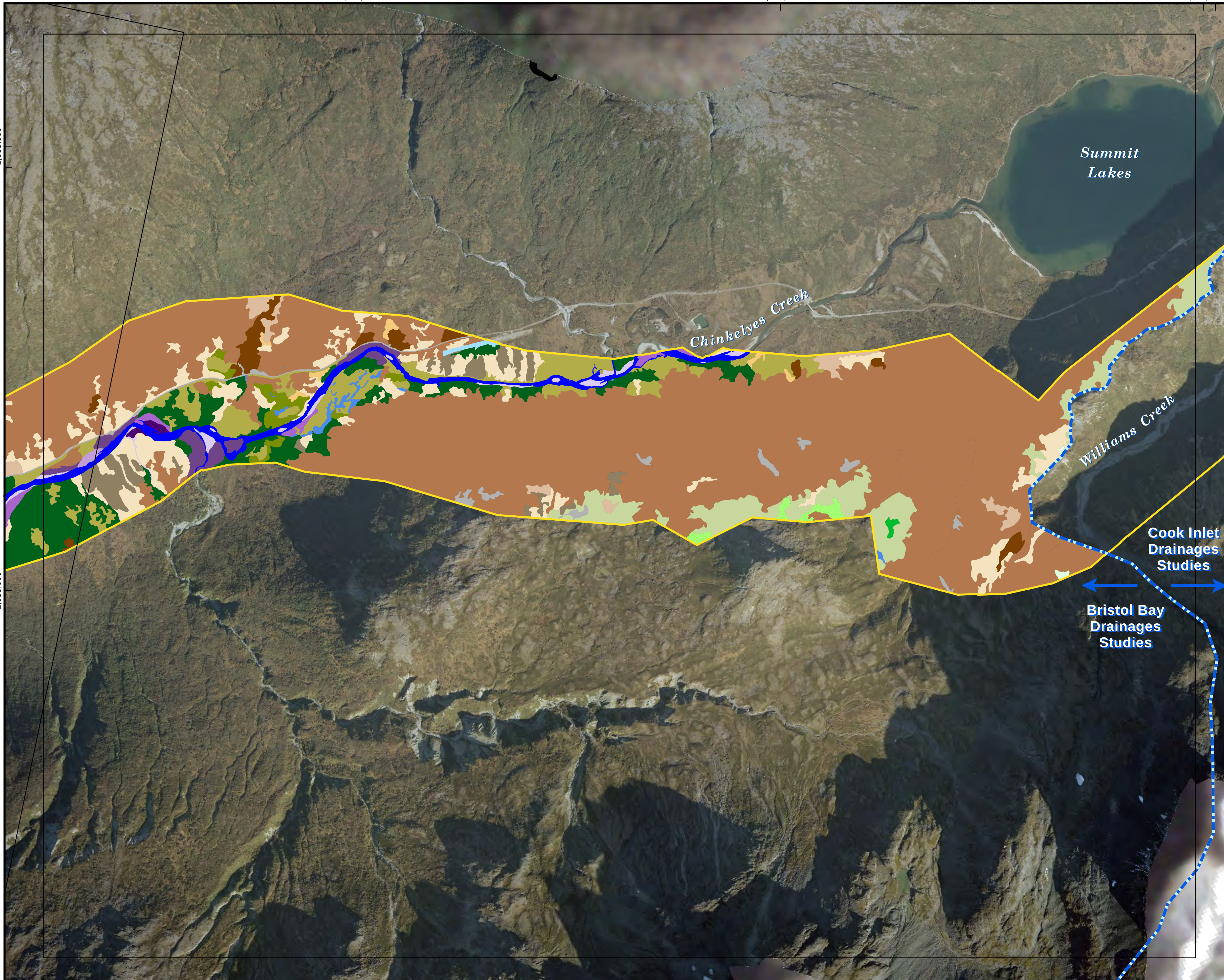
Version: 2	Author: ABR-AZC

Figure 16.6-2v
Wildlife Habitat Mapping, Transportation-corridor, Bristol Bay Drainages Study Area

THE pebble PARTNERSHIP



Legend

Wildlife Habitats – Tile 22

- Alpine Dry Barrens
- Alpine Moist Dwarf Scrub
- Alpine Wet Dwarf Shrub–Sedge Scrub
- Upland Dry Barrens
- Upland Dry Dwarf Shrub–Lichen Scrub
- Upland Moist Dwarf Scrub
- Upland Moist Low Willow Scrub
- Upland Moist Tall Alder Scrub
- Upland Moist Tall Willow Scrub
- Upland and Lowland Spruce Forest
- Upland and Lowland Moist Mixed Forest
- Rivers and Streams
- Rivers and Streams (Anadromous)
- Riverine Barrens
- Riverine Wet Graminoid–Shrub Meadow
- Riverine Low Willow Scrub
- Riverine Tall Alder or Willow Scrub
- Riverine Moist White Spruce Forest
- Riverine Moist Mixed Forest
- Lakes and Ponds
- Lacustrine Moist Barrens
- Lowland Sedge–Forb Marsh
- Lowland Ericaceous Scrub Bog
- Lowland Wet Graminoid–Shrub Meadow
- Lowland Low and Tall Willow Scrub

Mapping Area | Map Tile | Community

Color orthophotography for tiles 1–4 based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Note: When viewing the digital version of this map series in your PDF reader, scroll down to view the next map tile.

Scale 1:16,000

Feet: 0 500 1,000 1,500 2,000

Meters: 0 200 400 600

N

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

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Version: 2	Author: ABR-AZC

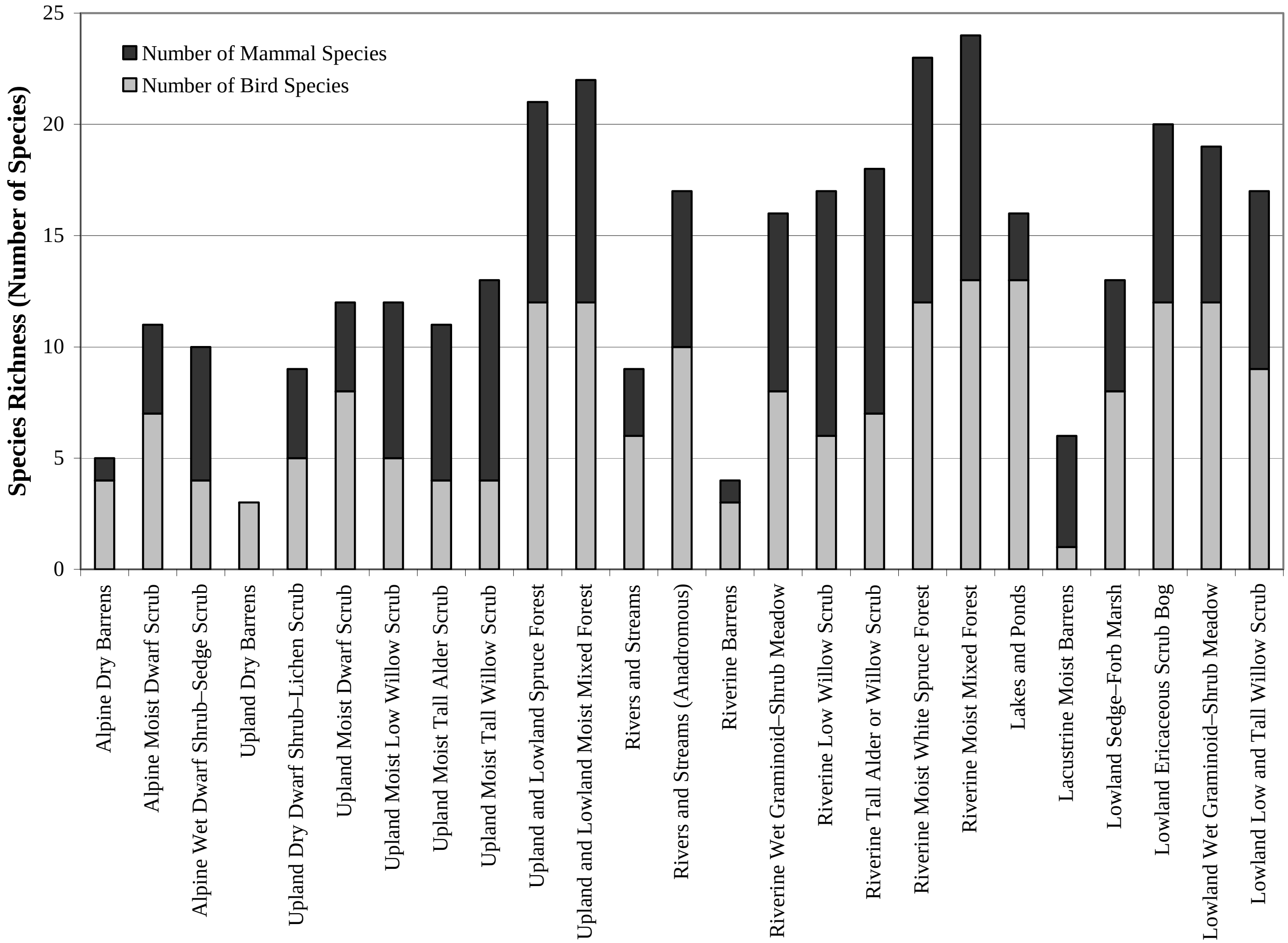


FIGURE 16.6-3
Species Richness of Bird and Mammal Species of Concern with Moderate- or High-value Habitat Rankings in Mapped Wildlife Habitat Types, Transportation-corridor, Bristol Bay Drainages Study Area

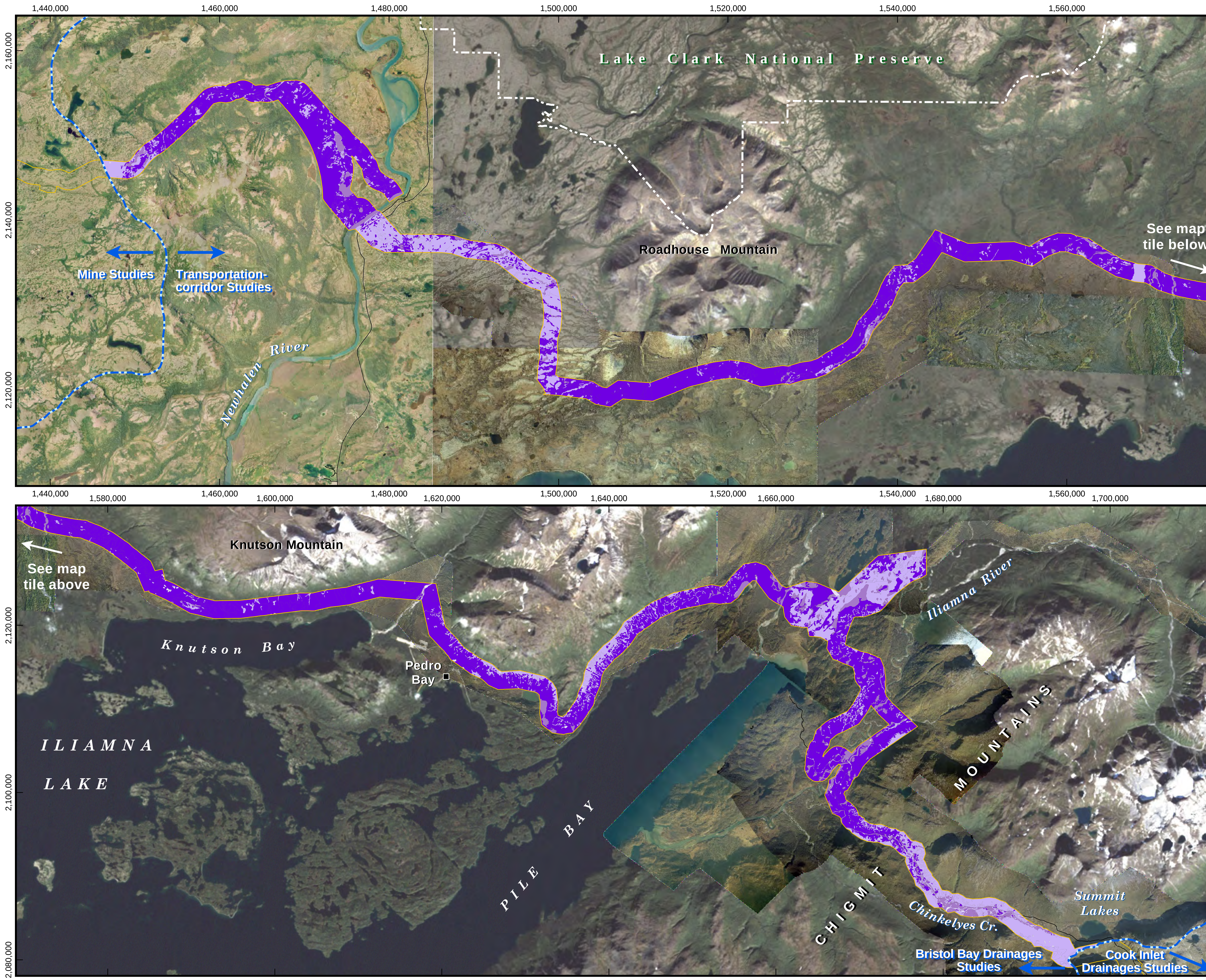


Figure 16.6-4
Species Richness for Bird and Mammal Species of Concern, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Number of Species with Moderate or High Habitat-value Rankings

- High (20–24 Species)
- Moderate–High (16–19 Species)
- Low–Moderate (9–13 Species
- Low (3–6 Species)

- Mapping Area
- Existing Road
- Community

Color orthophotography for the mine mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Miles 0 1 2 3 4
Kilometers 0 1 2 3 4 5 6
N
Scale 1:140,000

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

File: 16-6-4_Species_Richness_TC_PLP_EBD_v03.mxd	Date: March 15, 2011
Version: 3	Author: ABR-AZC

THE pebble PARTNERSHIP

Figure 16.6-5
Habitat Availability for Brown and Black Bears, Transportation-corridor, Bristol Bay Drainages Study Area

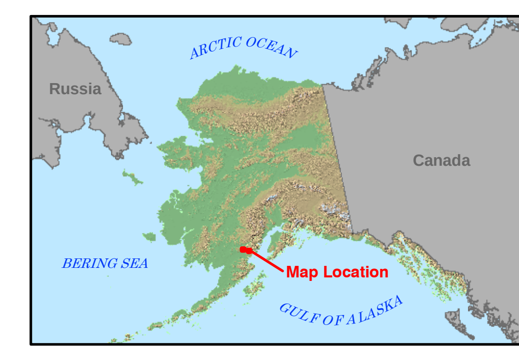
Legend

Number of Species with Moderate or High Habitat-value Rankings

- 2 Species
- 1 Species
- 0 Species

- Mapping Area
- Existing Road
- Community

Color orthophotography for the mine mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.



Miles 0 1 2 3 4
Kilometers 0 1 2 3 4 5 6
N

Scale 1:140,000

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

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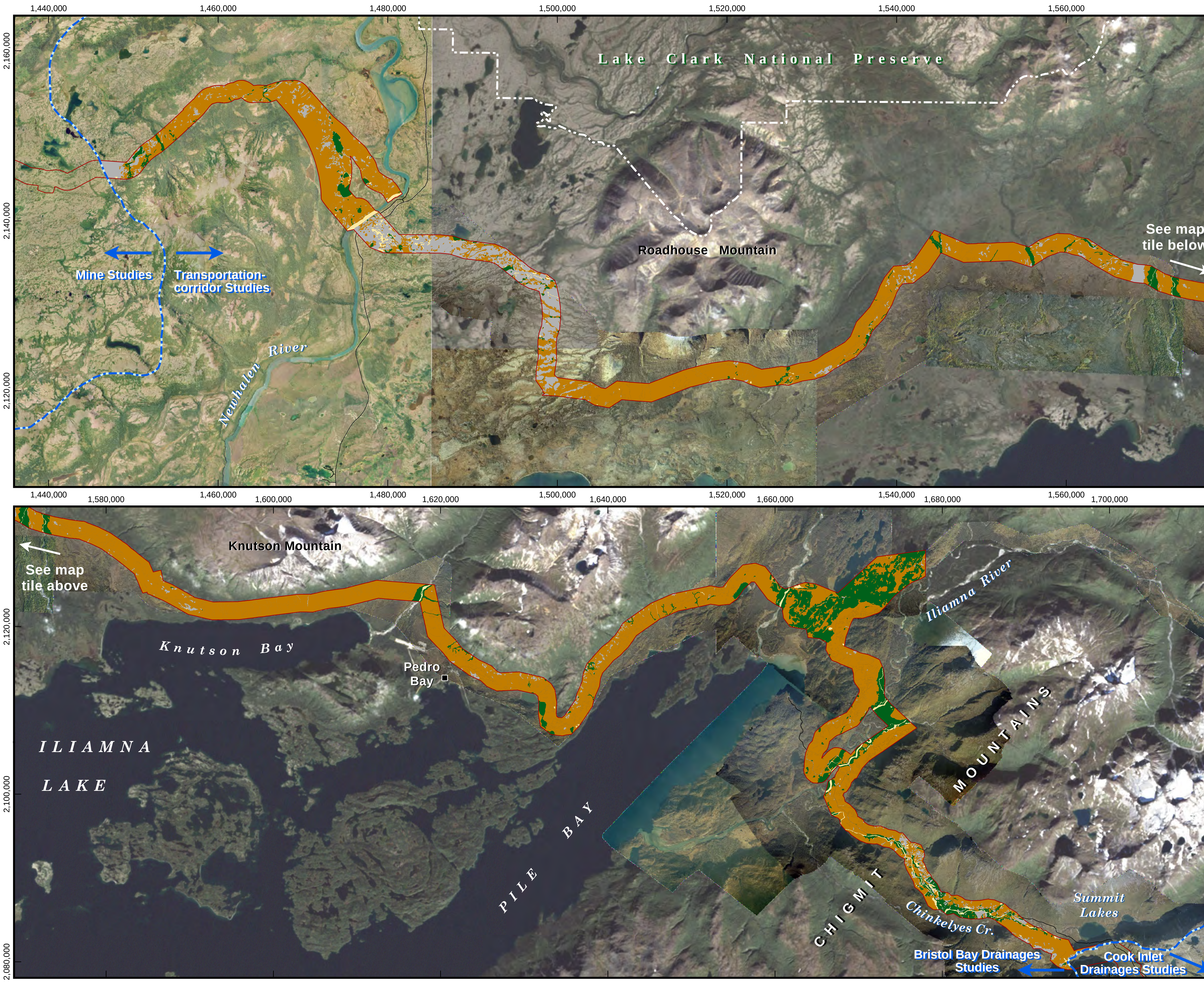
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.6-6
Habitat Availability for Moose, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Habitat Value Category for Moose

- High
- Moderate
- Low
- Negligible

- Mapping Area
- Existing Road
- Community

Color orthophotography for the mine mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Miles: 0 1 2 3 4

Kilometers: 0 1 2 3 4 5 6

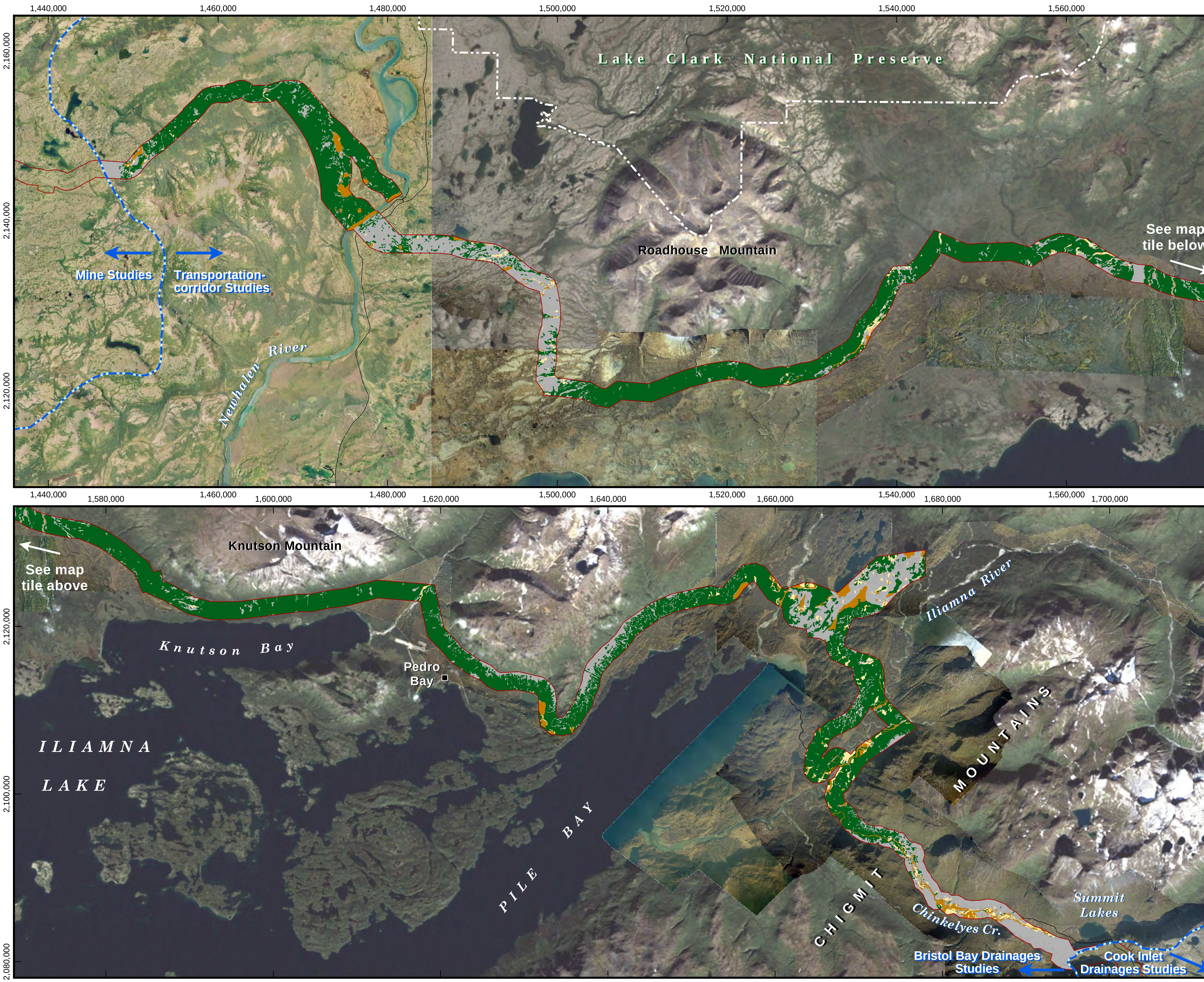
N

Scale 1:140,000

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

File: 16-6-6_Moose_HabAv_TC_PLP_EBD_v02.mxd	Date: March 20, 2011
Version: 2	Author: ABR-AZC

Figure 16.6-7
Habitat Availability for Tree-nesting Raptor Species of Concern, Transportation-corridor, Bristol Bay Drainages Study Area



THE pebble PARTNERSHIP

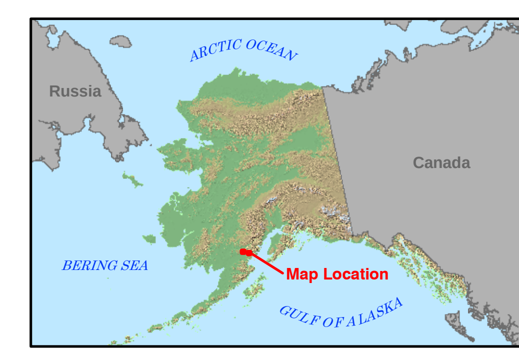
Legend

Number of Species with Moderate or High Habitat-value Rankings

- 3–4 Species
- 2 Species
- 1 Species
- 0 Species

- Mapping Area
- Existing Road
- Community

Color orthophotography for the mine mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 01, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.



Miles 0 1 2 3 4

Kilometers 0 1 2 3 4 5 6

N

Scale 1:140,000

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

File: 16-6-7_TreeRaptor_HabAv_TC_PLP_EBD_v03.mxd	Date: March 20, 2011
Version: 3	Author: ABR-AZC

THE pebble PARTNERSHIP

Figure 16.6-8
Habitat Availability for Cliff-nesting Raptor Species of Concern, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Number of Species with Moderate or High Habitat-value Rankings

- 3 Species
- 2 Species
- 1 Species
- 0 Species

- Mapping Area
- Existing Road
- Community

Color orthophotography for the mine mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 01, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Miles 0 1 2 3 4

Kilometers 0 1 2 3 4 5 6

N

Scale 1:140,000

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

File: 16-6-8_CliffRaptor_HabAv_TC_PLP_EBD_v03.mxd	Date: March 20, 2011
Version: 3	Author: ABR-AZC

THE pebble PARTNERSHIP

Figure 16.6-9
Habitat Availability for Waterbird Species of Concern, Transportation-corridor, Bristol Bay Drainages Study Area

Legend

Number of Species with Moderate or High Habitat-value Rankings

- 8 Species
- 3–5 Species
- 1–2 Species
- 0 Species

- Mapping Area
- Existing Road
- Community

Color orthophotography for the mine mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.

Miles 0 1 2 3 4

Kilometers 0 1 2 3 4 5 6

N

Scale 1:140,000

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

File: 16-6-9_Waterbirds_HabAv_TC_PLP_EBD_v03.mxd	Date: March 20, 2011
Version: 3	Author: ABR-AZC

THE pebble PARTNERSHIP

Figure 16.6-10
Habitat Availability for Shorebird Species of Concern, Transportation-corridor, Bristol Bay Drainages Study Area

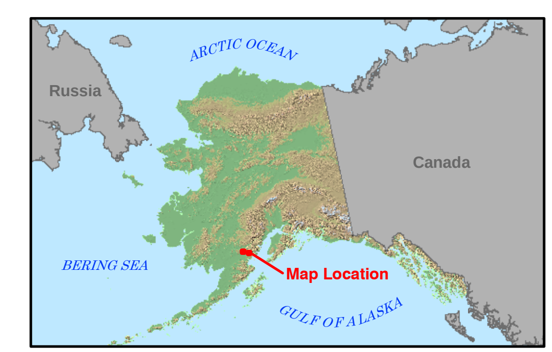
Legend

Number of Species with Moderate or High Habitat-value Rankings

- 3 Species
- 2 Species
- 1 Species
- 0 Species

- Mapping Area
- Existing Road
- Community

Color orthophotography for the mine mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.



Miles: 0 1 2 3 4

Kilometers: 0 1 2 3 4 5 6

N

Scale 1:140,000

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

File: 16-6-10_Shorebirds_HabAv_TC_PLP_EBD_v02.mxd	Date: March 20, 2011
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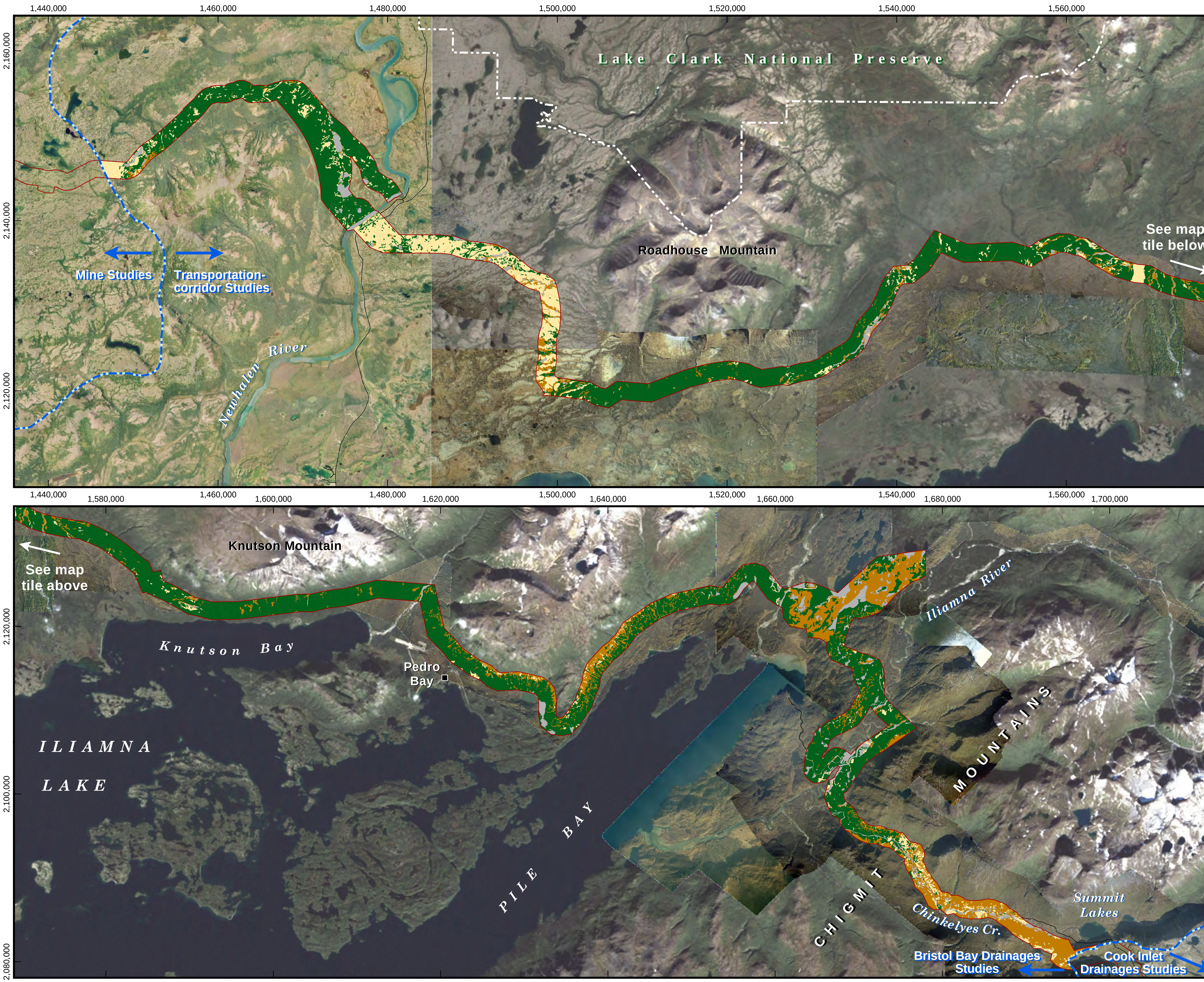


THE pebble PARTNERSHIP

Figure 16.6-11
Habitat Availability for Landbird Species of Concern, Transportation-corridor, Bristol Bay Drainages Study Area

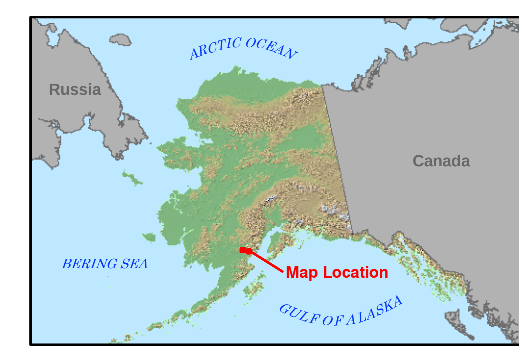
Legend

Number of Species with Moderate or High Habitat-value Rankings

- 6–7 Species
- 3–4 Species
- 1–2 Species
- 0 Species

- Mapping Area
- Existing Road
- Community

Color orthophotography for the mine mapping area surrounding the Pebble deposit based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Imagery by Kodiak Mapping Inc., Eagle Mapping Ltd., and Resource Data, Inc. Digital orthomosaic for the transportation-corridor mapping area from October 1, 2004 and September 28, 2008 aerial photography; ground resolution of 1.5 feet. Imagery by Aero-Metric, Inc.; additional processing by Resource Data, Inc. Background: Landsat 7 ETM+, September 6, 1999.



Miles: 0 1 2 3 4
Kilometers: 0 1 2 3 4 5 6
N

Scale 1:140,000

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

File: 16-6-11_Landbirds_HabAv_TC_PLP_EBD_v02.mxd	Date: March 20, 2011
Version: 2	Author: ABR-AZC

APPENDICES

APPENDIX 16.6A

AVERAGE OCCURRENCE FIGURES FOR SHOREBIRD AND LANDBIRD SPECIES OF CONCERN IN MAPPED WILDLIFE HABITAT TYPES, TRANSPORTATION-CORRIDOR STUDY AREA, 2010

APPENDIX 16.6A

Average-occurrence Figures [a] for Shorebird and Landbird Species of Concern in Mapped Wildlife Habitat Types, Transportation-corridor, Bristol Bay Drainages Study Area, 2010

Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist White Spruce Forest	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
	n=0	*n*=0	*n*=0	*n*=0	*n*=0	*n*=8	*n*=5	*n*=6	*n*=0	*n*=24	*n*=58	*n*=0	*n*=0	*n*=0	*n*=2	*n*=3	*n*=4	*n*=0	*n*=19	*n*=0	*n*=0	*n*=0	*n*=12	*n*=7	*n*=6
Spruce Grouse											0.017														
Willow Ptarmigan																									
Rock Ptarmigan											0.017														
American Golden-Plover																									
Lesser Yellowlegs																								0.286	
Solitary Sandpiper																									
Whimbrel																									
Hudsonian Godwit																									
Surfbird																									
Short-billed Dowitcher																									
Black-backed Woodpecker																									
Olive-sided Flycatcher										0.125	0.172														
Gray-cheeked Thrush								0.500		0.042									0.105						
Varied Thrush								0.333		0.208	0.259								0.474						
Blackpoll Warbler										0.167	0.190						0.500		0.737				0.083		0.167
Rusty Blackbird																									

Notes:

a. Data from breeding shorebird and landbird surveys conducted in the transportation-corridor, Bristol Bay drainages study area in 2005; average occurrence = number of bird detections divided by *n* (number of point-counts conducted) (see Section 16.11 for more information). Blanks indicate no observations of that species were made during point-count surveys in that habitat.

APPENDIX 16.6B

DESCRIPTIONS OF WILDLIFE HABITAT TYPES MAPPED IN THE TRANSPORTATION-CORRIDOR, BRISTOL BAY DRAINAGES STUDY AREA, 2010

PHOTO 1: Alpine Dry Barrens at PM2043 (ABR wildlife habitat dataset), August 2005.

ALPINE DRY BARRENS

Physiography and occurrence:	Alpine: Uncommon in the transportation-corridor study area. Occurs on ridge crests, steep upper slopes, rocky cliffs, and talus slopes.
Vegetation structure and composition:	Typically barren (less than 5 percent vegetation cover) or partially vegetated (5–30 percent cover), in a mosaic of barren and vegetated patches. When present, vegetation is composed of scattered dwarf shrubs (less than 0.2 meter in height), alpine cushion plants, and alpine forbs including *Empetrum nigrum, Salix arctica, Vaccinium uliginosum, Salix phlebophylla, Dryas octopetala, Diapensia lapponica,* and *Oxyria digyna*.
Substrate and drainage:	Rocky, extremely well-drained with little or no organic accumulation.

PHOTO 2: Alpine Moist Dwarf Scrub at plot YV2507 (ABR wildlife habitat dataset), August 2004.

ALPINE MOIST DWARF SCRUB

Physiography and occurrence: Alpine: Uncommon in the transportation-corridor study area. Concentrations of this type occur along ridge crests and upper slopes near Summit Lakes.

Vegetation structure and composition: Vegetation structure is dominated by dwarf shrubs (less than 0.2 meter in height) and lichens. Consists of dwarf-shrub communities variously dominated by *Empetrum nigrum, Vaccinium uliginosum, Loiseleuria procumbens, Luetkea pectinata, Betula nana, Salix reticulata, Dryas octopetala,* and often trace amounts of graminoids such as *Vahlodea atropurpurea* and *Calamagrostis canadensis*. These communities often are dominated by lichens.

Substrate and drainage: Rocky and well-drained with little organic accumulation.

PHOTO 3: Alpine Wet Dwarf Shrub–Sedge Scrub at plot PM409 (ABR wildlife habitat dataset, August 2004.

ALPINE WET DWARF SHRUB–SEDGE SCRUB

Physiography and occurrence:	Alpine: Uncommon in the transportation-corridor study area. Occurs in depressions and on low slopes in high alpine valleys.
Vegetation structure and composition:	Mosses (largely *Sphagnum* spp.) are dominant. A dwarf-shrub and graminoid (especially sedge) canopy occurs above the mosses. Dwarf shrubs (less than 0.2 meter in height) include *Vaccinium uliginosum, Betula nana, Andromeda polifolia*, and *Salix fuscescens*. Common sedge species occurring as co-dominants include *Carex aquatilis* and *Carex rariflora*. A common associated forb species is *Comarum palustre*.
Substrate and drainage:	Well-developed and wet organic (peat) layer is present in all cases.

PHOTO 4: Upland Dry Barrens at plot PR570 (ABR wildlife habitat dataset), August 2004.

UPLAND DRY BARRENS

Physiography and occurrence:	Upland: Uncommon in the transportation-corridor study area. Occurs primarily on glacially modified surfaces including scoured bedrock exposures, dry drained kettle depressions, colluvium deposits, and valley-floor moraine deposits. Artificial fill is included in this type.
Vegetation structure and composition:	Vegetation generally absent (less than 5 percent cover). Where present, vegetation is dominated by foliose and fruticose lichens and trace amounts of dwarf ericaceous shrubs.
Substrate and drainage:	Unconsolidated, extremely well-drained rock and gravel.

PHOTO 5: Upland Dry Dwarf Shrub–Lichen Scrub at plot PR2039 (ABR wildlife habitat dataset), August 2005.

UPLAND DRY DWARF SHRUB–LICHEN SCRUB

Physiography and occurrence:	Upland: Uncommon in the transportation-corridor study area. Occurs primarily on glacially modified surfaces and especially raised ridges within widespread valley-bottom moraine deposits. Most frequent near the Newhalen River and on middle slopes near Summit Lakes.
Vegetation structure and composition:	Dwarf ericaceous shrubs (less than 0.2 meter in height) are more or less co-dominant with crustose and foliose lichens; barren patches are common. Dominant dwarf-shrub species include *Dryas octopetala, Empetrum nigrum, Betula nana*, and *Loiseleuria procumbens*. Common, co-dominant lichen species noted were *Cladina stellaris, Flavocetraria nivalis*, and *Cetraria islandica*. Forbs and graminoids occur in trace amounts.
Substrate and drainage:	Rocky and well-drained with very little organic accumulation.

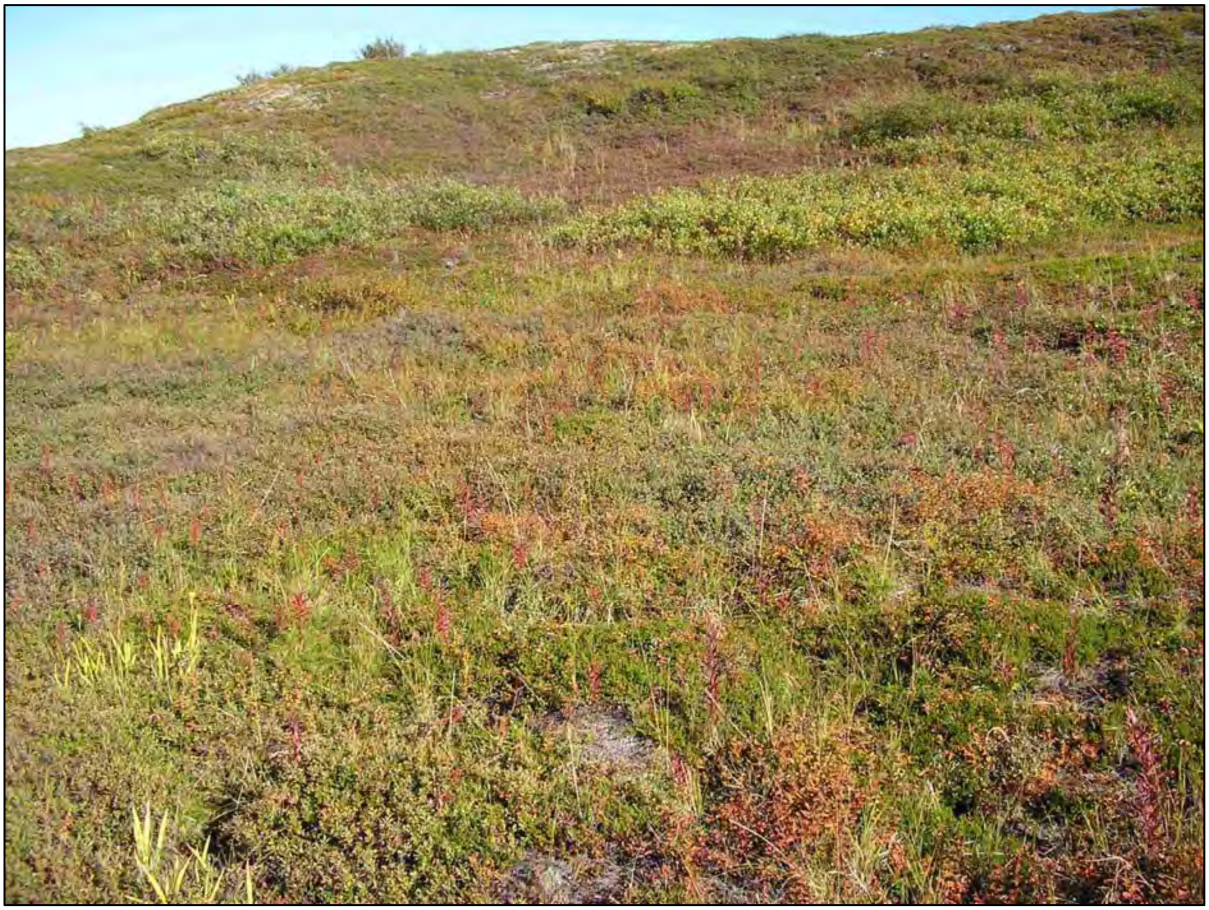


PHOTO 6: Upland Moist Dwarf Scrub at plot PR2633 (ABR wildlife habitat dataset), September 2005.

UPLAND MOIST DWARF SCRUB

Physiography and occurrence:	Upland: Occurs primarily on glacially modified surfaces. Common near the Newhalen River on valley-bottom moraine deposits and low mountain slopes.
Vegetation structure and composition:	Dwarf ericaceous shrubs (less than 0.2 meter in height) are strongly dominant. Generally mesic communities variously dominated by *Empetrum nigrum, Betula nana*, or prostrate willows. Co-dominant dwarf shrubs include *Vaccinium uliginosum, Loiseleuria procumbens, Ledum decumbens*, and *Salix glauca*. Mosses and lichens are common.
Substrate and drainage:	Well-drained, often significant organic accumulation over rock or cobbles.

PHOTO 7: Upland Moist Low Willow Scrub at plot PR2916 (ABR avian point count dataset), June 2005.

UPLAND MOIST LOW WILLOW SCRUB

Physiography and occurrence:	Upland: Occurs primarily on glacially modified surfaces including middle and lower slope concavities and in glacial moraine depressions.
Vegetation structure and composition:	Open (25–75 percent cover) to closed (greater than 75 percent cover) canopy of low willows (0.2–1.5 meters in height). Dominated by *Salix pulchra, Salix reticulata*, and *Salix richardsonii* with a largely herbaceous understory including *Equisetum arvense, Geranium erianthum,* and *Heracleum maximum*.
Substrate and drainage:	Poorly to moderately well-drained; moist to rarely wet loamy soils.

PHOTO 8: Upland Moist Tall Alder Scrub at plot PR2129 (ABR wildlife habitat dataset), August 2005.

UPLAND MOIST TALL ALDER SCRUB

Physiography and occurrence:	Upland: Occurs primarily on glacially modified surfaces, especially low to moderately steep upper and lower slopes throughout the transportation-corridor study area. Also occasionally in lowland settings.
Vegetation structure and composition:	Includes open (25–75 percent cover) and closed (greater than 75 percent cover) canopies of tall alders (greater than 1.5 meters in height). Most stands are dominated by *Alnus sinuata*, but some also may have willow co-dominants and patches of low shrub. Understory species include *Salix pulchra, Dryopteris dilatata, Gymnocarpium dryopteris, Oplopanax horridus, Athyrium filix-femina, Spiraea stevenii, Rubus spectabilis*, and *Calamagrostis canadensis*.
Substrate and drainage:	Common soils are moderately well-drained loams.

PHOTO 9: Upland Moist Tall Willow Scrub at plot PR712 (ABR wildlife habitat dataset), August 2004.

UPLAND MOIST TALL WILLOW SCRUB

Physiography and occurrence: Upland: Occurs primarily on glacially modified surfaces, especially low to moderately steep upper and lower slopes throughout the transportation-corridor study area.

Vegetation structure and composition: Includes open (25–75 percent cover) and closed (greater than 75 percent cover) canopies of tall willows (greater than 1.5 meters in height); occasionally includes patches of low willows (0.2–1.5 meters in height). Dominant willow species include *Salix pulchra, Salix richardsonii*, and *Salix barclayi*. Understory species include *Alnus sinuata, Oplopanax horridus*, and *Calamagrostis canadensis*.

Substrate and drainage: Soils are moderately well-drained loams.

PHOTO 10: Upland and Lowland Spruce Forest at plot PR2164 (ABR wildlife habitat dataset), September 2005.

UPLAND AND LOWLAND SPRUCE FOREST

Physiography and occurrence:	Occurs in both Upland and Lowland areas. Common and widely distributed throughout the transportation-corridor study area.
Vegetation structure and composition:	Generally a woodland type (less than 25 percent cover), but includes patches of open forest (25–75 percent cover). Dominant tree species is *Picea glauca*. In some cases, *Betula kenaica* or *Betula occidentalis* occur as tall shrubs or small trees in the woodland openings; rarely dwarf *Picea glauca* occur. The understory is dominated by *Ledum decumbens* and *Empetrum nigrum*. Foliose lichens such as *Cladina stellaris* may be present. In lowland and less well-drained areas, *Picea mariana* can occur in mixed stands with *Picea glauca*. Common understory shrubs include *Betula nana, Menziesia ferruginea, Myrica gale, Empetrum nigrum*, and *Ledum groenlandicum*.
Substrate and drainage:	Well-developed surface organics over loam or sandy loam.

PHOTO 11: Upland and Lowland Moist Mixed Forest at plot PR524 (ABR wildlife habitat dataset), August 2004.

UPLAND AND LOWLAND MOIST MIXED FOREST

Physiography and occurrence:	Occurs in both Upland and Lowland areas. Upland: Lower mountain slopes throughout the transportation-corridor study area. Lowland: Abandoned or inactive floodplains or kettle depressions surrounding the Newhalen River.
Vegetation structure and composition:	Upland: Includes open (25–60 percent cover) and closed (60–100 percent cover) forest types; generally dominated by *Betula kenaica,* with *Populus balsamifera, Populus trichocarpa*, and *Picea glauca* as co-dominants. Common understory shrubs include *Alnus sinuata, Menziesia ferruginea, Vaccinium uliginosum, Empetrum nigrum*, and *Cornus suecica*. Lowland: Includes open (25–60 percent cover) and woodland (less than 25 percent cover) forest types as well as dwarf-tree forests. Typically dominated by *Picea glauca*, but may include *Picea mariana* in wetter sites. Common understory shrubs include *Betula nana, Menziesia ferruginea, Myrica gale, Empetrum nigrum*, and *Ledum groenlandicum*.
Substrate and drainage:	Well-developed surface organics over loam or sandy loam.

PHOTO 12: Rivers and Streams (Anadromous), Knutson Creek, June 2005.

RIVERS AND STREAMS; RIVERS AND STREAMS (ANADROMOUS)

Physiography and occurrence:	Riverine: Permanently flooded river channels.
Vegetation structure and composition:	Stream channel morphology varies significantly throughout the transportation-corridor study area. Anadromous stream designation is based on data from the Alaska *Anadromous Waters Catalog* (ADF&G, 2010), which lists the presence of salmon by stream section.
Substrate and drainage:	Permanently flooded channels with bottoms of unconsolidated fine sediments, gravel, cobbles, or larger rocks.

PHOTO 13: Riverine Barrens at plot PR2107 (ABR avian point count dataset), June 2005.

RIVERINE BARRENS

Physiography and occurrence:	Riverine: Discrete areas on point bars or interfluvial islands; typically along larger stream channels.
Vegetation structure and composition:	Vegetation absent or nearly so (less than 5 percent cover) or partially vegetated (5–30 percent cover).
Substrate and drainage:	Extremely well-drained sands and gravels.

PHOTO 14: Riverine Wet Graminoid–Shrub Meadow at plot PR2594 (ABR wildlife habitat dataset), August 2005.

RIVERINE WET GRAMINOID–SHRUB MEADOW

Physiography and occurrence:	Riverine: Bordering rivers and streams throughout the transportation-corridor study area; occurs in active floodplains.
Vegetation structure and composition:	Strongly dominated by graminoid plants. Grass-dominated communities have extensive cover of *Calamagrostis canadensis*, but also include *Carex aquatilis, Salix pulchra, Chamerion angustifolium*, and *Equisetum arvense*. Sedge-dominated communities, often on wetter sites, include *Carex utriculata, Carex lyngbyei*, *Comarum palustre, Calmagrotis canadensis, Salix fuscescens*, and *Salix pulchra*.
Substrate and drainage:	Soils are wet and loamy with substantial organic accumulation.

PHOTO 15: Riverine Low Willow Scrub at plot PR2610 (ABR wildlife habitat dataset), August 2004.

RIVERINE LOW WILLOW SCRUB

Physiography and occurrence:	Riverine: Commonly occurs on interfluvial islands or flat banks within active floodplains throughout the transportation-corridor study area.
Vegetation structure and composition:	Most occurrences of this type have an open canopy (25–75 percent cover) of low shrubs (0.2–1.5 meters in height). The most common willow species include *Salix pulchra, Salix barclayi, Salix richardsonii*, and *Salix alaxensis*. Understory species include graminoids and herbs: *Calamagrostis canadensis, Carex utriculata, Equisetum arvense*, and *Comarum palustre*. This type also includes plant communities dominated by low *Myrica gale* instead of willows; the vegetation structure is the same in the two communities.
Substrate and drainage:	Soils are moderately well-drained loams to sandy loams.

PHOTO 16: Riverine Tall Alder or Willow Scrub at plot PR2622 (ABR wildlife habitat dataset), August 2005.

RIVERINE TALL ALDER OR WILLOW SCRUB

Physiography and occurrence:	Riverine: Occurs in active floodplains throughout the transportation-corridor study area.
Vegetation structure and composition:	Generally consists of a closed canopy (greater than 75 percent cover) of tall-shrubs (greater than 1.5 meters in height); may have 5–10 percent cover of overtopping broadleaf tree species in some sites. Alder sites are dominated by *Alnus sinuata*. Willow sites are dominated by *Salix alaxensis, Salix pulchra, Salix barclayi*, and *Salix richardsonii*. Other broadleaf woody species include *Populus balsamifera*, *Populus trichocarpa*, and *Betula kenaica*. Herbs commonly present are *Chamerion angustifolium, Athyrium filix-femina*, and *Artemisia tilesii*.
Substrate and drainage:	Soils are moderately well-drained sands and gravels, frequently found with evidence of flooding.

PHOTO 17: Riverine Moist White Spruce Forest at plot PR2593 (ABR wildlife habitat dataset), August 2005.

RIVERINE MOIST WHITE SPRUCE FOREST

Physiography and occurrence:	Riverine: Occurs in riverine corridors throughout the transportation-corridor study area.
Vegetation structure and composition:	Typically an open, woodland canopy (less than 25 percent cover) of *Picea glauca* with a high occurrence of standing dead trees. Understory is dominated by tall willow species, including *Salix barclayi* and *Salix pulchra*. Common associated herbaceous species include *Equisetum sylvaticum, Gymnocarpium dryopteris*, and *Calamagrostis canadensis*.
Substrate and drainage:	Soils are poorly drained to moderately drained loams with little organic accumulation.

PHOTO 18: Riverine Moist Mixed Forest at plot PR2631 (ABR wildlife habitat dataset), September 2005.

RIVERINE MOIST MIXED FOREST

Physiography and occurrence:	Riverine: Occurs in active floodplains throughout the transportation-corridor study area.
Vegetation structure and composition:	Variously dominated by *Populus balsamifera* and *Populus trichocarpa* or *Betula kenaica* with *Picea glauca* as a co-dominant. Understory species include *Alnus sinuata, Salix barclayi, Gymnocarpium dryopteris*, and *Calamagrostis canadensis*.
Substrate and drainage:	Soils are well-drained with layered sands and often buried organic layers indicative of flooding events.

PHOTO 19: Lakes and Ponds at plot PR2533 (ABR wildlife habitat dataset), August 2005.

LAKES AND PONDS

Physiography and occurrence:	Lacustrine: Kettle lakes and ponds and alpine lakes throughout the transportation-corridor study area.
Vegetation structure and composition:	None
Substrate and drainage:	Permanently flooded to seasonally flooded shallow waterbodies (some small ponds drain in late summer; see Lacustrine Moist Barrens below).

PHOTO 20: Lacustrine Moist Barrens at plot HDR3424 (photo courtesy of HDR Alaska, Inc.), August 2005.

LACUSTRINE MOIST BARRENS

Physiography and occurrence:	Lacustrine: Occurring on pond margins and in basins of seasonally flooded ponds in kettle depressions throughout the region of moraine deposits in the transportation-corridor study area.
Vegetation structure and composition:	Vegetation absent or nearly so (less than 5 percent cover) or partially vegetated (5–30 percent cover).
Substrate and drainage:	Seasonally flooded, well-drained with no organic accumulation.

PHOTO 21: Lowland Sedge–Forb Marsh at plot PR2618 (ABR wildlife habitat dataset), August 2005.

LOWLAND SEDGE–FORB MARSH

Physiography and occurrence:	Lowland: Permanently flooded depressions found in lowland areas or along the margins of kettle lakes.
Vegetation structure and composition:	Herbaceous-dominated type. May be graminoid or forb-dominated with various plant communities. Common species include *Carex aquatilis, Carex rostrata, Carex utriculata, Arctophila fulva, Equisetum fluviatile, Hippuris vulgaris*, and *Menyanthes trifoliata*.
Substrate and drainage:	Flooded organics.

PHOTO 22: Lowland Ericaceous Scrub Bog at plot PR2173 (ABR wildlife habitat dataset), September 2005.

LOWLAND ERICACEOUS SCRUB BOG

Physiography and occurrence:	Lowland: Occurs in depressions and on low slopes throughout the transportation-corridor study area; sometimes adjacent to riverine floodplains.
Vegetation structure and composition:	Wet communities typically dominated by ericaceous dwarf and low shrubs (less than 0.2 and 0.2–1.5 meters in height, respectively). Plant communities dominated by ericaceous shrubs or *Myrica gale*, or occasionally, these shrubs are co-dominant with sedge tussocks. Common species include *Vaccinium uliginosum, Empetrum nigrum, Ledum decumbens, Salix fuscescens, Betula nana, Myrica gale*, and *Andromeda polifolia*. Commonly occurring graminoids include *Calamagrostis canadensis, Carex aquatilis, Carex rariflora*, and *Eriophorum vaginatum*. Various *Sphagnum* moss species are common.
Substrate and drainage:	Organic accumulation is moderate with peat layers often occurring above rocky substrates. Surface water is common; poorly drained.

PHOTO 23: Lowland Wet Graminoid–Shrub Meadow at plot P2109 (ABR wildlife habitat dataset), August 2005.

LOWLAND WET GRAMINOID–SHRUB MEADOW

Physiography and occurrence:	Lowland: Occurs on low-lying features such as concave toe-slopes and kettle depressions; common within valley-bottom wetland complexes.
Vegetation structure and composition:	Graminoids and dwarf shrubs (less than 0.2 meter in height) are co-dominant. Common graminoid species include *Carex aquatilis, Trisetum caespitosum, Calamagrostis canadensis*, and *Eriophorum chamissonis*. Common dwarf shrubs include *Empetrum nigrum* and *Betula nana*. Associated forbs include *Eriophorum angustifolium* and *Comarum palustre*. *Sphagnum* moss species are common and sometimes provide substantial cover. Rarely included in this type are patches of more well-drained, moist meadows dominated by graminoids and dwarf shrubs.
Substrate and drainage:	Soils are wet to moist, with substantial organic accumulation. Surface water is generally present.

PHOTO 24: Lowland Low and Tall Willow Scrub at plot PR715 (ABR wildlife habitat dataset), August 2004.

LOWLAND LOW AND TALL WILLOW SCRUB

Physiography and occurrence: Lowland: Often occurs in swales and other low-lying areas bordering active or inactive riverine features.

Vegetation structure and composition: Shrub canopy ranges from open (25–75 percent cover) to closed (greater than 75 percent cover). Shrub heights are mixed with both low (0.2–1.5 meters) and tall (greater than 1.5 meters) shrubs occurring. Dominant willow species include *Salix barclayi, Salix alaxensis, Salix pulchra* and *Salix richardsonii*. The understory is commonly herbaceous and includes *Calamagrostis canadensis, Aconitum delphinifolium, Chamerion angustifolium*, and *Heracleum maximum*.

Substrate and drainage: Soils are moist and loamy; moderately well-drained.

APPENDIX 16.6C

WILDLIFE HABITAT VALUES FOR A SELECTED SET OF BIRD AND MAMMAL SPECIES OF CONCERN, TRANSPORTATION-CORRIDOR, BRISTOL BAY DRAINAGES STUDY AREA, 2010

Wildlife Habitat Values for a Selected Set of Bird and Mammal Species of Concern, Transportation-corridor, Bristol Bay Drainages Study Area, 2010 [a, b]

Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist White Spruce Forest	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
Birds																									
Trumpeter Swan [c]	0	0	0	0	0	0	0	0	0	0	0	1	1	0	*2*	*2*	0	0	0	**3**	0	1	2	**3**	1
Tundra Swan [c]	0	0	0	0	2	2	1	0	0	0	0	1	1	0	2	1	1	0	0	2	0	1	2	2	1
Harlequin Duck [c]	0	0	0	0	0	0	0	0	0	0	0	1	**3**	1	3	3	2	2	2	0	0	0	0	0	0
Surf Scoter [c]	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	**2**	0	*2*	*2*	*2*	0
Black Scoter [c]	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	1	0	0	0	**2**	0	2	*2*	2	1
Long-tailed Duck [c]	0	0	0	0	1	2	2	0	0	0	0	1	1	0	0	0	0	0	0	**2**	0	2	*2*	2	1
Spruce Grouse	0	0	0	0	0	0	0	0	0	3	**3**	0	0	0	0	0	0	3	3	0	0	0	0	0	0
Willow Ptarmigan	0	3	0	0	0	**3**	3	3	3	0	0	0	0	0	1	2	2	0	0	0	0	0	2	1	**3**
Rock Ptarmigan	3	3	0	2	2	2	1	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-throated Loon	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	2	0	2	0
Common Loon	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	**3**	0	3	1	3	0
Bald Eagle	0	0	*0*	0	*1*	*1*	*1*	*0*	*0*	1	**2**	**2**	**3**	2	2	1	1	**3**	**3**	**2**	1	1	1	1	1
Northern Goshawk	0	0	0	0	1	1	1	*0*	*0*	2	**2**	1	1	*0*	1	1	0	2	**3**	*1*	0	1	1	1	1
Golden Eagle	**3** [d]	**2**	**2**	**2**	**2**	**2**	**2**	*1*	*1*	1	1	**2** [d]	**2** [d]	*0*	0	0	0	1	1	1	1	*0*	1	1	1
Merlin	1	1	1	1	1	1	1	**1**	**1**	2	2	2	2	1	1	1	1	2	2	2	1	1	1	1	2
Gyrfalcon	**2** [d]	**2**	**2**	**2**	**2**	**2**	**2**	*1*	*1*	*1*	*1*	*0*	*0*	0	0	0	0	0	0	1	0	0	0	0	0
Peregrine Falcon	1	*2*	*2*	1	1	1	1	0	1	1	2	**3** [d]	**3** [d]	2	2	2	1	2	**3**	**3**	2	2	2	2	2
American Golden-Plover	0	3	2	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*1*	0	3	3	0
Solitary Sandpiper	0	0	0	0	0	0	0	0	0	2 [e]	0	2	2	0	0	0	2	0	0	3	*1*	**3**	2	0	2
Lesser Yellowlegs	0	0	0	0	0	0	0	0	0	2 [e]	0	2	2	0	2	0	2	0	0	3	*1*	3	3	**3**	2
Whimbrel	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0
Hudsonian Godwit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0
Surfbird	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Short-billed Dowitcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0
Arctic Tern	0	0	0	0	0	0	0	0	0	0	0	1	**3**	2	2	0	0	0	0	**2**	0	0	1	2	0
Great Horned Owl	0	0	0	0	0	0	0	0	0	**2**	**2**	1	1	1	2	2	1	**3**	**3**	1	1	*0*	1	2	2
Black-backed Woodpecker	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	3	**3**	0	0	0	0	0	0
Olive-sided Flycatcher	0	0	0	0	0	0	0	0	0	**3**	**3**	0	0	0	0	0	0	3	**3**	0	0	0	2	0	0
Gray-cheeked Thrush	0	0	0	0	0	0	2	**3**	3	**1**	0	0	0	0	0	2	2	1	**2**	0	0	0	0	0	2
Varied Thrush	0	0	0	0	0	0	0	**2**	2	**2**	**2**	0	0	0	0	0	2	3	**3**	0	0	0	0	0	**2**

Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist White Spruce Forest	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
Blackpoll Warbler	0	0	0	0	0	0	0	2	2	**2**	**2**	0	0	0	0	0	**3**	3	**3**	0	0	0	**1**	0	**2**
Rusty Blackbird	0	0	0	0	0	0	0	0	0	3	**3**	0	0	0	0	0	1	2	2	0	0	0	3	0	1
Mammals																									
Wolf	1	**2**	2	1	2	2	**2**	1	2	2	2	1	2	1	2	2	2	**2**	2	1	2	1	2	2	2
Red fox	1	1	2	1	1	1	2	1	2	2	2	1	2	1	2	2	2	2	2	1	1	1	2	2	2
River otter	0	0	0	0	0	0	0	0	0	0	0	3	3	2	2	2	2	2	2	**3**	2	1	1	1	1
Wolverine	1	**2**	2	1	**2**	2	2	2	2	2	2	1	2	1	2	2	2	2	**2**	1	1	2	2	2	2
Black bear	0	0	0	0	0	0	1	3	2	2	3	1	2	1	2	2	3	3	3	1	2	2	2	2	3
Brown bear	**1**	**2**	2	1	**2**	**2**	**2**	**2**	**2**	2	**2**	**2**	**3**	1	2	**2**	**2**	2	**2**	**1**	2	2	**2**	**2**	2
Moose	0	0	0	0	0	0	1	**2**	**3**	**2**	**2**	1	1	1	2	**3**	3	3	3	**3**	2	2	2	2	**3**
Arctic ground squirrel	2	2	2	1	3	2	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Red squirrel	0	0	0	0	0	0	0	*1*	0	3	3	0	0	0	0	0	*1*	3	2	0	0	0	0	0	0
Beaver	0	0	0	0	0	0	0	1	1	0	2	3	3	1	1	2	2	2	3	3	1	0	0	0	1
Northern red-backed vole	0	1	1	0	1	1	2	2	2	3	3	0	0	0	1	2	2	3	3	0	0	1	2	1	1
Tundra vole	0	1	2	0	0	1	2	2	2	1	1	0	0	0	3	2	2	1	1	0	0	2	2	3	2
Snowshoe hare	0	0	0	0	0	1	2	2	2	3	2	0	0	0	0	2	3	2	2	0	0	0	1	0	3

Notes:

a. See Methods text (Section 16.6.6.3) and Table 16.6-1 for information on how species of concern were selected.

b. Key to habitat-value codes: 3 = high, 2 = moderate, 1 = low, 0 = negligible; data quality indicated by font type as data-supported from project-specific data and scientific literature (bold), partially data-supported from literature only (regular), and professional judgment (italic).

c. Nesting by these waterfowl species in upland and lowland habitats occurs more commonly when those habitats occur in association with lacustrine waterbodies.

d. Nesting by these raptor species can occur in these habitats only in areas where suitable cliffs occur.

e. Breeding by these shorebird species in Upland and Lowland Spruce Forest will occur only in wetter, lowland settings.

16.7 Terrestrial Mammals—Transportation-corridor Study Area

16.7.1 Introduction

Based on historical reports (Osgood, 1904; Schiller and Rausch, 1956; Cahalane, 1959) and recent field inventories (Cook and MacDonald, 2004a, 2004b; Jacobsen, 2004; MacDonald and Cook, 2009), 40 species of mammals (Appendix 16.2A) are known (or are strongly suspected) to occur in the geographic region of the Bristol Bay drainages in which the transportation-corridor study area for the Pebble Project is located.

The caribou is the most abundant large mammal in the region of the Bristol Bay drainages and is harvested in the largest numbers by both subsistence and sport hunters. The transportation-corridor study area is at the eastern edge of the annual range of the Mulchatna Caribou Herd, one of the larger herds in the state. Other species of large mammals also are ecologically and economically important inhabitants of the region. Brown bears are abundant in the project region, and black bears are present in lower densities. Moose occur throughout the study area in low densities. These species were of primary interest for the Pebble Project surveys, but all mammal species encountered incidentally, such as gray wolf and other large species of furbearers, were recorded. Another source of mammal observations was incidental sightings during other wildlife surveys conducted for the Pebble Project, notably waterfowl, raptor, and breeding-bird surveys, and field delineation of wildlife habitats.

No surveys were conducted specifically for furbearers or small mammals because of the availability of furbearer harvest data (Schwartz, 2006) and recent inventory surveys conducted in Lake Clark and Katmai national parks and preserves for NPS (Cook and MacDonald, 2004a, 2004b) and in the area northwest of Iliamna Lake and in the Kvichak and Nushagak river drainages for BLM (Jacobsen, 2004).

The following discussion summarizes the terrestrial mammal surveys conducted in the transportation-corridor study area for the Pebble Project during 2004 through 2010 (no surveys were conducted in this study area in 2007 or 2008).

16.7.2 Study Objective

The study objective established for terrestrial mammal surveys in the transportation-corridor study area was the same as that established for the mine study area (Section 16.2.2): to characterize the distribution and abundance of caribou, bears, moose, and other species of large mammals in the study area at various biologically important times of the year, including estimation of the population densities of bears and moose.

16.7.3 Study Area

Reconnaissance surveys only were flown in the transportation-corridor study area in 2004 (Figure 16.7-1). The survey routes were modified and broadened in 2005 and 2006. Strip transects for aerial surveys were established from the eastern ends of the strip transects in the mine study area (Section 16.2.3) and extended east as far as the vicinity of Canyon Creek and Knutson Mountain (Figure 16.7-1). For this reason, data collected on the western ends of those transects (west of the study-area line shown in Figure 16.7-1) also are depicted on map figures in Section 16.2. In the mountainous area east of the transect-survey area, reconnaissance surveys were flown along a specific corridor from Canyon Creek east to the adjoining Cook Inlet drainages study area (Figure 16.7-1).

A survey was conducted in August 2004 along salmon-spawning streams in the study area east of the Newhalen River. The stream-survey area was chosen to enumerate brown bears during a time of year when many bears congregate along streams used for spawning by anadromous fish.

The linear route for the aerial survey of active beaver colonies in October 2006 was selected to sample a representative set of drainages, waterbodies, and wetlands within the transportation-corridor study area.

The line-transect survey to estimate the population density of bears in the area surrounding Iliamna Lake in May 2009 was conducted in the same regional study area described in Section 16.2.3 (Figure 16.2-1B).

For the aerial survey of moose density in April 2010, the entire survey area (mine and transportation-corridor study areas) was divided into 146 sample units, as was described in Section 16.2.3 (Figure 16.2-1B).

The transportation-corridor study area in the Bristol Bay drainages is entirely within state GMU 9B.

16.7.4 Previous Studies

Most of the available information on mammal distribution and abundance in the study area comes from studies done by or for government resource agencies, such as ADF&G survey and inventory studies (e.g., ADF&G, 1985; Butler, 2006, 2007a, 2007b, 2008a; Woolington, 2007) and nearby NPS studies (e.g., Bennett, 1996; Putera and Drummer, 2005). Under an agreement with Cominco Alaska Exploration, ADF&G surveys focused mostly on the area of the Pebble Deposit in the early 1990s (Boudreau et al., 1992; Van Daele and Boudreau, 1992; Van Daele, 1994), but also covered parts of the transportation-corridor study area. Some other surveys (Smith, 1991) were conducted for Cominco at that time, when the Pebble Deposit was first being evaluated. Other studies in the region in recent years were conducted as part of broad-scale species inventories by NPS and BLM, emphasizing small mammals (Cook and MacDonald, 2004a, 2004b; Jacobsen, 2004); the BLM study included several sites in and near the study area.

16.7.5 Scope of Work

Field surveys were conducted periodically during April through November 2004, March through December 2005, December 2006, May 2009, and April 2010. The mammal study was conducted by Brian Lawhead and Alexander Prichard, supported by other biologists from ABR, Inc. Local-knowledge observers Carl Jensen of Pedro Bay and James Lamont of Newhalen participated in surveys in August and October 2004 and in May 2005. Earl Becker of ADF&G designed and led the bear population survey in May 2009, using observers from both ADF&G and ABR.

The bear survey in 2009 and moose survey in 2010 were designed to estimate the density of those species in their respective study areas. Other aerial surveys were intended to obtain information on the distribution, relative abundance, and general patterns of use of the study area by large mammals, rather than to derive detailed population estimates. Regional population estimation is conducted by ADF&G and requires substantially greater survey effort over larger areas for a meaningful assessment. Thus, the surveys described here complement, rather than duplicate, ADF&G population surveys.

Specific work elements included the following tasks:

- Collection and review of relevant literature on all species of mammals inhabiting the project region.
- Aerial reconnaissance and strip-transect surveys of the study area scheduled periodically throughout the year.
- Aerial line-transect survey to estimate the population density of bears in and near the study area.
- Aerial quadrat survey to estimate the population density of moose in and near the study area.
- Aerial survey of brown bears along salmon-spawning streams and examination of reported dens of brown bears and gray wolves.
- Aerial survey of beaver colonies.
- Acquisition and analysis of radio-telemetry data for the MCH.
- Collection of wildlife observations by other Pebble Project personnel.

16.7.6 Methods

16.7.6.1 Large Mammal Reconnaissance Surveys

In 2004, aerial reconnaissance surveys of the study area were conducted in a fixed-wing airplane (Cessna 206) on April 12, May 21, June 30, October 20-21, and November 30 (Table 16.7-1). Two observers searched for mammals on opposite sides of the aircraft, viewing as far out to the side as vegetation allowed (in practice, 400 to 800 meters). The airplane was flown at an airspeed of approximately 140 kilometers per hour and an altitude of 150 meters above ground level (occasionally higher or lower as dictated by terrain). In 2005 and once in 2006, reconnaissance surveys only were conducted in the area east of Canyon Creek, where steep mountainous terrain made aerial transect surveys unfeasible.

The coordinates of mammal locations were recorded using GPS receivers. The data collected for each sighting included species, number of animals, sex and age composition (when possible), activity, and direction of movement.

16.7.6.2 Large Mammal Aerial Transect Surveys

In 2005, strip transects were established in the area between the eastern ends of the strip transects in the mine study area (Section 16.2.3) and Canyon Creek (Knutson Bay); east of there, steep terrain restricted survey efforts to a reconnaissance level. East-west transects were created to cover the north shore of Iliamna Lake and the mountains to the north (Figure 16.7-1). Those transects were surveyed by fixed-wing airplane (Cessna 206) six times in 2005 (March 29-30, May 9-10 and 24-25, June 28-29, October 11, and December 12-13) and once in 2006 (December 2).

Sightability was much lower in the transportation-corridor study area than in the mine study area because of large forested areas and thick vegetation, which lower the sightability of mammals considerably. To address this concern, simultaneous double counts were conducted during the transect surveys in 2005. Two observers independently scanned for large mammals in a 400-meter-wide strip on the same side of the airplane, recording whether each animal was seen by the front observer, the rear observer, or both observers. Modified Lincoln-Petersen estimates were applied to the results to estimate sightability (Graham and Bell, 1989).

16.7.6.3 Bear Population Survey

An aerial survey of the spring population density of brown and black bears in the area surrounding Iliamna Lake was conducted jointly during May 16-29, 2009, by ADF&G and ABR biologists, with major funding from PLP (Becker, 2010). The survey included both the mine and transportation study areas as well as a greater regional area, as described in Section 16.2.6.3.

16.7.6.4 Moose Population Survey

An aerial survey of quadrat sampling units in the mine and transportation-corridor study areas was conducted by an ABR biologist to estimate moose population density during April 6-10, 2010, as described in Section 16.2.6.4.

The entire 2,398-km^2 survey area comprised 146 sample units in both the mine and transportation-corridor study areas. Thirty sample units were selected randomly within the entire survey area; 19 of the selected units were located in the transportation-corridor study area, encompassing 301 km^2 (24.7 percent) of the 1,219-km^2 portion of the survey area located in that study area.

16.7.6.5 Other Surveys

A bear survey along salmon-spawning streams was conducted in a turbine helicopter (Hughes 500D) on August 18-20, 2004. Streams mapped by ADF&G (2004) as providing spawning habitat for salmon were preselected for the survey, and additional streams were added on the recommendation of local-knowledge observer Carl Jensen or if spawning salmon were seen during the survey. Two observers searched on the right side of the helicopter and one observer and the pilot searched on the left side. Flight altitude varied depending on topography, but was usually 60 to 90 meters above ground level. Location coordinates of bears and other mammals were recorded using GPS receivers. The data collected for each sighting were species, number of animals, sex and age composition (when possible), and activity.

In place of a bear survey along spawning streams in summer 2005, bear observations instead were tallied during brood-rearing surveys for Harlequin Ducks (Section 16.10) to reduce helicopter overflights. Incidental observations of large mammals also were recorded on aerial surveys for waterfowl and raptors in 2004 and 2005.

Ground visits at prospective bear dens in the study area were conducted by helicopter on August 19-20, 2004, and on May 11-12 and August 29-30, 2005. Most effort in those surveys was concentrated west of the Newhalen River, consistent with the locations of prospective bear dens. The forested habitats in the study area generally precluded effective aerial surveys for bear dens.

A survey of active beaver colonies was flown along a single transect that followed the length of the transportation corridor study area in a piston helicopter (Robinson R44) on October 16-17, 2006, to locate and map active beaver colonies, as indicated by fresh food caches near lodges (Hay, 1958; Payne, 1981). Survey altitude was generally about 60 meters above ground level, descending lower occasionally to check specific sites, and the focus of the survey was fairly narrow, deviating from the transect by up to several hundred meters to examine possible colony locations.

Aerial reconnaissance and strip-transect surveys for mammals, den checks, and the 2004 survey along salmon streams are referred to collectively below as large mammal surveys. Incidental sightings of mammals also were recorded during aerial and ground surveys for beaver colonies, waterfowl, raptors, and breeding birds. Those sightings are referred to below as having been made during other wildlife surveys.

Harvest data acquired from the ADF&G statistics section (Schwartz, 2006) provided supplemental information on the distribution and relative abundance of several species of furbearing mammals, which are difficult to enumerate using field methods.

16.7.7 Results and Discussion

16.7.7.1 Aerial Transect Surveys

The detectability (sightability) of mammals on strip-transect surveys decreased from west to east in the study area in relation to vegetation type. Sightability was highest in the tundra habitats at higher elevations on the western ends of survey transects (which were actually in the eastern portion of the mine study area), was intermediate in the scattered woodlands and open-canopy forests from the western side of the Newhalen River east to the vicinity of Canyon Creek, and was lowest in the closed-canopy forests between Canyon Creek and the Iliamna River in the eastern portion of the transportation-corridor study area.

Simultaneous double counts in 2005 were used to estimate the sightability of mammals in the transportation-corridor study area. Because of the small number of large mammals seen on transects during double-count surveys (Table 16.7-2), all bears and moose seen were combined to derive one estimate of sightability. Overall, seven mammal groups were seen by just the front observer (five moose and two brown bears), four mammal groups were seen by just the rear observer (four moose), and four mammal groups were seen by both observers (two moose and two brown bears). No black bears were observed on transect during the double-count surveys, although two adults were seen off-transect on Roadhouse Mountain. A modified Lincoln-Petersen estimate (Graham and Bell, 1989) was applied to the results of the 2005 transect surveys to calculate sightability. With two observers looking out the same side of the airplane, an estimated 72.8 percent of all mammal groups (95 percent confidence interval = 51-100 percent) were seen, resulting in an SCF of 1.37. The front observer alone saw an estimated 53.4 percent of all large-mammal groups and the rear observer alone saw 38.8 percent of all large-mammal groups.

This application of double counts to estimate sightability on strip-transect surveys had several limitations. The method assumed that all groups had equal sightability; this assumption is unlikely to be true, however, because sightability varied by habitat, time of year (because of snow cover and presence of leaves on deciduous shrubs), species, and group size. The sample sizes of mammals observed in this study were not adequate to calculate different sightability estimates for each of these factors. Graham and Bell (1989) noted that sightability was higher for larger groups, especially from survey aircraft flying at higher altitudes. In addition, in habitats with heavy vegetative cover, sightability could approach zero. Animals with very low sightability in such habitats likely would not be seen by either observer and thus would not be factored into the sightability estimate. Therefore, the estimate of sightability would be too high and any densities derived from it for the study area would underestimate the true density. Thus, the unadjusted data presented below represent minimal counts of the numbers of mammals present during the transect surveys. Nevertheless, because of the repeated nature of the surveys, the transect survey data represent a reasonable sampling of the distribution and relative abundance of large mammals among seasons.

16.7.7.2 Bears

Both brown bears and black bears are fairly common inhabitants of the regional survey area; black bears are much more common in the forested habitats of the transportation-corridor study area than in the tundra habitats of the mine study area, however. Like the mine study area, the transportation-corridor study area is an area of transition between substantially higher coastal densities of brown bears and lower inland densities (Becker, 2007). Assuming a mean density of approximately 50 bears/1,000 km^2, population-density extrapolations by ADF&G in 1989 estimated that 879 brown bears inhabited state lands in GMU 9B (that part of the subunit encompassing the Kvichak River drainage, including streams entering Iliamna Lake but excluding the Lake Clark and Katmai national park lands; Butler, 2005). A rigorous population survey in May 1999-2000 produced a lower density estimate of 38.6 brown bears/1,000 km^2 in GMU 9B North (Becker, 2001, 2003; Butler, 2007), including the lands north of Iliamna Lake (just east of the mine study area) and Lake Clark National Park and Preserve. The 1999-2000 survey detected 272 brown bears in 167 groups; 155 (57 percent) of the bears were in family groups and 117 (43 percent) were independent bears, including 60 (22 percent) large males (Butler, 2007). The mean litter size over both years was 1.7 for cubs of the year and yearlings and 2.0 for 2-year-olds or older; the litters in 2000 were larger than in 1999 (Butler, 2005).

The line-transect survey in May 2009 produced sightings of 152 brown bear groups throughout the regional survey area (Figure 16.2-14), 144 of which were within the 510-meter effective survey width and 914-meter maximum-elevation limit used for the density calculation (Becker, 2010). Preliminary estimates of population density were derived using two similar analytical methods, one employing double-count methods to calculate individual detection functions for the pilot and the observer (following Becker and Quang, 2009) and the other combining observations for both the pilot and the observer and calculating a single detectability function for the airplane crew (plane model; Becker, 2010). The resulting estimates of population density were 47.7 brown bears/1,000 km^2 (standard error = 7.66) using the double-count method, indicating a minimum population of 412 brown bears in the area surveyed, and 58.3 bears/1,000 km^2 using the plane model.

The density of black bears estimated from the 1999-2000 survey in GMU 9B North (76.6 bears/1000 km^2) was twice that for brown bears (Becker, 2003), although black bears occurred almost entirely in the northernmost portion of the subunit (Lake Clark National Park and Preserve), north of the transportation corridor. Thus, the density of black bears in the transportation-corridor study area probably is less than 76.6 bears/1,000 km^2. During the May 2009 survey, 25 black bears were observed in 18 groups in the entire regional survey area, but the sample size was inadequate to estimate the population density (Becker, 2010). Most of the black bears were observed in the eastern portion of the survey area, especially near the Iliamna River (Figure 16.2-14).

In 2004, one brown bear and one black bear were observed in the transportation-corridor study area during five reconnaissance surveys, and two brown bears and no black bears were recorded incidentally during bird surveys (Table 16.7-1, Figure 16.7-2). In 2005, three brown bears and two black bears (off transect) were observed during transect surveys, one brown bear and no black bears were observed during the August den survey, and 55 brown bears (most of which were not mapped) and five black bears (two of which were not mapped) were observed incidentally during bird surveys (Table 16.7-1, Figure 16.7-2). The preference of black bears for forest cover and their tendency to avoid brown bears probably rendered them less visible than brown bears on surveys conducted after leaves emerged on deciduous vegetation.

After applying the SCF (1.37) calculated from double counts, researchers calculated an average density of 10 bears/1,000 km² in the transect survey area, based on animals observed on transects during double-count surveys in 2005 (the transect survey area included the easternmost portion of the mine study area, Figure 16.7-2). This density underestimated the true population density because of the limitations of estimating sightability using double counts, as described in the preceding section.

Brown bears congregate to feed along salmon-spawning streams in late summer and fall, but sightability of bears was low during the stream surveys because of the dense stands of riparian shrub vegetation. Brown bears were seen more frequently on the stream surveys than were black bears, suggesting dominance by the larger species. Fifteen brown bears and no black bears were seen in the study area during the stream survey in mid-August 2004 (Table 16.7-1). The greatest amount of salmon-spawning activity at the time of the survey was in the eastern portion of the study area, from Canyon Creek east; spawning activity west of Canyon Creek appeared to have peaked already by mid-August, judging from the lack of live salmon in the streams and from the presence and appearance of salmon carcasses along the streams. The number of bears observed on transect surveys was insufficient to draw conclusions about the seasonal pattern of bear density in the area, but incidental observations of bears peaked in July, August, and September (Table 16.7-1), when salmon-spawning runs occur in most of the streams in the study area.

Despite several reported prospects in the transportation-corridor study area, no bear dens were confirmed during den checks by helicopter in August 2004 and May 2005. One reported bear den turned out to be a wolf den and the other prospects either could not be located or turned out to be surface diggings by foraging bears.

The reported harvest of brown bears in the six reporting units in and adjacent to the study area was 20 animals in the 1991 regulatory year (1 July 1990-30 June 1991, increased to a peak of 78 in 1999, and then decreased steadily to 28 in 2005 (Schwartz, 2006). In contrast, black bear harvest never exceeded four animals per year during that period. The declining harvest of brown bears since 1999 does not necessarily reflect a declining population, however. Butler (2005) reported that the brown bear population in GMU 9 had grown since 1991. Harvest statistics are imperfect metrics that depend heavily on hunter effort and success, which is influenced in turn by factors such as weather conditions, regulatory changes, and the number of hunting guides operating in the area.

16.7.7.3 Moose

Moose are distributed throughout the study area at low density, with the greatest local densities occurring east of Roadhouse Mountain (Figure 16.7-4). Twelve moose were recorded during the five reconnaissance surveys in 2004, 24 moose were observed during six transect surveys in 2005, and the high count of 27 moose was recorded during the single transect survey in December 2006 (Table 16.7-1).

Incidental observations during bird surveys totaled nine moose in 2004 and 30 in 2005 (Table 16.7-1), reflecting a greater survey effort of productive wetland habitats in 2005.

Pebble researchers calculated a mean density of 0.03 moose/km^2 in the transect-survey portion of the study area by applying the SCF (1.37) calculated from double counts on transect surveys in 2005 (Table 16.7-2; the transect survey area included the easternmost portion of the mine study area). This density underestimated the true population density because of the limitations of estimating sightability using double counts, as described in Section 16.7.7.

During the 2010 aerial survey, 19 of 78 (24.4 percent) sample units in the transportation-corridor study area were surveyed during April 6-10 (Figure 16.7-3). Eighteen moose were seen in sample units surveyed and another 13 moose were seen outside of them (Table 16.2-3). The highest number of moose observations occurred in lower elevation areas along the Pile River and Chekok Creek.

Approximately a foot of snow fell in the survey area on April 4 (two days before the survey began) and weather conditions remained cool and calm during the surveys, so little snow melted and survey conditions were classified as good or excellent for 29 of the 30 units sampled. Moose tracks were readily visible in the fresh snow and nearly every set of moose tracks seen could be followed until the animals were found. By the final day of the survey, the network of moose trails was extensive enough to make locating moose more challenging than earlier in the survey.

For six sample units (five in the transportation corridor and one in the deposit area), intensive surveys were conducted in one-quarter of the sample unit to calculate an SCF. Moose were observed in four of these sample units during the initial survey. No more moose were observed during the intensive survey, resulting in an estimated SCF of 1.0. Combined with the favorable snow conditions, this result indicated that sightability was high during the survey. Therefore, the estimates were not adjusted to account for moose missed during the surveys.

The estimated population for the entire 2,398-km^2 survey area (mine and transportation-corridor study areas combined) was 96.2 moose (0.04 moose/km^2). Because moose density was highly variable among sampling units, with all moose observations occurring in just six of the 30 units sampled, the variance associated with the estimates was large (Table 16.2-4). The 95 percent confidence interval around the estimated population for the entire survey area was 38 to 176 moose. The estimated density in the transportation-corridor study area was 0.05 moose/km^2, producing an estimated population of 63 moose and a 95 percent confidence interval of 38 to 176 moose.

It is possible that these numbers underestimate the true density. Five moose in three groups were observed just outside (within 200 m) of surveyed sample units. If those groups had been inside the surveyed sample units, the GSPE population estimate for the entire study area would have been 119 moose (95 percent confidence interval = 38-205).

Because the survey was conducted long after bulls had dropped their antlers, it was not possible to reliably classify the sex of all of the moose observed. Of all 38 moose observed in the entire survey area, 9 were classified as adult males, 6 were adult females, 7 were calves, and 16 were adults of unknown sex. If it is assumed that all adults of unknown sex were females, then the minimum population ratios were 31.8 calves:100 cows and a minimum of 40.9 bulls:100 cows.

ADF&G biologists conducted two aerial surveys in March 1992 between the deposit area and the coast. The first survey, done on March 25, 1992, under poor survey conditions, found an estimated density of 0.07 moose/km^2 in the area between the Newhalen River and Williamsport. The second survey, on March 27, 1992, was flown under better conditions and found an estimated 0.16 moose/km^2 in the area between the deposit area and Iniskin Bay (Boudreau et al., 1992). All of the moose on both of those surveys were observed along the Iliamna Lake shore because of deep snow in the area east of the lake in the Iliamna River drainage and between Pile Bay and Williamsport. Those surveys used different methods and were conducted in different areas than the Pebble Project surveys reported above. Sightability is greatest in winter when snow cover is complete, deciduous trees and shrubs lack leaves, and moose are concentrated in low-lying riparian areas. During the survey in late March 2005, Pebble researchers saw 10 moose (9 on transect surveys) for an estimated density of 0.09 moose/km^2. That density was within the range of densities recorded on the surveys in March 1992. ADF&G estimated that 2,000 moose occurred in all of GMU 9B in the mid-1980s (Butler, 2008a), for a mean density of 0.094 moose/km^2. Moose populations reportedly have been relatively stable in GMU 9 since the early 1990s (Butler, 2008a).

A trend-count area was established by ADF&G to establish a population index for the lower Chekok Creek drainage, a 324-km^2 area described as "a localized area of moderate moose density" (Boudreau et al., 1992). Between 25 (0.08 moose/km^2) and 147 (0.45 moose/km^2) moose were observed in the Chekok trend-count area during seven surveys conducted between 1969 and 2005 (Butler, 2008b). The high count was recorded in November 1989, and the two subsequent counts in 1998 and 2005 were much lower. Only 31 moose (0.01 moose/km^2) were counted in 1998, and the low count of 25 moose was recorded in 2005. NPS researchers conducted sightability trials for moose in Lake Clark National Park and Preserve in 1996 and 1998 and used that information to adjust population surveys conducted in 2003 and 2004 (Putera and Drummer, 2005). They estimated that an average of 76.8 percent of moose groups was observed, and reported that sightability was significantly related to group size, percent vegetative cover, and percent snow cover. Estimates (± 95 percent confidence interval) of the moose population in Subunit III South of the park, which is nearest to the transportation corridor study area, were similar in 1992 (241 ± 88 moose), 1998 (229 ± 45 moose), and 2003 (220 ± 57 moose).

The reported harvest of moose in the six reporting units in and adjacent to the study area ranged between 11 and 32 animals during the regulatory years 1991 through 2005 (Schwartz, 2006). The highest harvests occurred in regulatory years 1996 and 1997, and the lowest occurred in regulatory years 2002 and 2003. Reported harvest increased slightly since 2003 to a reported harvest of 19 moose in regulatory year 2005. Over half (51.8 percent) of the harvest occurred in one reporting unit south of Iliamna Lake. Reduced harvest in recent years may reflect lower hunter effort and changes in regulations rather than a decline in population (Butler, 2008a).

16.7.7.4 Other Mammals

Caribou

No caribou were observed in the transportation-corridor study area during mammal reconnaissance and transect surveys in 2004 and 2005. One caribou was observed in the western portion of the study area during a bird survey in June 2004 (Table 16.7-1). Ten caribou sightings from the MCH telemetry data set occurred during 1981-2010 in the western portion of the transportation-corridor study area; half of those locations were west of the Newhalen River (Figure 16.2-11). No locations of satellite-collared caribou from the MCH were recorded in the study area, and only three VHF-collared caribou locations occurred there during 1981-2010. Two VHF-collared caribou were located at the western edge of the transportation-corridor study area on July 10, 1990, and May 22, 2000. The other locations were observations of uncollared caribou that were included in the MCH telemetry data set. Other references on the MCH indicate little use of the area east of the Newhalen River (Van Daele and Boudreau, 1992; Van Daele, 1994; Woolington, 2007, 2010; Hinkes et al., 2005).

Reported harvest of caribou in the six reporting units in and adjacent to the study area was fairly high in regulatory year 1998 (475 animals), but declined thereafter to only 21 caribou in regulatory year 2005 (Schwartz, 2006). Most of the harvest (63.7 percent) occurred in the Newhalen River drainage in the western portion of the transportation-corridor study area, reflecting both better hunting access near Iliamna and the higher densities of caribou in the western portion of the area.

Other Species

The survey in October 2006 to enumerate active beaver colonies (indicated by lodges with fresh food caches) in the transportation-corridor study area found only a small number of colonies (Figure 16.7-4). The active colonies located on that survey were clustered at the western and eastern ends of the survey route. It is likely additional colonies would have been found with a wider survey swath, but the focus of the survey was limited to a single transect extending the length of the study area, rather than being an attempt to conduct a comprehensive survey of all wetlands between Iliamna Lake and the southern boundary of Lake Clark National Park and Preserve.

No wolves or wolverines were observed in the transportation-corridor study area during the mammal reconnaissance and strip-transect surveys in 2004 or 2005 (Table 16.7-1), but the tracks of a wolf pack numbering at least six animals were found on November 30, 2004, north of the study area near Chekok Lake during a Bald Eagle survey along Chekok Creek. During other field surveys in 2005, ABR researchers in the study area observed lone wolves on two occasions and one wolverine (Figure 16.7-4). Researchers observed one coyote during mammal strip-transect surveys in 2005 and two coyotes during waterbird surveys—one in 2004 and one in 2005 (Table 16.7-1, Figure 16.7-4). River otters were observed incidentally during waterbird surveys in 2004 (eight otters in three groups) and 2005 (ten otters in three groups; Figure 16.7-4).

The reported harvest of wolves in the six reporting units in and adjacent to the study area ranged between zero and 12 during the regulatory years 1991 through 2004 and averaged approximately five wolves annually (Schwartz, 2006). The reported harvest of beavers ranged between zero and 100 during regulatory years 1991 through 2003 and averaged approximately 23 beavers annually. River otters were harvested consistently in small numbers (2 to 27 per year, averaging 10) during 1991-1999, but then harvests became more sporadic. The reported harvest of other furbearers (lynx, marten) was scant during 1991 through 2004.

16.7.8 Summary

The distribution and abundance of large mammals in the Bristol Bay drainages portion of the transportation-corridor study area were evaluated during five aerial reconnaissance surveys by fixed-wing airplane in mid-April, mid-May, late June, mid-October, and late November 2004; six aerial transect surveys in late March, early May, late May, late June, mid-October, and mid-December 2005; and one transect survey in early December 2006. In addition, bear use of salmon-spawning streams was surveyed in mid-August 2004 and examinations of bear dens were conducted in mid-August 2004, mid-May 2005, and late August 2005. Incidental observations of large mammals also were recorded during other wildlife surveys.

The transportation corridor study area contained moderate densities of brown bears and low densities of black bears, moose, coyotes, wolves, and wolverines. Judging from telemetry data collected during 1981-2008, caribou from the MCH were found in the area only rarely; their principal range is located farther west. Because of the low densities of large mammals and the thick vegetation in the survey area, accurate calculation of density was difficult, requiring calculation of SCFs.

One brown bear and one black bear were observed on fixed-wing surveys during 2004, and three brown bears and two black bears were observed on fixed-wing surveys during 2005. Fifteen brown bears were observed during the helicopter survey of salmon-spawning streams in August 2004. Incidental observations in the study area during other wildlife surveys produced sightings of two brown bears in 2004, 55 brown bears in 2005, and five black bears in 2005. A bear population survey conducted in May 2009 in the region surrounding Iliamna Lake produced density estimates of 47.7 and 58.3 brown bears/1,000 km^2, depending on the analytical method used (Becker, 2010). Although the numbers of black bears seen on that survey were insufficient to calculate a density estimate, all but one of the 18 sightings occurred in the northeastern quadrant of the bear survey area, east of Nondalton and north of Kokhanok.

Pebble researchers recorded 12 moose throughout the study area during the five aerial reconnaissance surveys in 2004, 24 moose during six aerial transect surveys in 2005, and 27 moose during the single transect survey in December 2006. During bird surveys, biologists recorded incidental observations of nine moose in 2004 and 30 in 2005. Among all surveys in 2005, the estimated mean density of moose in the study area was 0.03 moose/km^2, incorporating the sightability correction estimated by simultaneous double-count surveys. A moose population survey in April 2010 estimated 63 moose in the 1,219-km^2 portion of the survey area in the transportation-corridor study area, for an estimated density of 0.05 moose/km^2.

Incidental observations during other wildlife surveys in the study area produced sightings of small numbers of wolves, coyotes, river otters, and a wolverine.

Because most of these mammal species are highly mobile and cover relatively large home ranges, the numbers in the study area vary seasonally and even daily; in addition, the detectability of animals in thick forest vegetation is low. Therefore, the numbers observed and densities calculated from these surveys are low estimates of the use of the study area by mammals throughout the year.

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16.7.10 Acknowledgments

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TABLES

TABLE 16.7-1
Species and Numbers of Mammals Recorded during Wildlife Surveys, Transportation Corridor Study Area, Bristol Bay Drainages, 2004-2006

Survey Type	Year	Date	Brown Bear	Black Bear	Moose	Caribou	Coyote	Wolf	Wolverine
Fixed-wing Surveys	2004	April 12	0	0	3	0	0	0	0
		May 21	1	0	6	0	0	0	0
		June 30	0	1	0	0	0	0	0
		Oct. 20-21	0	0	3	0	0	0	0
		Nov. 30	0	0	0	0	0	0	0
		TOTAL	**1**	**1**	**12**	**0**	**0**	**0**	**0**
	2005	Mar. 29-30	0	0	10	0	0	0	0
		May 9-10	0	0	1	0	0	0	0
		May 24-25	0	0	4	0	0	0	0
		June 28-29	2	2	0	0	0	0	0
		October 11	1	0	5	0	1	0	0
		Dec. 12-13	0	0	4	0	0	0	0
		TOTAL	**3**	**2**	**24**	**0**	**1**	**0**	**0**
	2006	Dec. 2	0	0	27	0	0	0	0
Stream/Den Survey	2004	Aug. 18-20	15	0	0	0	0	0	0
Den Checks	2005	May 11-12	0	0	1	0	0	0	0
		Aug. 29-30	1	0	0	0	0	0	0
		TOTAL	**1**	**0**	**1**	**0**	**0**	**0**	**0**
Beaver Survey	2006	Oct. 16-17	0	0	0	0	0	0	0
Incidental Observations (during other wildlife surveys)	2004	April	1	0	2	0	0	0	0
		May	0	0	2	0	0	0	0
		June	0	0	0	1	0	0	0
		September	1	0	1	0	0	0	0
		October	0	0	4	0	1	0	0
		TOTAL	**2**	**0**	**9**	**1**	**1**	**0**	**0**
	2005	April	0	0	3	0	0	1	0
		May	8	2	13	0	1	0	1
		June	4	0	2	0	0	0	0
		July	15	1	2	0	0	0	0
		August	18	2	1	0	0	1	0
		September	10	0	2	0	0	0	0
		October	0	0	7	0	0	0	0
		TOTAL	**55**	**5**	**30**	**0**	**1**	**2**	**1**

TABLE 16.7-2
Number of Large-mammal Groups Seen by Front Observer Only, Rear Observer Only, and Both Observers during Double-count Aerial Transect Surveys, Transportation Corridor Study Area, Bristol Bay Drainages, March-October 2005

Observer	Moose	Brown Bear	Black Bear	TOTAL
Front only	5	2	0	**7**
Rear only	4	0	0	**4**
Both	2	2	0	**4**
TOTAL	**11**	**4**	**0**	**15**

FIGURES

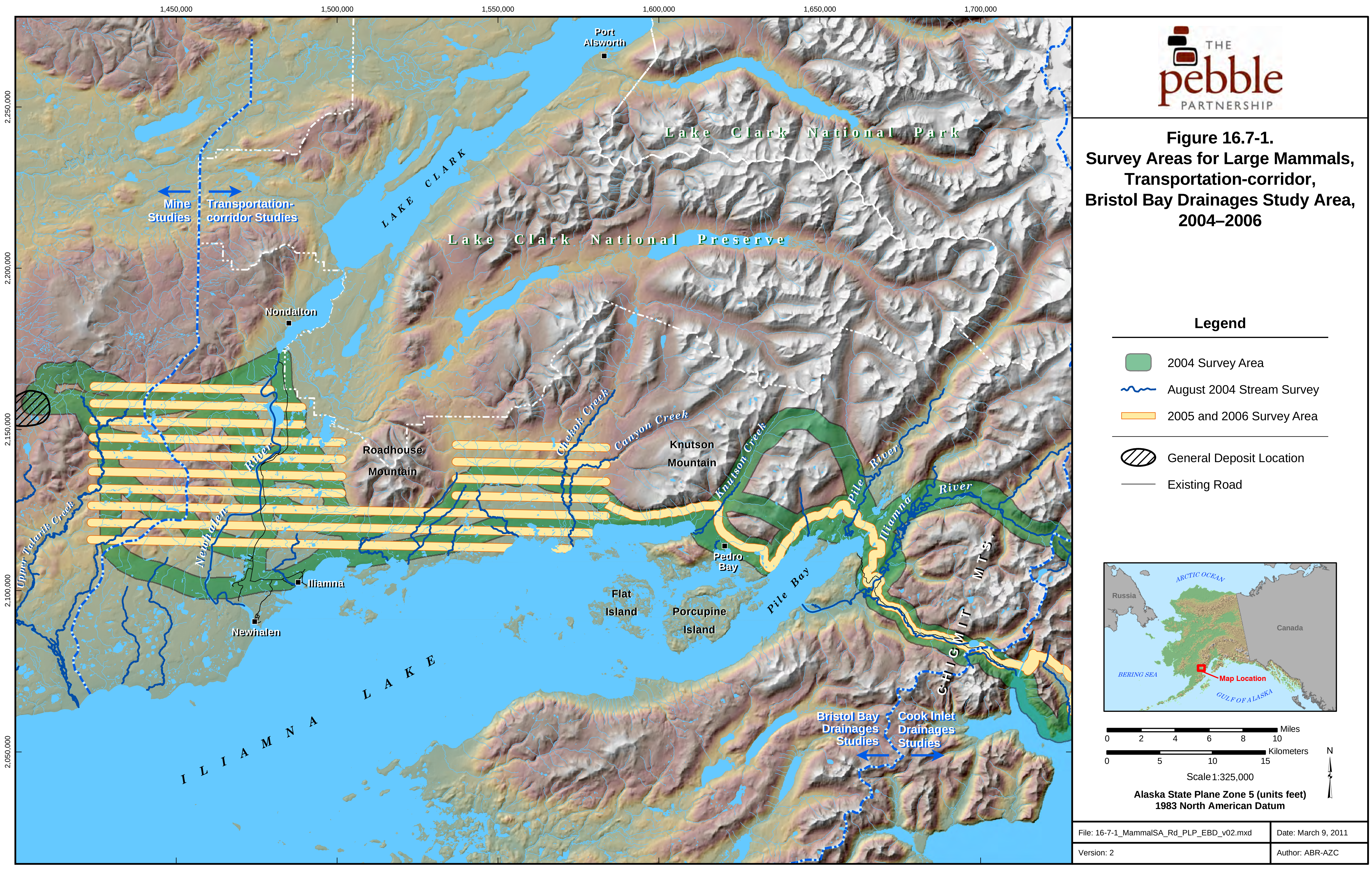


Figure 16.7-1.
Survey Areas for Large Mammals, Transportation-corridor, Bristol Bay Drainages Study Area, 2004–2006

File: 16-7-1_MammalSA_Rd_PLP_EBD_v02.mxd	Date: March 9, 2011
Version: 2	Author: ABR-AZC

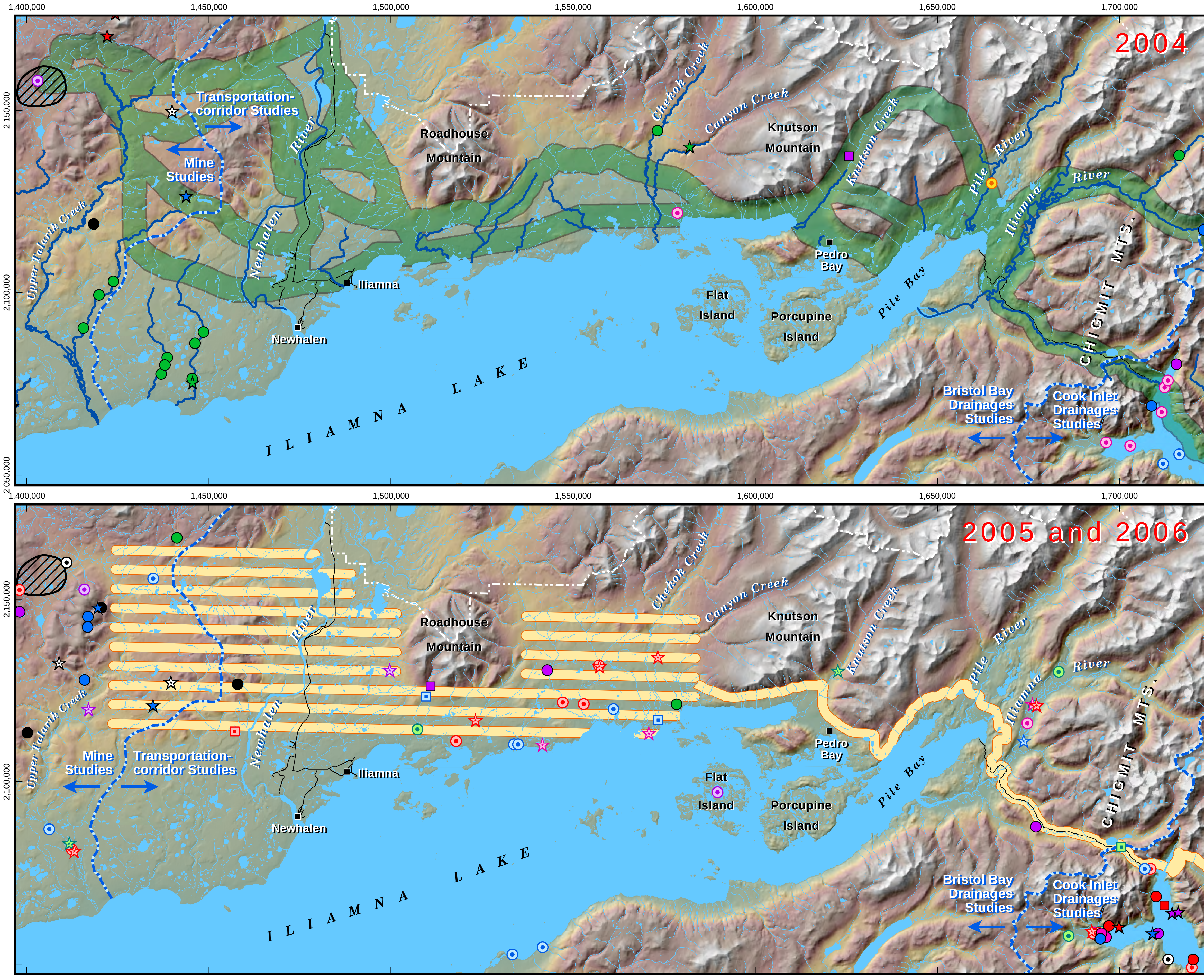
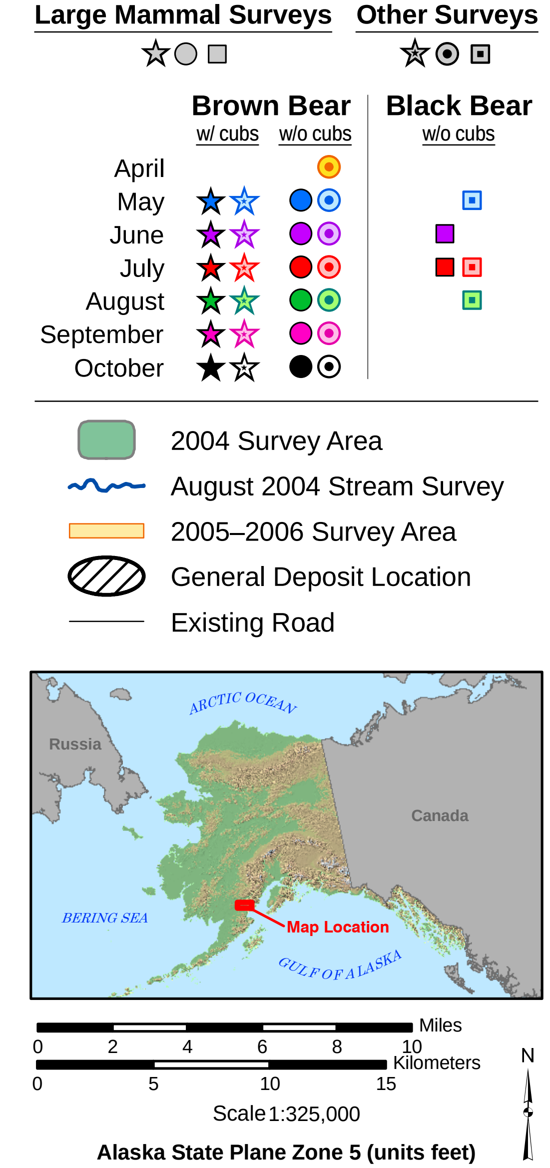


Figure 16.7-2
Bear Observations, Transportation-corridor, Bristol Bay Drainages Study Area, 2004–2006

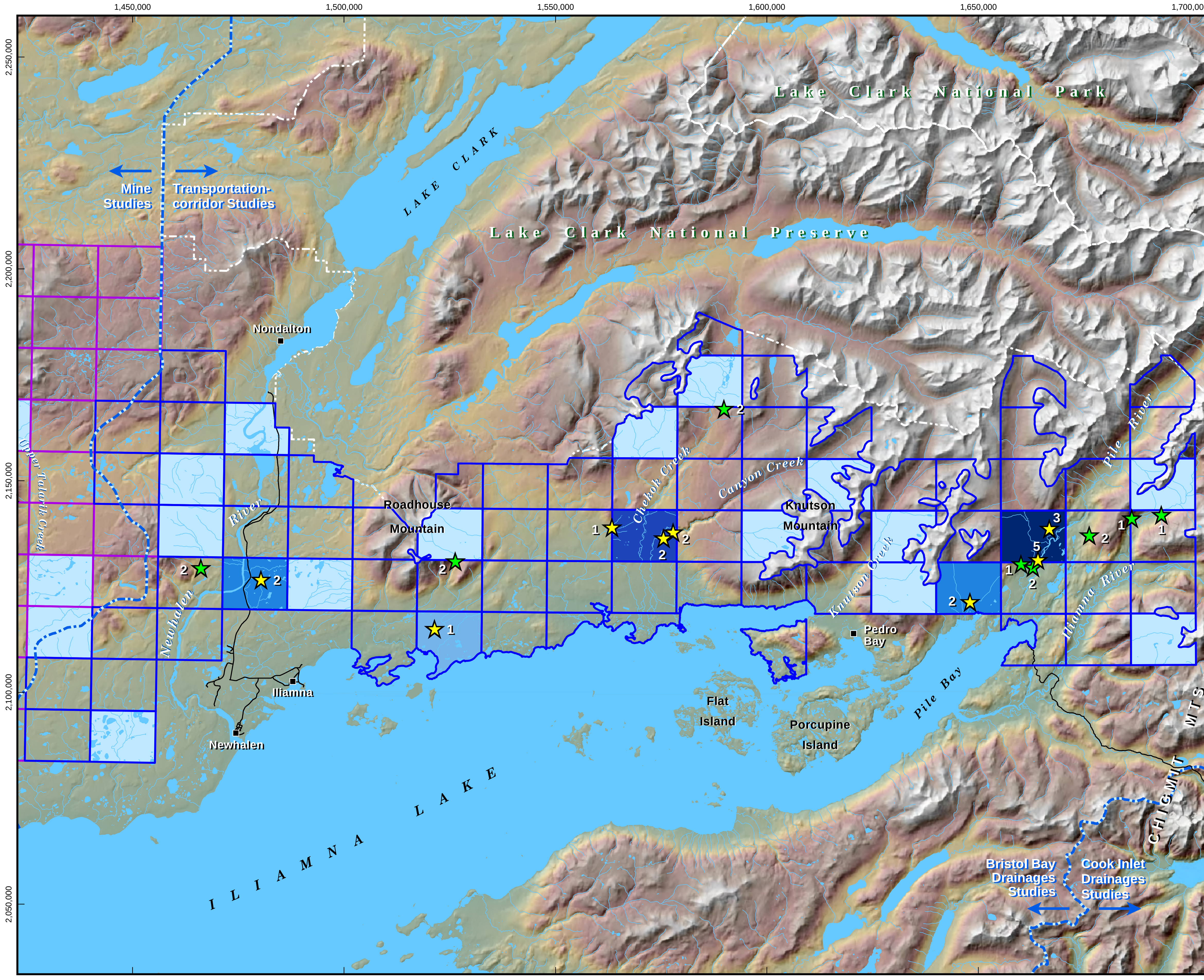
Legend



Scale 1:325,000

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

File: 16-7-2_BearObs_Rd_PLP_EBD_v02.mxd	Date: March 9, 2011
Version: 2	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.7-3
Moose Population Survey Results, Transportation-corridor, Bristol Bay Drainages Study Area, April 2010

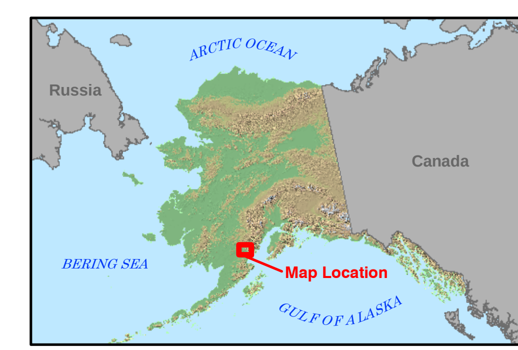
Legend

Number of Moose
Out of Surveyed Area (#)
In Surveyed Area (#)

Number of Moose in Surveyed Sample Units
0
1
2 – 3
4 – 5
6 – 8

Sample Units not Surveyed
Mine
Transportation-Corridor

Existing Road



Miles 0 2 4 6 8 10
Kilometers 0 2 4 6 8 10 12 14
Scale 1:280,000
N

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

File: 16-7-3_MoosePop_Rd_PLP_EBD_v02.mxd	Date: March 9, 2011
Version: 2	Author: ABR-AZC

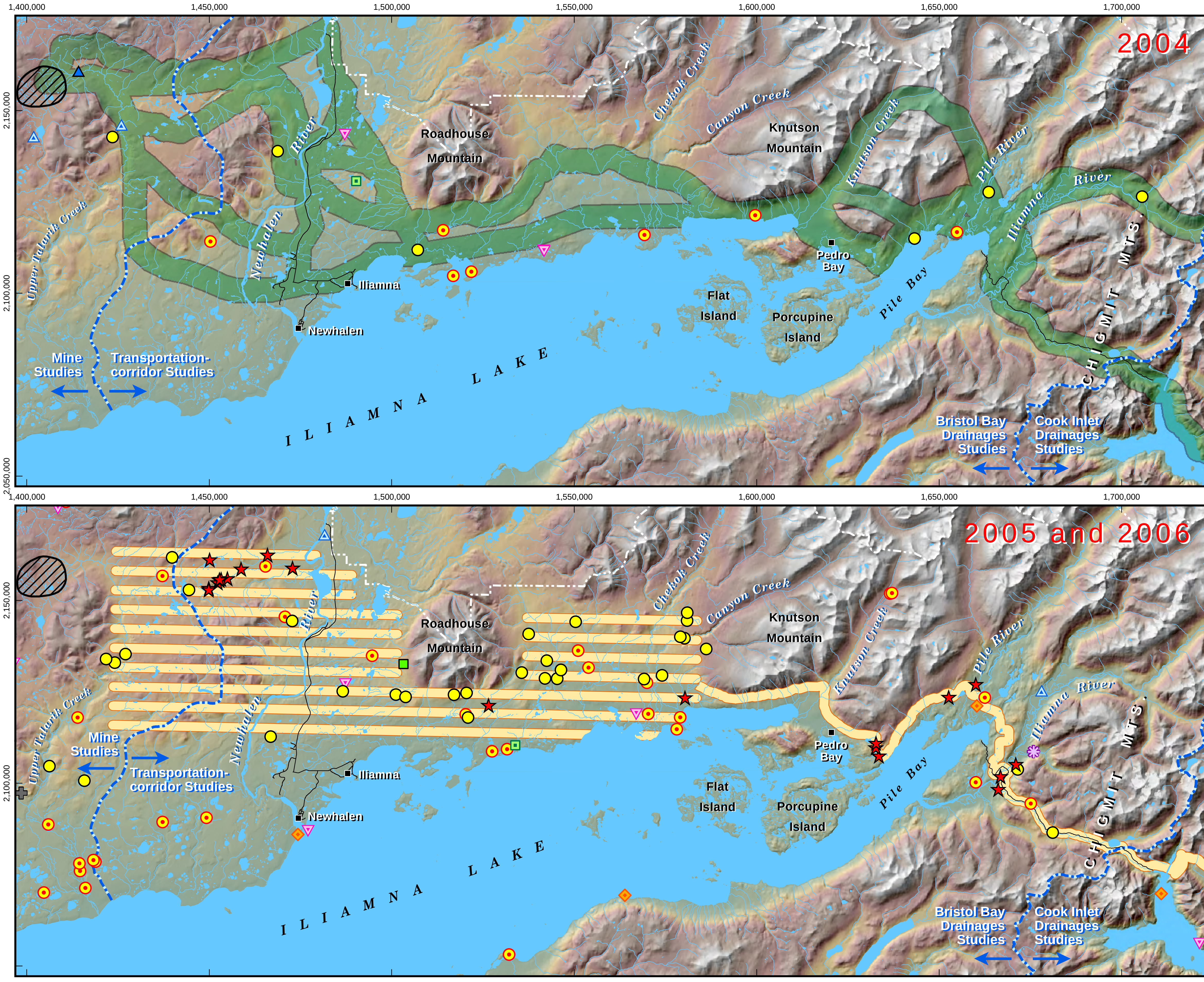


Figure 16.7-4
Observations of Moose and Other Mammals, Transportation-corridor, Bristol Bay Drainages Study Area, 2004–2006

Legend

	Large Mammal Surveys	Other Surveys
Moose	●	◉
Coyote	■	▣
Red Fox		◆
Beaver Colony	★	
River Otter		▽
Wolf	▲	△
Wolverine		✲

2004 Survey Area
2005–2006 Survey Area
General Deposit Location
Existing Road

0 2 4 6 8 10 Miles
0 5 10 15 Kilometers
Scale 1:325,000

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

File: 16-7-4_OtherMam_Rd_PLP_EBD_v02.mxd	Date: March 9, 2011
Version: 2	Author: ABR-AZC

16.8 Harbor Seals in Iliamna Lake

16.8.1 Introduction

The harbor seal (*Phoca vitulina*) typically inhabits marine waters, but also enters freshwater rivers and lakes (Mansfield, 1967; Pitcher, 1985; Hoover, 1988). The species has been known to occur in Iliamna Lake for many years (e.g., Nelson and True, 1887). The Alaska Department of Fish and Game (ADF&G) depicted the eastern end of Iliamna Lake (from Triangle Island east) as harbor seal habitat (ADF&G, 1973). Although they are not landlocked because the lake system is connected to Bristol Bay by the Kvichak River, harbor seals are considered to be year-round residents of the lake (Pitcher, 1985; Hoover, 1988).

Freshwater populations of harbor seals are rare. The best-known populations of freshwater seals, which inhabit lakes Baikal and Ladoga and the Caspian Sea in Russia and Lake Saimaa in Finland, all derived from ringed seal (*Pusa hispida*) progenitors (Palo, 2003). Harbor seals inhabit freshwater rivers and lakes along the western shore of Hudson Bay in Canada (Mansfield, 1967; Beck et al., 1970), but the most notable freshwater population occurs in Lacs des Loups Marins (Seal Lakes) on the Ungava Peninsula in northern Québec and is distinctive enough to have been classified as a unique subspecies (*Phoca vitulina mellonae*; Smith et al., 1994; Smith, 1997). Debate about the degree of isolation of that subspecies notwithstanding (Mansfield, 1967; Beck et al., 1970; Smith and Horonowitsch, 1987), the available evidence on morphology, genetics, and movements appears to support the distinction (Smith et al., 1994, 1996, 2006; Smith, 1997). In contrast, comparable analyses have yet to be conducted on the harbor seals in Iliamna Lake, although the study plans of several current research projects include biosampling and genetic analysis. The seals in Iliamna Lake currently are considered to be *Phoca vitulina richardii*, the same subspecies found throughout the Alaska range of the species (Pitcher, 1985; Hoover, 1988; Westlake and O'Corry-Crowe, 2002; MacDonald and Cook, 2009), but recent genetic analyses suggest that subspecific classification of the harbor seal is in need of revision (MacDonald and Cook, 2009).

Harbor seals are protected by the federal Marine Mammal Protection Act (MMPA) and there is concern about the status of the species elsewhere in southcentral Alaska (Chapter 45, Threatened and Endangered Species and Species of Conservation Concern). Harbor seals, both in Iliamna Lake and in the coastal bays of Cook Inlet (Chapter 44, Marine Wildlife), are a subsistence resource for local Alaska Natives, who are allowed to harvest the species under the MMPA. The following discussion describes the study of harbor seals in Iliamna Lake undertaken for the Pebble Project in 2005, 2007, and 2008.

16.8.2 Study Objectives

Surveys of harbor seals in Iliamna Lake were conducted to assess the seasonal occurrence and abundance of the species in and near the transportation-corridor study area for the Pebble Project. This study had four objectives:

- Review existing information on the population of harbor seals inhabiting the lake.
- Count harbor seals at known haulout sites during spring, summer, and fall.
- Search for additional haulout sites.
- Examine factors affecting haulout use.

16.8.3 Study Area

Iliamna Lake is the largest freshwater lake in Alaska. A study conducted by the Fisheries Research Institute (FRI) of the University of Washington calculated the total surface area of Iliamna Lake as 2,622 square kilometers, the volume as 115 cubic kilometers, the mean depth as 44 meters, and the maximum depth as 301 meters (Anderson, 1969). The Pebble Project study area for lake seals encompassed island groups in the eastern and central portions of Iliamna Lake (Figures 16.8-1 through 16.8-3). The islands surveyed were chosen specifically for their past use as haulouts (Mathisen and Kline, 1992; Small, 2001) and several previously undescribed sites were added during the surveys in 2005, 2007, and 2008. The locations of several other suspected haulout sites were provided by R. Small of ADF&G (pers. comm., 2006) and D. Withrow of the National Marine Mammal Laboratory (NMML), part of the National Marine Fisheries Service (NMFS; pers. comm., 2006).

16.8.4 Previous Studies

Although the presence of harbor seals in Iliamna Lake has been noted in various publications for many years (e.g., Nelson and True, 1887; ADF&G, 1973; Pitcher, 1985; Hoover, 1988), actual survey data were sparse at the time this study began. The population was estimated by ADF&G to number 150 to 300 animals in the early 1970s (USDOI, 1974), but no supporting data for that estimate were located. The first published attempt to enumerate seals using lake haulouts was by Mathisen and Kline (1992), in conjunction with salmon research in the lake system by FRI. Later surveys conducted in 1998 and 1999 by ADF&G enumerated seals at haulout sites in Iliamna Lake while the survey aircraft was traveling to and from marine survey areas in the Bristol Bay region (Small, 2001; Small, pers. comm., 2006). Small (2001) surveyed the same haulout sites as Mathisen and Kline (1992), but was unable to locate one of them (LI-08) conclusively. The preceding two studies provided the information used to plan the Pebble seal surveys in 2005. Following the 2005 surveys, unpublished count data were received from state and federal agency biologists (Small, pers. comm., 2006; Withrow, pers. comm., 2006). Hauser (2001) briefly studied hauling-out behavior at one site, and Hauser et al. (2008) investigated the summer food habits of harbor seals in eastern Iliamna Lake. Withrow and Yano (2009) summarized the results of haulout surveys by NMML and ADF&G biologists in Iliamna Lake through 2008. Additional surveys were flown by NMML biologists in 2009 (Withrow and Yano, 2010), and a collaborative study of the lake seal population by local Alaska Native entities, NMML, and ADF&G began in fall 2009 (Chythlook et al., 2010; Withrow and Yano, 2010). As part of that collaborative effort, the data from the Pebble haulout surveys are being added to the database maintained by NMML.

16.8.5 Scope of Work

The scope of work focused on counting seals at haulout sites:

- Enumerate harbor seals hauled out at known and newly discovered sites in Iliamna Lake during spring, summer, and fall in 2005 and 2007; the 2008 surveys focused on the time of year when maximal counts were expected to occur.
- Examine factors influencing haulout counts.
- Compare other data on the use of lake haulouts by harbor seals with the Pebble survey results.

16.8.6 Methods

The surveys in 2005, 2007, and 2008 focused on replicating counts at haulouts for which previous data were available. Most haulout sites were identified, using existing literature (Small, 2001), before surveys began in 2005, but five more sites were found in 2005, two were added in 2007, and one was added in 2008 (Table 16.8-1). Twenty aerial surveys were flown over eastern and central Iliamna Lake between March 30 and December 13, 2005; nine surveys were flown between May 21 and October 11, 2007 (a survey was attempted on April 17-18, 2007, but was canceled because of poor weather conditions); and seven surveys were flown between August 2 and 18, 2008. Most flights were scheduled to coincide with aerial surveys for terrestrial mammals in the transportation-corridor study area (Section 16.7) and for terrestrial and marine mammals in the Cook Inlet study area (Section 41.2 and Chapter 44), or with selected waterfowl-migration surveys (Sections 16.10 and 41.4). During each survey, one or two observers and the pilot examined each potential haulout location from a fixed-wing aircraft (Cessna 206 floatplane or Piper PA-18 “Super Cub”) flying at an altitude of 305 meters (1,000 feet) above lake level. Observers scanned for additional haulouts while flying between known sites. Each haulout site was circled by the aircraft several times to allow the crew to count the number of seals hauled out on land or in the water at the site and to photograph the site. Observers used 10-power, image-stabilizing binoculars when counting the seals. If more than approximately 20 seals were present, photographs were taken using a 35-millimeter camera with a 70-to-210-millimeter zoom lens early in 2005 and a 5-megapixel digital camera with a 12-power optical zoom lens later in 2005 and in 2007 and 2008. The seals in the photographs were counted, and the photographic counts were used instead of the field counts when the numbers differed, if the photographs were of sufficient quality to yield accurate counts. Seals in the water at haulout sites were included in the haulout counts, whereas the few seals seen in the water away from haulout sites during surveys were tallied separately. Weather conditions at the time of the surveys were noted on data forms, and air temperature, wind speed, and wind direction at the Iliamna airport were obtained from an internet source (http://www.wunderground.com/history/airport/PAIL/).

16.8.7 Results and Discussion

16.8.7.1 Haulout Locations

During surveys in 2005, harbor seals were found at 12 haulout sites (Appendix 16.8A, Figure 16.8-1), seven of which had been described previously (Table 16.8-1; Mathisen and Kline, 1992; Small, 2001). Sites LI-04 and LI-05, both located on what Mathisen and Kline (1992) called Seal Island (their Sites S1a and S1b, respectively), were combined as Site LI-05 for the Pebble surveys. No site was found by Small (2001) or during the Pebble surveys at the coordinates reported for site LI-08 (Site Th1 of Mathisen and Kline, 1992), although it is likely that Mathisen and Lopp’s coordinates refer to the site designated by Small (2001) as LI-07. There is likely some minor error in the coordinates reported for some haulouts because of map datum differences and uncertainty about the method by which the coordinates were recorded by various studies (e.g., topographic maps or GPS receivers in aircraft). Haulout sites were plotted on a georeferenced satellite image (Landsat-5 TM, acquired June 26, 2005) to obtain the coordinates listed in Table 16.8-1. The locations of sites LI-10 and LI-11 were received from ADF&G (Small, pers. comm., 2006) after the 2005 survey season, but both were located west of the study area, so they were not surveyed for the Pebble study (Small saw no seals at those locations). The location of Site LI-13 was received from NMML (Withrow, pers. comm., 2006) after the 2005 surveys ended; it was not included in the 2005 surveys, but was added for the 2007 and 2008 surveys (no seals were seen there in either year, however). Seals were counted at five previously unreported sites (LI-12, LI -14, LI -15, LI -16, and LI-18) during Pebble surveys in May and late June 2005; after the 2005 season ended, it was learned that seals had been seen at LI-12 by other researchers in August 2003 (Small, pers. comm., 2006). Previously unreported sites LI-20 and LI-17 were added to the survey in June and July 2007, when a few seals were seen there (Appendix 16.8B and Figure 16.8-2). Although only three seals were seen at LI-20 and they were in the water just off the beach, the site was considered to be a potential haulout location. Site LI-19 was added to the list in mid-August 2008 (Appendix 16.8C and Figure 16.8-3); the use of that site by a relatively large number of seals was surprising because none were recorded there in 2005 or 2007 and it had not been reported previously by other investigators.

Hunters have harvested seals hauled out at other locations in the lake, for example, in Lonesome Bay (probably near Lonesome Point, in northern Pile Bay; Johnson, 2004) and on Eagle Bay Island (MacDonald and Cook, 2001), but no descriptions of those sites are available. Much of the lake seal harvest occurs during the winter months when the lake is covered by ice (Fall et al., 2006), so harvest locations do not necessarily indicate haulout sites. The haulout sites surveyed in 2005, 2007, and 2008 for the Pebble study are within the general area of the lake in which residents of Iliamna and Newhalen reported harvesting seals (Fall et al., 2006), but some harvests were reported from locations that were not covered regularly by aerial surveys, such as the Rabbit Islands group and small unnamed islands in the northern portion of the lake near Newhalen and Iliamna. Those islands were surveyed on several occasions in the summers of 2005 and 2007, but no seals were found there, nor were seals reported at those locations by previous researchers (Mathisen and Kline, 1992; Small, 2001). Although site LI-12 was lumped in the Rabbit Islands group for data summaries in this report, it is located several miles away from the other islands in that group and is the only one at which seals were seen hauled out.

As previously noted, the focus of the surveys in 2005, 2007, and 2008 was on replicating surveys at verified haulouts for which previous data were available, rather than on the more time-consuming task of completely surveying all possible haulout locations on each survey. Based on the occurrence of similar habitat characteristics, some other islands in the lake may be suitable as additional haulouts—including Grassy Island, a small island north of Flat Island; the group of islands just off Squirrel Point; and the numerous islands in the vicinity of Intricate Bay, northeast of Kokhanok. Although no seals were found at any of those islands on the few occasions when they were examined during the Pebble surveys, they should be checked on future surveys. The dispersed nature of the seal population and the numerous islands and complex shoreline of Iliamna Lake make it likely that more haulouts will be located with more search effort, but the sites examined in this study appear to be used most consistently by the largest numbers of seals.

16.8.7.2 Seasonal Use of Haulouts

The number of seals using haulout sites were highest in the summer and lowest in the spring and fall (Tables 16.8-2 through 16.8-4, Figure 16.8-4). Total counts in 2005 ranged from 0 to 276 seals (mean = 76) on 20 aerial surveys from March 30 to December 13. Table 16.8-2 summarizes the number of seals counted during each survey in 2005 (including several seals seen in the water away from haulouts), and Appendix 16.8A lists the number of seals counted at each haulout site. The greatest numbers of seals counted by all researchers have occurred during the month of August. The highest count in 2005 occurred on August 17. Few seals were observed in spring, with the notable exception of 101 seals hauled out at Site LI-07 on May 4; no ice cover remained in the lake at that time. Number increased during the summer and early fall (June-September surveys) in 2005 (Figure 16.8-4), when from 30 to 276 seals (mean = 140.7) were observed per survey (Table 16.8-2). After September, the number of seals hauled out dropped sharply to two seals on October 10 and zero on December 13.

Total counts in 2007 ranged from 0 to 313 seals (mean = 124.3) on nine aerial surveys from May 21 to October 11. Table 16.8-3 summarizes the number of seals counted during each survey in 2007 (including one seal seen in the water away from any haulout), and Appendix 16.8B lists the number of seals counted at each haulout site. The highest counts in 2007 occurred on August 14 and 15 (311 and 313 seals, respectively), whereas none were seen at haulouts on the May or October surveys (Table 16.8-3, Figure 16.8-4).

Based on the results of the 2005 and 2007 surveys, the seven surveys in 2008 were focused on early to mid-August, when maximal counts were expected, and two replicate surveys were flown on each of two days to examine within-day variability. Total counts in 2008 ranged from 205 to 357 seals (mean = 264.7) on seven surveys during August 2 through 18. Table 16.8-4 summarizes the number of seals counted during each survey in 2008 (including one seal seen in the water away from any haulout), and Appendix 16.8C lists the number of seals counted at each haulout site. The highest count in 2008 occurred on the afternoon of August 17, but the morning and afternoon counts on the previous day were identical to each other (264 seals). The total number of seals observed among the seven surveys in August 2008 was relatively high, but there was substantial variability among days in the total number seen, and the use of haulout locations varied among surveys, even within the same day.

Small (2001) reported total counts of 321 seals on August 13, 1998, 218 seals on August 22, 1998, and 225 seals on August 23, 1999, at sites LI-01 through LI-07; the greatest numbers occurred on Seal Island (sites LI-04 and LI-05 combined). On six surveys during August 23-27, 1991, Mathisen and Kline (1992) observed 28 to 103 seals (mean = 63.8) hauled out on Seal Island and another island nearby (thought to be site LI-02 by Small [2001]) and 0 to 62 seals (mean = 35.8) hauled out at two sites in the vicinity of Thompson Island (LI-07 and LI-09). In August 2005, Pebble researchers counted 30 to 81 seals (mean = 50.3) at LI-05 (Seal Island) and 38 to 108 seals (mean = 61.7) at LI-02/LI-18 (Appendix 16.8A). Pebble researchers counted 75 to 121 seals (mean = 95.3) in the vicinity of Thompson Island in August 2005; by far, most of those used site LI-07, a small island east of Thompson Island that is the most consistently used haulout location in that vicinity, according to local pilots (Lang, pers. comm., 2005; LaPorte, pers. comm., 2005), and the remaining small number used site LI-09. Comparable counts on Pebble surveys in August 2007 were 0 to 190 seals (mean = 123.7) at LI-05, 0 to 44 seals (mean = 21.3) at LI-02/LI-18, and 57 to 102 seals (mean = 81.7) at LI-07/LI-09 (Appendix 16.8B). In August 2008, there were 34 to 185 seals (mean = 122.6) at LI-05, 0 to 15 seals (mean = 3.3) at LI-02/LI-18, and 57 to 106 seals (mean = 79.7) at LI-07/LI-09 (Appendix 16.8C).

The number of harbor seals hauled out in the marine environment of Alaska is strongly influenced by tidal stage or height, date and time of day (Frost et al., 1999; Boveng et al., 2003; Small et al., 2003) and, in some cases, by wind speed or sky conditions (Boveng et al., 2003). The high variability of seal numbers among dates and sites underscores the value of replicating surveys whenever possible. The 2005, 2007, and 2008 counts demonstrate that the use of certain haulout locations changes at different times of the open-water season. For example, the use of sites LI-12 and LI-14 tended to be concentrated in the month of July, whereas Seal Island (LI-05) was used little until August. Site LI-07 was used more consistently during the summer months, although the numbers hauling out there varied substantially.

Previous researchers have noted that the lake seals feed heavily on sockeye salmon during the spawning season in summer and early fall (Mathisen and Kline, 1992; Hauser et al. 2008), so it is likely that the use of specific haulouts changes as the numbers and distribution of salmon change seasonally.

Previous work at Iliamna Lake suggested a positive relationship between the number of seals hauled out and the time of day, wind direction, and wind speed. Using video monitoring of one haulout (Seal Island spit) in August 2001, Hauser (2001) found that the highest numbers of seals tended to haul out between 14:00 and 19:00 local time. Numbers tended to be higher during southerly winds at wind speeds of 7 to 10 knots (13 to 18 kilometers per hour), rather than during calmer winds. The haulout site was on the leeward side of the island during such winds, and the use of specific sections of shoreline on different sides of the spit was affected by wind direction. An anecdotal report by Johnson (2004) noted that seals used a haulout site in Lonesome Bay during easterly winds, but the aspect of that site is unknown.

The numbers of harbor seals hauled out in the marine environments of Alaska are strongly influenced by tidal stage or height, date, and time of day (Frost et al., 1999; Boveng et al., 2003; Small et al., 2003) and, in some cases, by wind speed or sky conditions (Boveng et al., 2003). The haulout behavior of seals in the lake probably differs from that of seals in marine habitats, where the tidal influence is strong (Chapter 44, Marine Wildlife). The peak counts of seals at haulouts in Iliamna Lake on the Pebble surveys in 2005, 2007, and 2008 occurred on August 17 (Table 16.8-2), August 15 (Table 16.8-3), and August 17 (Table 16.8-4), respectively, during the molting period and was similar to the seasonal timing of peak haulout counts observed in studies of seals in the marine environment (Frost et al., 1999; Boveng et al., 2003; Small et al., 2003).

16.8.7.3 Population Status

The data available from surveys of harbor seals in Iliamna Lake do not permit an estimate of the total population with a high degree of confidence, in view of a lack of understanding of the factors affecting the numbers hauling out and incomplete coverage of sites in some years. The number of seals counted at haulout sites has varied considerably among surveys. The population was estimated at 150 to 300 seals in the early 1970s (USDOI, 1974), but no survey data that may have been associated with that estimate are available. A high count of 137 seals and an estimate of more than 200 seals were reported for August 1991 (Mathisen and Kline, 1992), but those surveys covered only a subset of the most consistently used haulout sites. ADF&G surveys produced high counts of 321 seals in August 1998 (Small, 2001), 225 seals in August 1999, and 171 seals in August 2003 (Withrow and Yano, 2009). High total counts of 276, 313, and 357 seals were obtained in August 2005, 2007, and 2008, respectively, by Pebble researchers. Five surveys by NMML biologists in late July and August 2008 produced total counts of 24 to 235 seals each (Withrow and Yano, 2009), and five surveys in 2009 produced total counts of 180 to 230 seals in August (Withrow and Yano, 2010).

Mathisen and Kline (1992) suggested that summing the highest counts at different haulout sites over short time intervals might provide a better estimate of abundance, producing an estimate of 165 seals instead of 137 for their surveys in late August 1991. This approach assumes that seals show at least short-term fidelity to specific haulouts, which has not been confirmed, and the selection of the time interval is arbitrary. Nevertheless, applying this approach to the 2005, 2007, and 2008 Pebble survey results (Appendices 16.8A through 16.8C) produced estimates of 368 seals using haulouts during August 11 through 21, 2005; 367 seals during August 14 through 29, 2007; and 389 seals during August 16 through 18, 2008. The increase in the total number of seals counted over the 4-year period in which Pebble surveys were conducted was more likely due to the increasing number of haulout locations documented and surveyed, rather than an actual increase in the population. In view of the annual high counts of 276 to 357 seals at haulouts and considering the estimates of 367 to 389 seals from Mathisen and Kline's suggested approach, the population in the lake, including those not hauled out at the time of survey counts, probably numbered at least 400 to 500 seals during 2005 through 2008. It must be emphasized, however, that this estimate is speculative because this freshwater lake differs from the marine environment for which survey-correction factors have been developed to estimate population size. The volume of existing data is as yet insufficient to allow development of survey-correction factors for the lake seal population. If the estimated population range from the early 1970s was accurate, then it appears that the population has increased since then. Local residents thought the seal population declined during the early 1970s, a period of severe winter weather (Mathisen and Kline, 1992).

Information on pup production by the lake seal population is virtually nonexistent. The normal timing of pupping by harbor seals in the marine environment is between mid-May and late June in the northern Gulf of Alaska and between early June and mid-July in Bristol Bay (Jemison et al., 2006). One of the objectives of NMML surveys in 2009 was to obtain counts during pupping, but few adults and no pups were seen on a survey on June 14, 2009; local contacts reported that "everything here [in the lake] happens a month late," (Withrow and Yano, 2010). Although estimating pup production was not one of the objectives of the Pebble surveys in 2005, 2007, and 2008, the survey data suggest that pupping in the lake occurs between late June and late July. Small seals identified by observers as pups were included in the field counts at haulouts on June 28, 2005 (16 of 105 seals), June 29, 2005 (23 of 96 seals), June 20, 2007 (1 of 51 of seals), and July 16, 2007 (3 of 238 seals). However, because it was difficult to differentiate pups confidently without extended circling by the aircraft (especially in windy conditions), those small animals were lumped into the total counts for the tables and appendices in this report. Small seals that appeared to be pups were visible in photographs taken of several haulouts (LI-14, LI-12, LI-07, LI-02) on June 28 and 29, 2005, on July 16, 2007, and on July 22 and 26, 2005, but pups could not be differentiated reliably on the photographs. The pattern of haulout use during the probable pupping period differs from that seen later in the summer. The haulout used by the largest number of seals in the June and July surveys in 2005 and 2007 was LI-14 (Figures 16.8-1 and 16.8-2, Appendices 16.8A and 16.8B), which had up to 152 seals on July 16, 2007. Other haulouts used by smaller numbers of seals in late June and July 2005 and 2007 were LI-02, LI-03, LI-05, LI-06, LI-07, LI-09, LI-12, LI-15, LI-16, LI-17, LI-18, and LI-20, although several of those sites were not used in both years (Appendices 16.8A and 16.8B). A small seal assumed to be a pup was observed beside the carcass of a dead adult that had fetched up in shallow water at site LI-14 on August 17, 2008; both were gone the next day.

Besides population size, the other large unknown regarding the Iliamna Lake seal population is whether it is a closed or an open population; that is, whether seals move between the lake and Bristol Bay with any regularity. Observations and harvests of seals in the Kvichak River (which flows from Iliamna Lake to Bristol Bay) near Igiugig (Small, pers. comm., 2006; Burns, pers. comm., 2008) and experience in the Canadian Arctic (Mansfield, 1967; Beck et al., 1970; Smith and Horonowitsch, 1987) suggest that the Iliamna Lake population may not be as isolated as it might appear, despite the fact that seals are present year-round. The area where harbor seals occur most consistently is in the eastern half of Iliamna Lake, relatively far from the outlet at the Kvichak River. The distance from Bristol Bay to the area occupied by seals in the eastern portion of the lake is at least 200 kilometers, about half of which is in the lake itself. The elevation of Iliamna Lake is approximately 45 meters above sea level, and there are no rapids to navigate in the Kvichak River.

In comparison, Sealhole and Edehon lakes in the upper Thlewiaza River drainage of Nunavut are approximately 240 kilometers from Hudson Bay, and it is thought that harbor seals may move back and forth between those lakes and the bay (Mansfield, 1967; Beck et al., 1970). Lacs des Loups Marin in the Nastopoka River drainage of Québec are approximately 160 kilometers from Hudson Bay, although that river has numerous rapids and significant elevation gain above sea level (approximately 250 meters; Smith and Horonowitsch, 1987). The harbor seals in the latter system are thought to be an isolated, distinct population (*P. v. mellonae*; Smith et al., 1994, 1996, 2006; Smith, 1997), but the possibility of immigration from Hudson Bay cannot be ruled out conclusively (Mansfield, 1967; Smith and Horonowitsch, 1987).

16.8.7.4 Factors Affecting Habitat Use

Although physical factors affecting habitat use by harbor seals were not measured directly in this study, observations during the aerial surveys provided insights into factors that affect the use of haulouts and other lake habitats by seals. The shoreline morphology and substrates of the numerous islands in Iliamna Lake affect their suitability for use as seal haulouts. The haulout sites at which seals have been observed share the characteristic of low-gradient beaches with substrates of relatively small diameter, such as sand or gravel, which presumably allow easier access by seals, as opposed to steep shorelines or beaches covered by cobble, boulders, or angular rocks. The availability of haulouts also is affected by fluctuations in the lake level. Past research at FRI’s field camp on Porcupine Island demonstrated that the level of Iliamna Lake rose steadily throughout the ice-free months, from low levels in spring to the highest levels in fall; the mean annual increase in lake level during 1961-1970 was approximately 1 meter from mid-May to mid-September, and the lake level peaked in fall before dropping over the winter (Low, 1972). Survey observations in late summer and fall 2005 showed that the availability of portions of haulouts used earlier in the summer (most notably LI-14) diminished as the water level rose and submerged portions of beaches and spits on which seals had hauled out. Mathisen and Kline (1992) noted that one haulout site was covered by water during their survey period.

The distribution of seals in the lake and the use of specific haulouts probably are affected by the seasonal availability of food. Hauser et al. (2008) reported that the lake seals feed heavily on adult sockeye salmon when they are available during summer and early fall, but that enough other prey apparently occurs in the lake to provide sufficient food throughout the year; they found remains from six families of fishes in seal scats and noted that 27 species of fishes have been documented in the Kvichak River drainage, including Iliamna Lake. Both those authors and Mathisen and Kline (1992) noted the proximity of salmon-spawning areas to the haulout sites used in August in the area of Flat and Seal Islands.

The available evidence suggests that the harbor seals in Iliamna Lake reside there year-round, raising questions about their ability to survive in areas that freeze over, because the species normally does not inhabit marine areas with significant ice cover. Despite its surface extent (2,622 square kilometers) and depth (mean = 44 meters, maximum = 301 meters; Anderson, 1969), Iliamna Lake becomes covered completely by ice during periods of cold weather. For example, comparison of satellite imagery for the 2004/2005 and 2005/2006 winter seasons shows distinctly different habitat conditions in the two years (Figure 16.8-5). Ice cover in the cold winter of 2005/2006 was substantially greater and lasted longer than in 2004/2005. Ice cover was essentially still complete in early May 2006, and the ice did not break up until mid-May that year. In contrast, 101 seals hauled out at site LI-07 on May 4, 2005, when ice cover was absent; that observation was the largest number seen at a single site until mid-August that year.

The ability of seals to achieve access to breathing holes during periods of ice cover affects their distribution. One experienced marine-mammal biologist expressed the opinion that the seal population in the lake probably is limited by the occurrence of extreme cold and heavy ice during cold winters, such as occurred during the early 1970s (Burns, pers. comm., 2008). ABR biologists flying between Iliamna and the Pebble marine survey area on March 22, 2007, and February 20 and March 17, 2008, reported incidental observations of small groups of seals (6 to 23 animals each) hauled out at holes and cracks in the lake ice in the eastern portion of the lake, in the general area in which most summer haulouts are located. The first group was seen between Flat and Porcupine islands, the second was approximately 1 kilometer southwest of Triangle Island, and the third was approximately 1 kilometer east of Seal Island. The resolution of the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery is not fine enough to reveal microhabitat features that allow seals to find small areas of open water, cracks, leads, and other suitable breathing holes; thus, it cannot be used to identify specific areas of habitat that became unavailable to seals after freezeup. Nevertheless, MODIS imagery clearly identifies the periods when the availability of open water becomes severely restricted in winter. Groundwater upwelling may help to maintain ice-free breathing areas in winters of heavy ice cover, such as 2005/2006. In addition, under-ice chambers resulting from declining lake levels during winter may be available for use as breathing areas by seals even under complete ice cover (Smith and Horonowitsch, 1987).

16.8.8 Summary

Harbor seals inhabit Iliamna Lake year-round, but there are no geographic barriers to the movement of seals between the lake and Bristol Bay. Current evidence is insufficient to evaluate the degree of ecological or genetic isolation of the lake population from the marine population in Bristol Bay.

Aerial surveys of harbor seal haulout locations were conducted from March to December 2005, May to October 2007, and in August 2008 for this study. Previously described haulout locations were surveyed, and eight additional haulout locations were documented. The use of specific haulouts varies seasonally, and in winter seals also haul out on lake ice away from haulouts. The number of harbor seals hauled out varied substantially among seasons and was highest in summer, peaking in mid-August. Peak counts from Pebble surveys were observed on August 17, 2005 (276 seals), August 15, 2007 (313 seals), and August 17, 2008 (357 seals). The peak numbers counted during the 2005, 2007, and 2008 surveys were greater than the peak number counted in 1991 (137 seals; Mathisen and Kline, 1992) and were generally similar to the peak count in 1998 (321 seals; Small, 2001).

Haulout use by harbor seals in Iliamna Lake is influenced by the physical characteristics of beach substrates, by wind direction and strength, and by seasonal variations in the water level of the lake, as well as by annual variation in the extent and duration of winter ice cover. The timing and location of spawning activity by sockeye salmon in summer and early fall also appears to affect haulout use.

16.8.9 References

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TABLES

TABLE 16.8-1
Characteristics of Harbor Seal Haulout Sites Surveyed or Reported in Iliamna Lake

Site No. [a]	Description	Latitude (degrees North) [b]	Longitude (degrees West) [b]	Remarks
LI-01	Rocky islet	59.71334	154.21149	
LI-02	Island; sandy shore, west side	59.71237	154.39347	Site S2 of Mathisen & Kline (1992)?; across channel from LI-18
LI-03	Island; sandy shore	59.72308	154.42490	
LI-04	Seal Island; sandy shore	59.75050	154.44252	Site S1a of Mathisen & Kline (1992); combined with site LI-05 for Pebble surveys
LI-05	Seal Island; sand & gravel shore	59.74910	154.44233	Site S1b of Mathisen & Kline (1992)?
LI-06	Island; sand & gravel shore	59.72661	154.49408	
LI-07	Island; sand & gravel shore	59.55779	154.85677	Probably Site Th1 of Mathisen & Kline (1992)
LI-08	Site not found; location uncertain	59.55099	154.87385	Site Th1 of Mathisen & Kline (1992); same as site LI-07?
LI-09	Thompson Island; sandy shore	59.54180	154.92047	Site Th2 of Mathisen & Kline (1992)
LI-10	Not seen; west of survey area	59.56667	155.63331	Reported by Small (but no seals seen) [c]
LI-11	Not seen; west of survey area	59.50833	155.23831	Reported by Small (but no seals seen) [c]
LI-12	Island; rock ledges	59.68913	154.69354	Located May 10, 2005; also reported by Small [c]
LI-13	Island group with rocky beaches; not surveyed in 2005	59.53318	154.85175	Reported by Withrow (but no seals seen) [d]
LI-14	Island; sand & gravel shore	59.71145	154.34353	Located June 28, 2005
LI-15	Rocky islet	59.72515	154.22950	Located June 29, 2005
LI-16	Triangle Island; gravel beach	59.72020	154.44637	Located June 29, 2005
LI-17	Island; gravel spit	59.72541	154.36240	Located July 27, 2007
LI-18	Island; gravel beach	59.71143	154.38701	Located June 28, 2005; across channel from LI-02
LI-19	Island; gravel beach	59.73531	154.46089	Located August 16, 2008
LI-20	Island; gravel spit	59.71756	154.28849	Located June 20, 2007

Notes:

a. Sites LI-01 through LI-09 from Small (2001), who based his survey on sites reported by Mathisen and Kline (1992).

b. Coordinates given in decimal degrees, using map datum NAD 83.

c. From survey on August 6, 2003 (Small, pers. comm., 2006).

d. From survey on August 10, 2005 (Withrow, pers. comm., 2006).

TABLE 16.8-2
Total Number of Harbor Seals Counted and Weather Conditions during Aerial Surveys, Iliamna Lake, March-December 2005

		Number of Seals Counted			Weather Conditions			
Date	**Local Time**	**Hauled Out**	**In Water**	**Total**	**Air Temp. (°C)**	**Wind Direction**	**Wind Speed (kilometers/hour)**	**Sky Condition**
March 30	12:00	0	0	**0**	-16	WSW	15	Partly cloudy
April 25	12:00	0	1	**1**	11	ESE	11	Clear
May 4	15:00	101	0	**101**	9	E	28	Overcast
May 10	14:00	4	1	**5**	13	ESE	17	Scattered clouds
May 11	13:00	1	0	**1**	15	ESE	19	Mostly cloudy
May 25	19:00	0	0	**0**	12	ESE	22	Clear
May 26	13:00	0	0	**0**	9	E	17	Mostly cloudy
May 31	10:30	0	0	**0**	9	E	24	Light rain
June 28	16:00	105	0	**105**	22	SSW	17	Clear
June 29	09:30	96	2	**98**	14	S	9	Clear
July 21	12:00	30	0	**30**	14	SE	7	Overcast
July 22	12:00	107	0	**107**	17	E	30	Clear
July 26	16:00	125	0	**125**	14	ESE	17	Light rain
August 11	16:00	194	0	**194**	22	SSE	11	Clear
August 17	10:00	276	0	**276**	13	N	15	Light rain
August 21	11:00	211	0	**211**	15	WNW	17	Mostly cloudy
August 29	13:00	199	0	**199**	12	WSW	17	Mostly cloudy
September 8	15:00	64	0	**64**	12	E	11	Clear
October 10	14:00	2	0	**2**	3	NNE	13	Mostly cloudy
December 13	12:00	0	0	**0**	0	E	37	Overcast
TOTAL		**1,515**	**4**	**1,519**				
Mean		75.8	0.2	76.0				

Notes:

Data on air temperature, wind direction, and wind speed were obtained from http://www.wunderground.com/history/airport/PAIL/

TABLE 16.8-3
Total Number of Harbor Seals Counted and Weather Conditions during Aerial Surveys, Iliamna Lake, May-October 2007

		Number of Seals Counted			Weather Conditions			
Date	**Local Time**	**Hauled Out**	**In Water**	**Total**	**Air Temp (°C)**	**Wind Direction**	**Wind Speed (kilometers/hour)**	**Sky Condition**
May 21	16:00	0	0	**0**	0	ESE	13	Partly cloudy
June 20	11:30	51	0	**51**	9	Variable	7	Clear
July 16	15:00	238	0	**238**	10	SW	19	Overcast
July 27	10:30	40	0	**40**	16	Calm	–	Clear
August 14	13:00	311	0	**311**	9	SW	15	Light rain
August 15	14:30	313	0	**313**	9	N	13	Overcast
August 29	13:00	86	1	**87**	19	NNW	11	Partly cloudy
September 12	10:30	79	0	**79**	11	WSW	9	Overcast
October 11	11:00	0	0	**0**	5	E	22	Overcast
TOTAL		**1,118**	**1**	**1,119**				
Mean		124.2	0.1	124.3				

Notes:

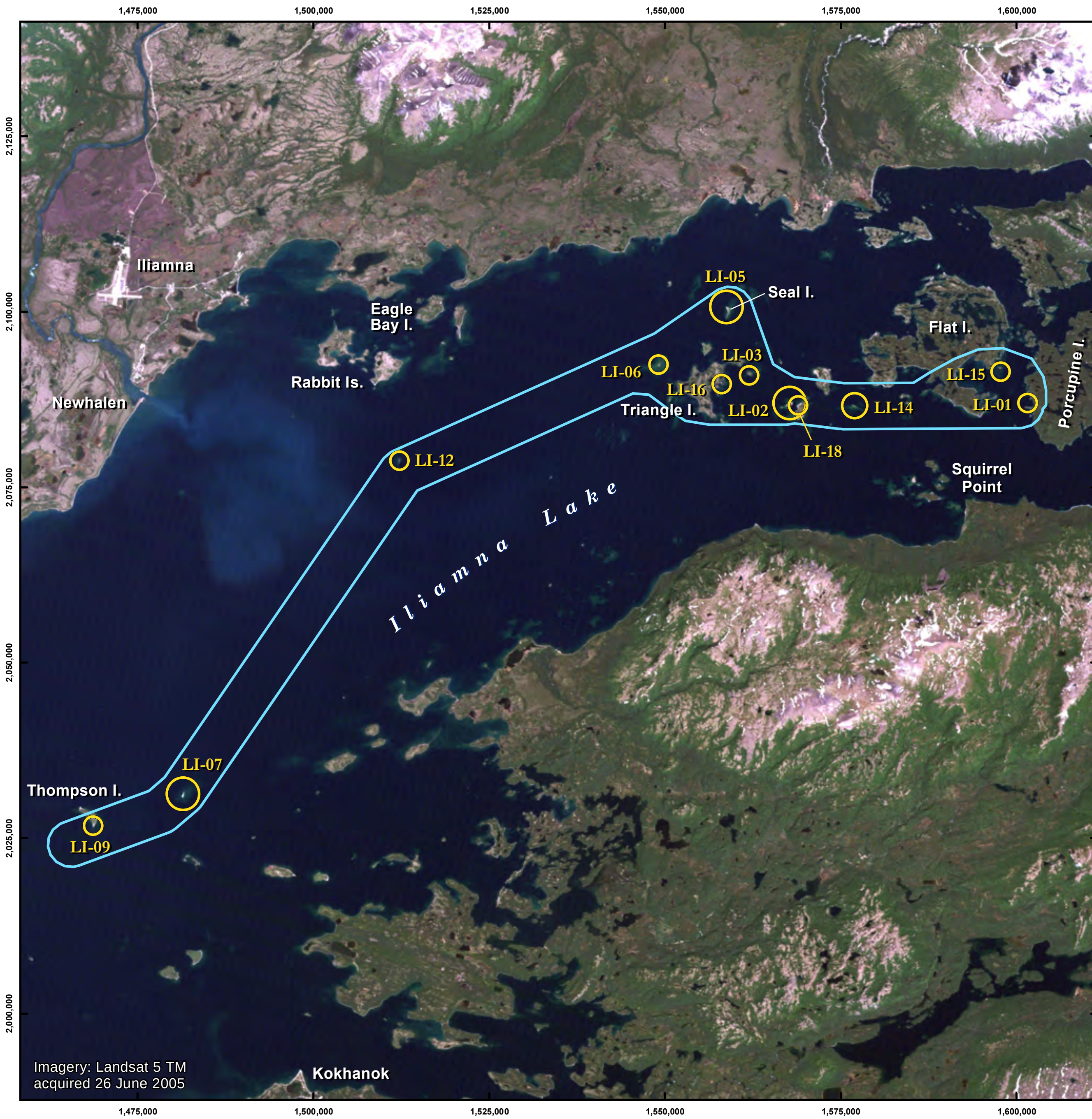
Data on air temperature, wind direction, and wind speed were obtained from http://www.wunderground.com/history/airport/PAIL/

TABLE 16.8-4
Total Number of Harbor Seals Counted and Weather Conditions during Aerial Surveys, Iliamna Lake, August 2008

		Number of Seals Counted			Weather Conditions			
Date	**Local Time**	**Hauled Out**	**In Water**	**Total**	**Air Temp (°C)**	**Wind Direction**	**Wind Speed (kilometers/hour)**	**Sky Condition**
August 2	11:00	230	0	**230**	13	SSE	9	Overcast
August 4	13:30	204	1	**205**	14	ESE	13	Overcast
August 16 am	11:00	264	0	**264**	12	Calm	0	Overcast
August 16 pm	17:00	264	0	**264**	14	SSE	22	Scattered Clouds
August 17 am	10:30	312	0	**312**	11	NNE	6	Mostly Cloudy
August 17 pm	16:30	357	0	**357**	13	E	24	Light Rain
August 18	12:30	221	0	**221**	14	ENE	6	Overcast
TOTAL		**1,852**	**1**	**1,853**				
Mean		264.6	0.1	264.7				

Notes:
Data on air temperature, wind direction, and wind speed were obtained from http://www.wunderground.com/history/airport/PAIL/

FIGURES



THE pebble PARTNERSHIP

Figure 16.8-1
Harbor Seal Haulouts, Iliamna Lake, 2005

Legend

Mean Number of Seals

- 0.1 – 5.0
- 5.1 – 15.0
- 15.1 – 40.0

2005 Iliamna Lake Seal Survey Area

Miles 0 1 2 3 4 5

Kilometers 0 2 4 6 8

N

Scale 1:270,000

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

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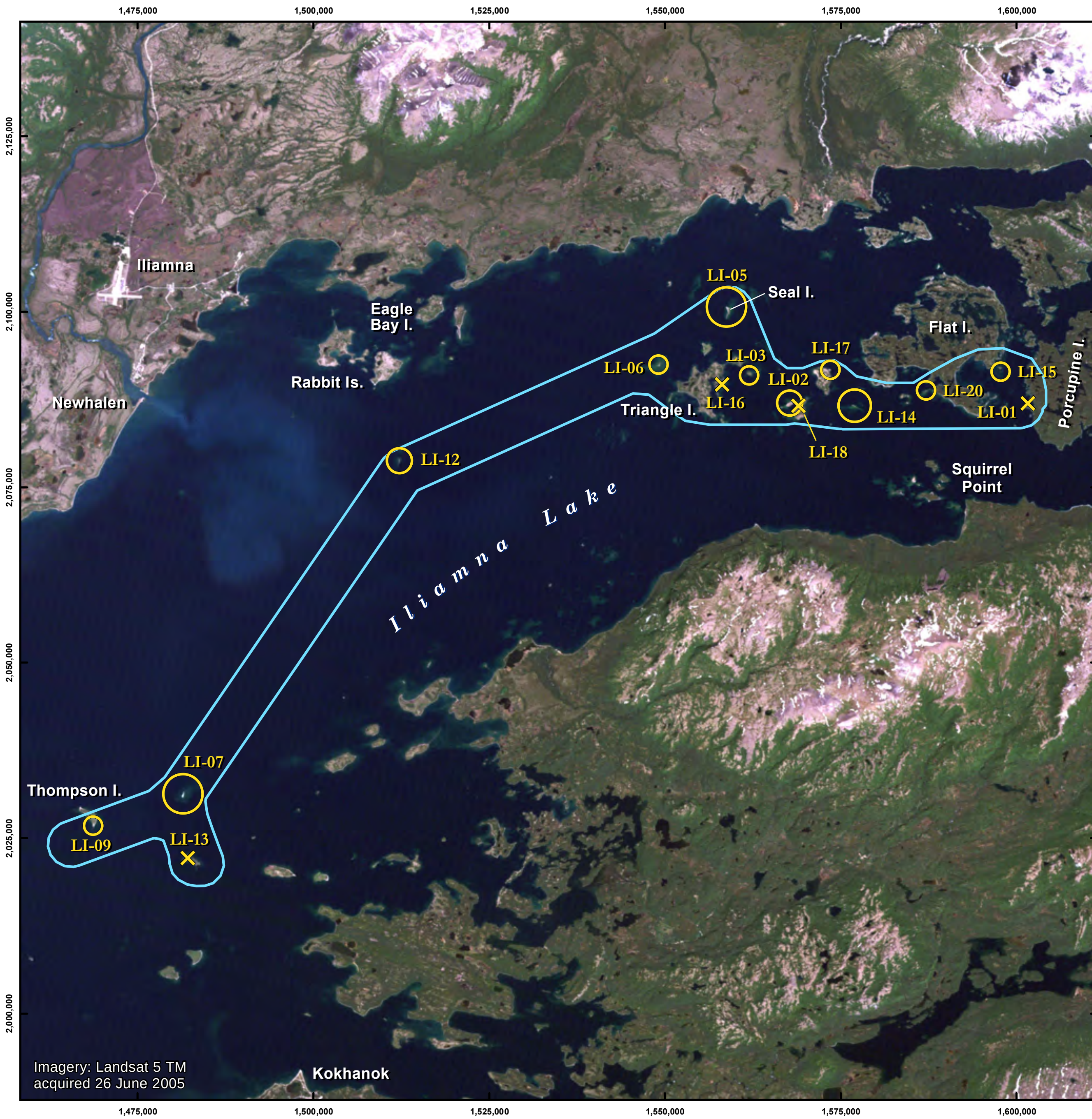

Figure 16.8-2
Harbor Seal Haulouts, Iliamna Lake, 2007

Legend

Mean Number of Seals

Symbol	Mean Number of Seals
✕	0
○ (smallest)	0.1 – 5.0
○	5.1 – 15.0
○	15.1 – 40.0
○ (largest)	40.1 – 60.0

2007 Iliamna Lake Seal Survey Area

Miles: 0 1 2 3 4 5

Kilometers: 0 2 4 6 8

N

Scale 1:270,000

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

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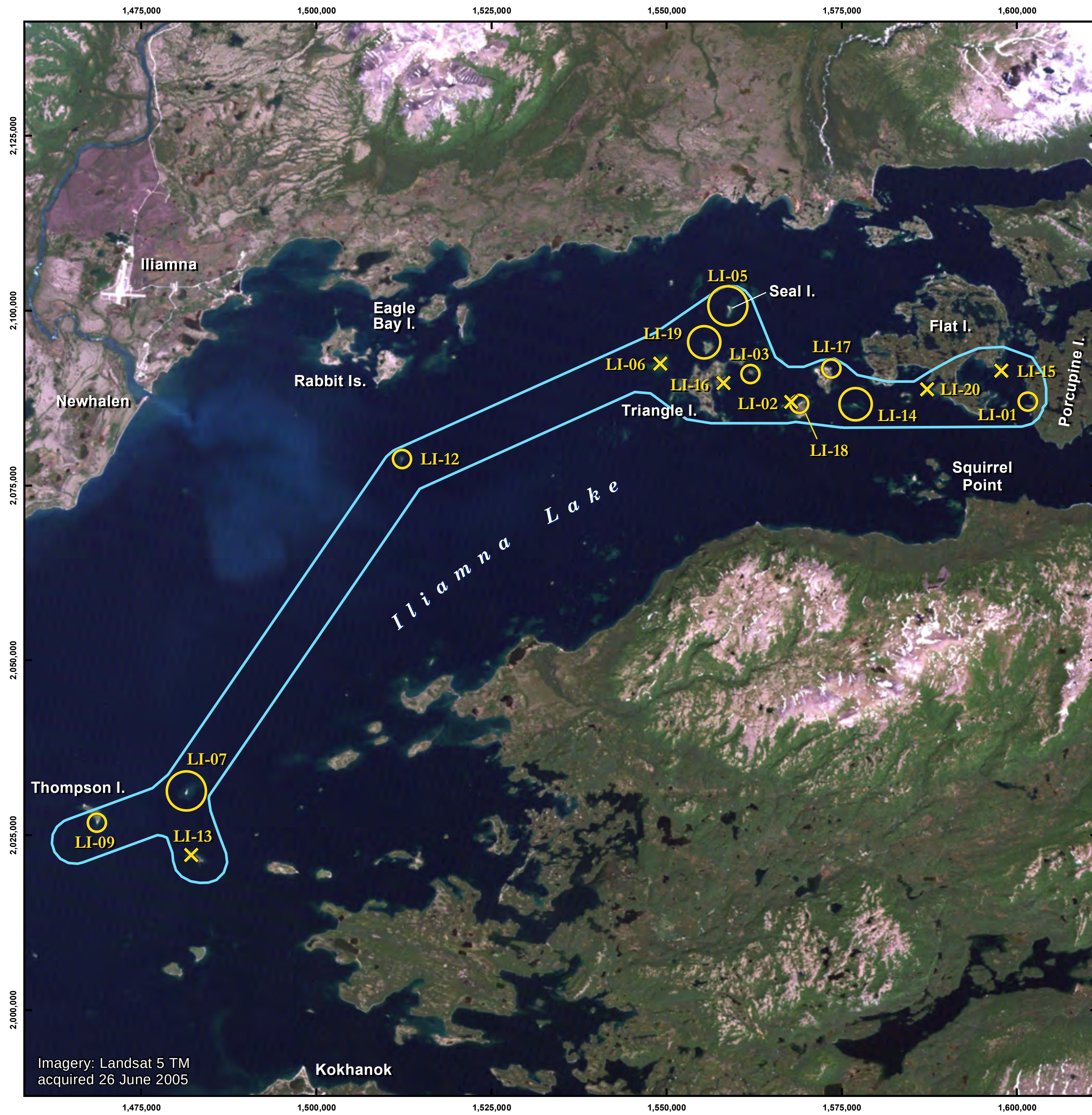
Version: 1	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.8-3
Harbor Seal Haulouts, Iliamna Lake, 2008

Legend

Mean Number of Seals

0

0.1 – 5.0

5.1 – 15.0

15.1 – 40.0

40.1 – 123.0

2008 Iliamna Lake Seal Survey Area

Miles 0 1 2 3 4 5

Kilometers 0 2 4 6 8

N

Scale 1:270,000

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

File: 16-8-3_SealsIliamnaL_2008_PLP_EBD_v01.mxd	Date: Sept. 1, 2010
Version: 1	Author: ABR-AZC

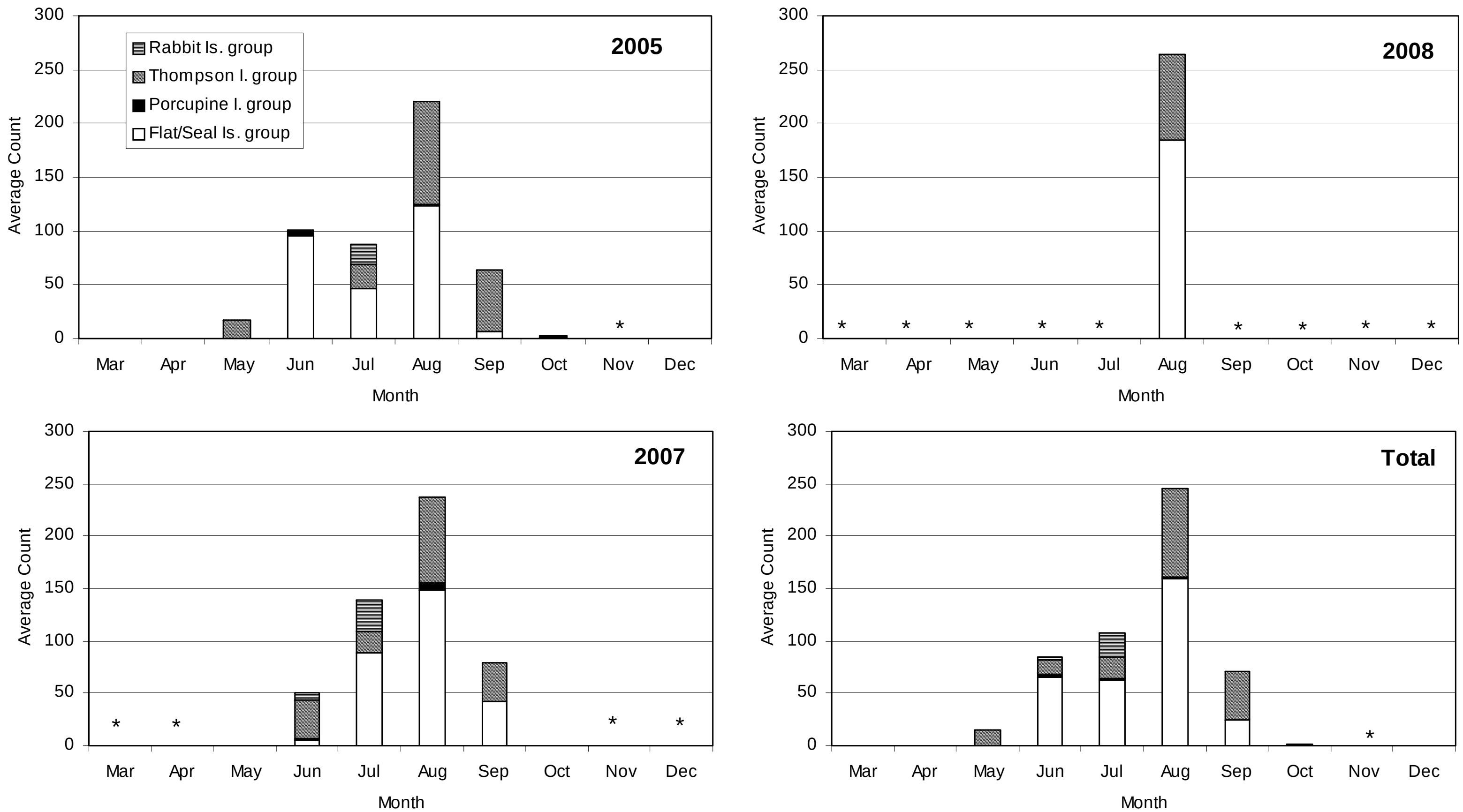
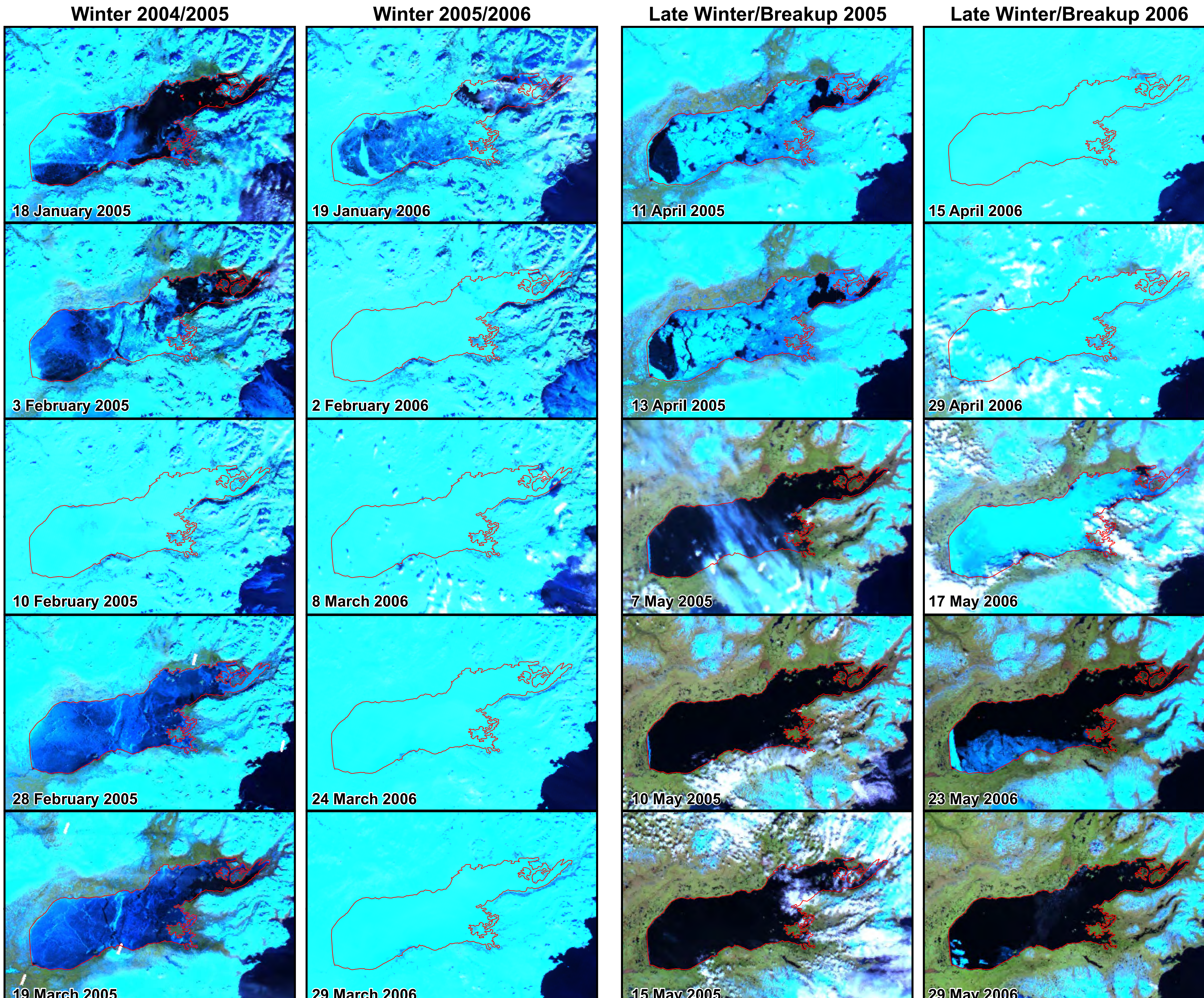


FIGURE 16.8-4.
Average (Mean) Count of Harbor Seals among General Island Groups by Month, Iliamna Lake, March-December 2005, May-October 2007, and August 2008.

Notes:

Asterisks indicate months when no surveys were flown.

See Appendices 16.8A through16.8C for source data.



THE pebble PARTNERSHIP

Figure 16.8-5 Satellite Imagery of Ice Cover on Iliamna Lake, Winter 2004/2005 and 2005/2006

Legend

- Iliamna Lake Outline
- Open Water
- Snow-covered Land or Snow-covered Lake Ice
- Snow-free Lake Ice
- Snow-Free Land (Vegetated)
- Clouds

Images are 500-m false color composites (Bands 6/2/1) produced from corrected reflectance swaths acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor onboard the NASA Terra platform. Data acquired from the Goddard Earth Sciences Data and Information Services Center.

Miles: 0 10 20 30 40 50 60
Kilometers: 0 10 20 30 40 50 60 70 80 90

N

Scale 1:1,900,000

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

File: 16-8-5_Ice_IliamnaLake_PebbleCEBD_v01.mxd	Date: Aug. 30, 2010
Version: 1	Author: ABR-AZC

APPENDICES

APPENDIX 16.8A

COUNTS OF HARBOR SEALS BY DATE AT 12 HAULOUT SITES
ILIAMNA LAKE
MARCH-DECEMBER 2005

APPENDIX 16.8A
Counts of Harbor Seals by Date at 12 Haulout Sites (by general island group), Iliamna Lake, March-December 2005

		Porcupine Island Group		Flat / Seal Islands Group							Thompson Island Group		Rabbit Islands Group	
Date	**In Water**	**LI-01**	**LI-15**	**LI-02**	**LI-03**	**LI-05**	**LI-06**	**LI-14**	**LI-16**	**LI-18**	**LI-07**	**LI-09**	**LI-12**	**TOTAL**
Mar. 30	0	0	0	0	0	0	0	0	0	0	0	0	ns	**0**
Apr. 25	1	0	0	0	0	0	0	0	0	0	0	0	ns	**1**
May 4	0	0	0	0	0	0	0	0	0	0	101	0	ns	**101**
May 10	1	0	0	0	0	0	0	0	0	0	1	0	3	**5**
May 11	0	0	0	1	0	0	0	0	0	0	0	0	ns	**1**
May 25	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
May 26	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
May 31	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
June 28	0	0	0	10	2	0	0	76	0	14	3	0	ns	**105**
June 29	2	0	7	4	0	0	0	61	18	6	0	0	ns	**98**
July 21	0	0	3	0	0	1	0	3	0	0	2	0	21	**30**
July 22	0	0	0	0	0	0	1	49	0	14	31	0	12	**107**
July 26	0	0	0	0	0	35	0	35	0	0	34	0	21	**125**
Aug. 11	0	0	3	38	0	30	0	0	48	0	68	7	0	**194**
Aug. 17	0	0	0	108	0	81	0	0	0	0	86	1	0	**276**
Aug. 21	0	0	0	39	0	51	0	0	0	0	121	0	0	**211**
Aug. 29	0	0	0	62	0	39	0	0	0	0	87	11	0	**199**
Sep. 8	0	0	0	0	0	7	0	0	0	0	57	0	0	**64**
Oct. 10	0	1	0	0	0	0	1	0	0	0	0	0	0	**2**
Dec. 13	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TOTAL	**4**	**1**	**13**	**262**	**2**	**244**	**2**	**224**	**66**	**34**	**591**	**19**	**57**	**1,519**

Notes:

Refer to Figure 16.8-1 and Table 16.8-1 for locations and descriptions of haulout sites.

ns = not surveyed.

APPENDIX 16.8B

COUNTS OF HARBOR SEALS BY DATE AT 15 HAULOUT SITES
ILIAMNA LAKE
MAY-OCTOBER 2007

APPENDIX 16.8B
Counts of Harbor Seals by Date at 15 Haulout Sites (by general island group), Iliamna Lake, May-October 2007

		Porcupine Island Group		Flat / Seal Islands Group										Thompson Island Group		Rabbit Islands Group	
Date	**In Water**	**LI-01**	**LI-15**	**LI-02**	**LI-03**	**LI-05**	**LI-06**	**LI-13**	**LI-14**	**LI-16**	**LI-17**	**LI-18**	**LI-20**	**LI-07**	**LI-09**	**LI-12**	**TOTAL**
May 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
June 20	0	0	2	0	0	2	0	0	0	0	0	0	3	36	0	8	**51**
July 16	0	0	0	9	0	0	0	0	152	0	0	0	0	35	0	42	**238**
July 27	0	0	0	0	1	0	0	0	15	0	1	0	0	3	2	18	**40**
Aug. 14	0	0	0	44	0	181	0	0	0	0	0	0	0	84	2	0	**311**
Aug. 15	0	0	1	20	0	190	0	0	0	0	0	0	0	97	5	0	**313**
Aug. 29	1	0	20	0	0	0	9	0	0	0	0	0	0	50	7	0	**87**
Sep. 12	0	0	0	0	0	42	0	0	0	0	0	0	0	37	0	0	**79**
Oct. 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TOTAL	**1**	**0**	**23**	**73**	**1**	**415**	**9**	**0**	**167**	**0**	**1**	**0**	**3**	**342**	**16**	**68**	**1,119**

Notes:

Refer to Figure 16.8-2 and Table 16.8-1 for locations and descriptions of haulout sites.

APPENDIX 16.8C

COUNTS OF HARBOR SEALS BY DATE AT 16 HAULOUT SITES
ILIAMNA LAKE
AUGUST 2008

APPENDIX 16.8C
Counts of Harbor Seals by Date at 16 Haulout Sites (by general island group), Iliamna Lake, August 2008

Date	In Water	Porcupine Island Group		Flat / Seal Islands Group											Thompson Island Group		Rabbit Islands Group	TOTAL
		LI-01	LI-15	LI-02	LI-03	LI-05	LI-06	LI-13	LI-14	LI-16	LI-17	LI-18	LI-19	LI-20	LI-07	LI-09	LI-12	
Aug. 2	0	0	0	0	9	34	0	0	121	0	0	0	0	0	63	2	1	**230**
Aug. 4	1	0	0	0	8	42	0	0	88	0	1	8	0	0	54	3	0	**205**
Aug. 16 am	0	0	0	0	0	170	0	0	0	0	0	15	0	0	68	11	0	**264**
Aug. 16 pm	0	0	0	0	0	154	0	0	0	0	0	0	24	0	82	4	0	**264**
Aug. 17 am	0	1	0	0	0	164	0	0	0	0	0	0	60	0	87	0	0	**312**
Aug. 17 pm	0	1	0	0	0	185	0	0	1	0	0	0	64	0	106	0	0	**357**
Aug. 18	0	0	0	0	5	109	0	0	0	0	0	0	28	0	78	0	1	**221**
TOTAL	**1**	**2**	**0**	**0**	**22**	**858**	**0**	**0**	**210**	**0**	**1**	**23**	**176**	**0**	**538**	**20**	**2**	**1,853**

Notes:

Refer to Figure 16.8-3 and Table 16.8-1 for locations and descriptions of haulout sites.

16.9 Raptors—Transportation Corridor

16.9.1 Introduction

Researchers conducted breeding surveys in 2004 and 2005 for all large tree- and cliff-nesting birds of prey (raptors) and winter surveys in 2005 and 2006 for Bald Eagles within the transportation-corridor study area in the Bristol Bay drainages. Several raptor species were included in these predevelopment studies because of their legal or conservation status, traditional use of nesting territories, and potential sensitivity to disturbance. Bald and Golden eagles were included because they are afforded special protection under the Bald and Golden Eagle Protection Act (16 USC, Section 668). The American Peregrine Falcon (*Falco peregrinus anatum)*, whose range probably includes the Lake Clark/Iliamna region (White, 1968), was delisted as an endangered species in 1999 (64 FR 46542). This subspecies was included in the Pebble Project studies with other cliff-nesting raptors (including Golden Eagle, the coastal subspecies of Peregrine Falcon [*F. p. pealei*], Gyrfalcon, and Rough-legged Hawk) because of continued agency interest in their populations (USFWS, 2002; Audubon, 2002). In addition, raptors are highly traditional in their use of nesting habitats and, because some of these raptors are sensitive to disturbance—particularly near their nests during the breeding season—knowledge of nest locations is very valuable for reducing potential disturbances. The Northern Goshawk is a tree-nesting raptor and the coastal race in southeast Alaska is a State of Alaska Species of Special Concern (ADFG, 1998; Audubon, 2002). Identifying goshawk nest sites is typically a component of baseline surveys throughout interior and coastal Alaska. Other tree-nesting species (including Osprey and Great Horned Owl) were also identified during surveys. Finally, nests of Common Ravens were recorded because of the birds' close association with raptors (i.e., ravens build many nests subsequently used by raptors) and humans (e.g., attraction to camps).

16.9.2 Study Objectives

The goal of raptor surveys in the transportation-corridor study area in the Bristol Bay drainages (study area) in 2004 and 2005 was to determine the distribution, abundance, and nesting status of raptors. All raptor species and raptor nests observed in the field were recorded. However, special emphasis was placed on locating nests or individuals of protected or sensitive species, such as Bald and Golden eagles, Peregrine Falcon, and the Northern Goshawk. No concerted efforts were made to determine the nesting status or abundance (or to locate nests) of small raptors, including Merlin and small woodland owls (e.g., Boreal Owl); extensive ground surveys would be required to census for these species. In addition, , surveys were conducted in the winters of 2005 and 2006 to gather information on wintering Bald Eagles. Raptor surveys in the study area in 2004 and 2005 had the following objectives:

- Locate, identify, and map primary cliff- and tree-nesting raptor nest sites.
- Delineate important cliff-nesting raptor habitats.
- Compile a comprehensive list of raptor species nesting in and using the area.

Two additional study objectives were added in 2005:

- Determine the rates of nesting success and productivity of nesting raptors.

- Determine winter use of the area by Bald Eagles (2005 and 2006).

16.9.3 Study Area

For the Bristol Bay drainages, the transportation-corridor study area for raptors included all suitable cliff habitats and woodland tracts that could provide nesting platforms for large cliff- and tree-nesting raptors in those portions of the transportation corridor located in drainages flowing into Bristol Bay (Figure 16.9-1). This study area lies primarily in the Alaska Peninsula ecoregion (Nowacki et. al., 2001). The eastern mountainous portion and hills west of the Newhalen River straddle the Alaska Range and Lime Hills ecoregions (Nowacki et. al., 2001). The corridor follows areas of low relief along the shoreline of Iliamna Lake, but ascends into steeper relief east of Knutson Creek. The western portion of the transportation corridor runs through an ecological transition between the Bristol Bay/Nushagak Lowlands (scattered trees and tundra) and Interior Forested Lowlands and Uplands (Gallant et al., 1995), where interior mixed spruce/hardwood forests transition into alpine and coastal tundra habitats at the southern extent of the Alaska Range at the eastern end of Iliamna Lake.

Suitable habitats for cliff-nesting raptors in the study area include extensive high (more than 100 meters of vertical relief) cliff faces in the mountains, primarily east from Knutson Mountain to the edge of the study area. Larger, isolated cliffs (more than 50 meters) occur on some lakes between the Pile and Iliamna rivers, along the Iliamna River, and on Canyon Creek. Additionally, scattered smaller cliffs (less than 30 meters) occur along the northeastern and southeastern shoreline and on islands at the eastern end of Iliamna Lake, and along the lower Newhalen River. Suitable forest groves for tree-nesting species increase substantially as one proceeds east along the transportation corridor, but these are found primarily along riparian and lacustrine shorelines and alluvial deltas. Primary nest trees in the study area are cottonwood and white spruce.

16.9.4 Previous Studies

Information on raptors, specifically their nesting status and nest sites, is limited for the study area. Exceptions include some nest locations identified in regional avifaunal investigations (e.g., Williamson and Peyton, 1962) and a cliff-nesting raptor survey in areas adjacent to Iliamna Lake (Haugh and Potter, 1975). Finally, a few raptor nest sites were identified from an inventory of raptor nest records summarized from U.S. Geological Survey (USGS) 1:250,000-scale quadrangle maps (unpublished map files housed at ABR Inc., Fairbanks, AK). Most records from the Iliamna Quadrangle were provided by a fisheries research biologist with numerous years of field experience in the region (Russell, pers. comm., 2004).

General information on the relative abundance and distribution of all raptor species was summarized from a search of published literature and unpublished agency reports for the greater Lake Clark/Iliamna region. Primary accounts from this region include biological reconnaissance at the turn of the century (Osgood, 1904) and more recent natural resource inventories on national interest lands (e.g., Cahalane, 1959; Racine and Young, 1978; Bennett, 1996). A major source of reports and references was *An Annotated Bibliography of Alaskan Raptor Literature* (Ritchie et al., 1982).

16.9.5 Scope of Work

The research and field work for this study were conducted during the summers of 2004 and 2005 and the winters of 2005 and 2006. The study was conducted by Robert J. Ritchie and John E. Shook, of ABR, Inc., Fairbanks, Alaska, according to the approach described in Chapter 9 of the *Draft Environmental Baseline Studies, Proposed 2004 Study Plan* (NDM, 2004) and the *Draft Environmental Baseline Studies, 2005 Study Plans* (NDM, 2005). Minor modifications in study protocols are described in the methods section. Specific project activities were as follows:

- Compile a list of possible raptors and synthesize literature to help determine their probable breeding status in the region (2004-2005).
- Conduct aerial surveys to locate cliff- and tree-nesting raptors in the study area (2004-2005).
- Identify habitats for nesting raptors in the study area (2004-2005).
- Conduct aerial surveys to locate wintering Bald Eagles in the study area (2005, 2006).
- Revisit known nest sites during the nestling period to assess nesting success and productivity (2005).

16.9.6 Methods

16.9.6.1 Occupancy Surveys

Field personnel conducted two aerial surveys by helicopter in the study area each year in 2004 and 2005 to identify potential habitats and to locate and document the status (occupancy) of raptor nests (Table 16.9-1). These surveys followed the same methodology as was used for the mine study area as described in Section 16.3.6.1 of this chapter.

16.9.6.2 Productivity Surveys

In 2005, a second set of aerial surveys was conducted during the nestling period to determine the success and productivity of nests found during the first surveys in the study area (Table 16.9-1). One survey that served primarily to determine the success of early-nesting species (e.g., Gyrfalcon, Golden Eagle) was conducted in late June/early July. A second survey was conducted in mid-July for later nesting species (e.g., Rough-legged Hawks) or species with a long nestling period (e.g., Bald Eagle). A third survey was conducted in early August to more clearly determine nesting success and productivity at some late-hatching sites (e.g., Bald Eagle), where brooding adults did not allow a good view of the nest contents in early July. These surveys followed the same methodology as was used for the mine study area as described in Section 16.3.6.2 of this chapter.

16.9.6.3 Wintering Bald Eagle Surveys

Biologists conducted four aerial surveys—two in 2005 (February and November) and two in 2006 (November and December)—to determine if Bald Eagles used the study area in winter and whether or not suitable open-water habitats (e.g., substantial areas of slow-moving water) were available for feeding by eagles (Table 16.9-1). These surveys followed the same methodology as was used for the mine study area as described in Section 16.3.6.3 of this chapter.

16.9.7 Results and Discussion

At least 19 species of raptors (12 diurnal raptors and 7 owl species) may occur in the greater Iliamna Lake/Lake Clark Region, including the study area (Appendix 16.9A). (This list was developed from the literature and unpublished reports, our aerial surveys, and incidental observations from other wildlife surveys (e.g., land bird and waterbird studies.) Twelve raptor species and Common Ravens were recorded in the study area during aerial surveys (Table 16.9-2). Of these, eight raptor species and Common Ravens were confirmed as nesting, but only Bald and Golden eagle nests were common (Table 16.9-3). Nesting success and productivity data could be determined for five raptor species (Table 16.9-4). Behavior, habitat suitability, and historical records also suggest moderate to high probability of nesting for Northern Harrier, Northern Goshawk, Merlin, and Short-eared Owls in the study area although no nests were observed.

16.9.7.1 Nest Distribution, Abundance, and Occupancy

Researchers identified at least 125 raptor nests in the study area during the 2004-2005 study; 71 raptor nests were found in the study area during 2004 and 115 were found in 2005 (Table 16.9-3). As indicated by the totals, some nests found in 2004 were also used in 2005, but the greater number of nests found in 2005 was because a larger area was searched in that year (Figure 16.9-1). The greatest densities of tree-nesting raptor sites were located along the Newhalen River and sections of the shoreline of Iliamna Lake (Figure 16.9-2).The greatest densities of cliff-nesting raptor sites were found on Canyon Creek and along the southern edge of the Alaska Range north of Iliamna Lake (Figure 16.9-3). (Readers should note that some nests located in the mine study area to the west [Section 16.3] and the Cook Inlet Drainage study area to the east [Section 41.3] may appear on figures in this section on the transportation-corridor, Bristol Bay drainages study area.)

Rough-legged Hawk

Researchers located two nests of Rough-legged Hawks in the transportation-corridor, Bristol Bay drainages study area. (Table 16.9-3, Figure 16.9-3). Distribution of Rough-legged Hawks in the study area suggests that they are most closely associated with tundra areas west of the Newhalen River. No Rough-legged Hawk nests were found east of the Newhalen River during these surveys or other avifaunal investigations (Williamson and Peyton, 1962; Haugh and Potter, 1975). The Rough-legged Hawk is a pan-boreal species typically associated with tundra areas during the breeding season (Bechard and Swem, 2002). Rough-legged Hawks nest throughout southwestern Alaska, including on the Alaska Peninsula and the Aleutian Islands (Osgood, 1904; Cahalane, 1959; Gill et al., 1981; Bechard and Swem, 2002). Rough-legged Hawks regularly nest on cliffs and more rarely in trees in Alaska (Bechard and Swem, 2002), but occasionally nest on the ground or on human-built structures (Ritchie, 1991). Rough-legged Hawks have been described as uncommon breeders near Iliamna (Williamson and Peyton, 1962). Their nests have been reported at Lake Clark (Osgood, 1904) and Upper Talarik Creek (Russell, pers. comm., 2004).

Red-tailed Hawk

Researchers found a single nest of the Red-tailed Hawk in the study area (Figure 16.9-2). (The location of this nest was first reported by ground parties doing bird point-counts.) The nest was located in a 10-meter-high spruce tree within 50 meters of a large lake west of the Newhalen River. The birds were individuals of the *harlani* subspecies (Preston and Beane, 1993), lacking the distinct red tail of the western race of

Red-tailed Hawk. Harlan's hawks are the predominant Red-tailed Hawk recorded in interior Alaska. Another individual Red-tailed Hawk was observed during caribou surveys in 2004 (Lawhead, pers. comm., 2004)

Red-tailed Hawks do not appear in regional reports and publications for the Lake Clark/Iliamna region (Cahalane, 1959; Williamson and Peyton, 1962; Racine and Young, 1978) and, from all accounts, appear to be extra-limital—nesting beyond their southwestern range limits in Alaska—in the study area (Preston and Beane, 1993). Red-tailed Hawks have been described as an uncommon breeding bird in the Lake Clark area (Appendix 16.9A).

Golden Eagle

Researchers located 24 Golden Eagle nests at 14 distinct cliff or river-bluff formations in the study area (Figure 16.9-3). Nearly half of these locations (46 percent) had multiple (or supernumerary) nest sites at a cliff, and some of the more widely spaced nests may also represent supernumerary nests within territories (supernumerary nests can be separated by a few kilometers [Kochert et al., 2002]). Therefore, occupancy rates of 5 percent in 2005 and 14 percent in 2004 (Table 16.9-3) are probably not an accurate reflection of territory occupancy, only nest-site occupancy. Probably fewer than 10 territories are represented by the 24 eagle nests.

Golden Eagles nest throughout Alaska, including the Lake Clark/Iliamna region in southwestern Alaska. Golden Eagles have been reported as fairly common in Lake Clark National Park and likely breed there (Racine and Young, 1978). They also have been found breeding in mountains around Iliamna Lake (Haugh and Potter, 1975; this study, Sections 16.3 and 41.3). Golden Eagles are probably less common along the Alaska Peninsula and were absent from species accounts for some areas to the south (Cahalane, 1959; Osgood, 1904). Golden Eagles show a strong fidelity to their breeding territory (Kochert et al., 2002).

Bald Eagle

The Bald Eagle was the most common nesting raptor in the study area, with a total of 54 different nests recorded in 2004 and 2005 (Figure 16.9-2). Although widely distributed, most Bald Eagle nests (74 percent) were on the Newhalen and Iliamna rivers and along the shoreline of Iliamna Lake. Nest-site occupancy ranged from 26 percent in 2004 to 48 percent in 2005 (Table 16.9-3). (The lower occupancy rate in 2004 may have been an artifact of survey timing, because only some areas were surveyed in late April prior to maximum nest initiation by Bald Eagles.) Nest-site occupancy was 38 percent in 1994 and 47 percent in 1996 for Bald Eagle nests on the Cook Inlet coastline of Lake Clark National Park (Bennett, 1996). Rates described during the Pebble Project study were lower than the mean long-term rates of territory occupancy by Bald Eagles recorded on the Kodiak National Wildlife Refuge (60 percent; Zwiefelhofer, 1997) and for seven continental North America populations (mean = 71 percent, range 53.7 to 91.0 percent; Stalmaster, 1987).

Although some older accounts of Bald Eagles in the region (e.g., Osgood, 1904) described them as occurring sparingly over the area, the Bald Eagle has more often been described as common and often breeding in the Iliamna and Lake Clark region (Gabrielson and Lincoln, 1959; Haugh and Potter, 1975; Racine and Young, 1978; Bennett, 1996). Bald Eagle populations have increased in interior regions of Alaska in the past decades following over a half century of persecution (Ritchie and Ambrose, 1996).

Increasing numbers of nesting pairs on Kodiak Island suggest the possibility of population increases in southwestern Alaska as well (Zwiefelhofer, 2005, pers. comm.).

Osprey

Researchers identified six Osprey nests at five locations during aerial surveys in the study area in 2004 and 2005 (Table 16.9-3; Figure 16.9-2). Eighty-three percent of nests were located in spruce trees. One nest was constructed on a navigation tower near the Iliamna Airport. Typically, Ospreys build stick nests on top of dead snags or live trees with broken tops; however, they often will use man-made structures (Poole et al., 2002). Osprey nests are usually close to fish-bearing lakes and streams, their key foraging habitats. However, two nests in the study area appeared to be located 10 kilometers from major fish-bearing habitats (Figure 16.9-2).

Within Alaska, Ospreys nest along rivers and coastlines south of the Brooks Range, including southwestern Alaska (Poole et al., 2002). In southwestern Alaska, Ospreys are locally common to uncommon along rivers and coastal areas of the Alaska Peninsula east of the Chignik River. Ospreys are considered common nesting birds in the rivers draining into Bristol Bay (Gabrielson and Lincoln, 1959). A small number of Ospreys have been reported at Lake Clark National Park (Racine and Young, 1978) and near Iliamna Lake (Osgood, 1904; Williamson and Peyton, 1962). Osprey nests have been reported in the study area on Chekok and Roadhouse creeks near the north shore of Iliamna Lake (Russell, pers. comm., 2004). Ospreys occasionally nest close to other nesting Ospreys, suggesting limited territoriality (Poole et al., 2002).

Gyrfalcon

Researchers found two Gyrfalcon sites in the study area in 2004 and 2005 (Table 16.9-3). Both sites were in hills east of the mine study area (Figure 16.9-3). No Gyrfalcons or traditional nest sites were found farther east in the mountains north of Iliamna Lake. The Gyrfalcon could be described as an uncommon summer visitor with scattered resident breeders in the study area. Although much of southwest Alaska has not been surveyed, numerous nest sites have been recorded between the Alaska Peninsula and the Aleutian Islands (Swem et al., 1994). Gyrfalcons were not recorded during avifaunal investigations in Lake Clark National Park (Racine and Young, 1978; Ruthrauff et al., 2005) and are listed as a rare breeder there (NPS, 2000). Although Gyrfalcons were not reported in some ornithological accounts for the area near Iliamna Lake (Williamson and Peyton, 1962), in other studies two nests were identified in the Iliamna Lake area including one site near Stonehouse Lake in the Pebble study area (Haugh and Potter, 1975; Russell, 2004, pers. comm.).

Peregrine Falcon

Researchers located Peregrine Falcons nesting at four nest sites in three cliff areas in the study area in 2004 and 2005 (Table 16.9-3, Figure 16.9-3). Two cliffs (Newhalen River and Canyon Creek) were very typical of riverine habitats used by the *anatum* subspecies of Peregrine Falcon and were occupied in both 2004 and 2005. The third site, however, was found in 2005 on a large cliff on an island in Iliamna Lake. Records of nest sites of Peregrine Falcons on lakes are limited in Alaska (Ritchie et al., 2004), but do include one probable nest on Grosvenor Lake in Katmai National Monument (Cahalane, 1959).

Observations from the helicopter, as well as photographs of at least one of the adults at Canyon Creek in 2005, also support the classification of these Peregrine Falcons as individuals of the *anatum* subspecies. Unfortunately, the study area falls within a transition zone among the three subspecies of Peregrine Falcons (White, 1968; White et al., 2002), so use by any specific subspecies cannot be definitively determined. Subspecies determination would require closer scrutiny. Interestingly, photographs of an adult at Canyon Creek did reveal an aluminum band on one of the bird's legs. Both *anatum* and *tundrius* are regularly banded on migration and on their breeding range.

In general, records of Peregrine Falcons are limited for the Iliamna/Lake Clark region (Osgood, 1904; Cahalane, 1959; Williamson and Peyton, 1962; Racine and Young, 1978). No Peregrine Falcons were recorded during surveys for this species in the 1970s (Haugh and Potter, 1975); however, these surveys occurred during the period of widespread decline of Peregrine Falcon populations in North America due to pesticide contamination (White et al., 2002). Since the late 1970s and early 1980s, *anatum* populations in Alaska have rebounded substantially (Ambrose et al., 1988), and many areas without a clear history of use have been found to be occupied.

The discovery of Peregrine Falcon nests in the study area may be an indication of this phenomenon of an increasing population and suggests greater possibilities for Peregrine Falcon occupancy of suitable habitat in the region. Although Peregrine Falcons are probably more common north of the study area (e.g., tributaries of the Kuskokwim River), good cliff habitat for this species occurs along the Newhalen River, Canyon Creek, the Iliamna River, the eastern portion of Iliamna Lake, and small lakes between Pedro Bay and the Iliamna River.

Great Horned Owl

Researchers found Great Horned Owls nesting at three locations in the study area in 2005; two nests were in stick nests in cottonwood trees and one nest was in a cavity on a cliff face (Figure 16.9-2). Suitable nesting habitat for this species occurs throughout woodland areas in the study area. Great Horned Owls most commonly use stick nests made by other birds (i.e., Bald Eagles, hawks, ravens), but will nest in cavities, including in cliffs (Houston et al., 1998).

Within the greater Iliamna Lake/Lake Clark region, Great Horned Owls are probably uncommon, but regular, breeding and resident raptors. Williamson and Peyton (1962) thought that they were well distributed in woodlands near Iliamna Lake. Racine and Clark (1978) considered them probable regular breeders in Lake Clark National Park. Great Horned Owls have been recorded nesting in the Iliamna Lake region (Haugh and Potter, 1975).

Northern Goshawk

Researchers observed only one Northern Goshawk in the study area in 2005. It was observed flying near a nest (in poor condition) where the species that constructed the nest could not be determined. The Iliamna Lake area is included in the range of the Northern Goshawk in southwestern Alaska (Squires and Reynolds, 1997), and nests have been reported near the village of Iliamna (Russell, pers. comm., 2004) and near Bristol Bay (Petersen et al., 1991). Williamson and Peyton (1962), however, regarded this "hawk as rare in the Iliamna area" and thought that they probably occurred in small numbers. They have been described as an uncommon breeder in the Lake Clark National Park (NPS, 2000) and are probably more abundant in woodland regions north of the study area. Generally resident, irruptive migratory movements (i.e., not seasonally or geographically predictable) of Northern Goshawks often coincide with population lows of their primary prey species (snowshoe hare and grouse; Squires and Reynolds, 1997). Observations of a few goshawks at Katmai National Monument in late August through September 1954 were described in this context (Cahalane, 1959).

Other Raptors and Common Raven

Researchers regularly observed Merlins at cliffs in the study area during aerial surveys in 2004 and 2005; however, no nests were verified. Pairs or single birds were recorded on the Newhalen, Pile, and Iliamna rivers and Canyon Creek, and the behaviors of these birds and available habitats (e.g., alder-covered slopes) often suggested ground nesting. The distributional range of Merlins includes the Iliamna Lake area (Sodhi et al., 1993), and they have been reported as nesting in the area (Williamson and Peyton, 1962; this study, Section 16.3). Besides using stick nests, Merlins have been found nesting on cliffs and on the ground (Sodhi et al., 1993).

Common Ravens were observed regularly and their nests were found at 16 locations in the study area in 2004 and 2005 (Figure 16.9-3). Occupancy ranged from 40 percent (2005) to 57 percent (2004) in the study area (Table 16.9-3). Most nests were located on cliff faces, but Common Ravens regularly use both cliff and tree substrates, as well as man-made structures, for nesting platforms (Boarman and Heinrich, 1999). Ravens have been described as uncommon (Williamson and Peyton, 1962) to common in the region (Kakhtul [Koktuli]: Osgood, 1904; NPS, 2000). The locations of raven nests are important because ravens often associate with humans and identifying nests before development may be useful in assessing increases in their population. They also “improve” habitats for some cliff-nesting species that do not build their own nests (e.g., Gyrfalcon, Peregrine Falcon; Cade, 1960).

16.9.7.2 Nesting Success and Productivity

Researchers located 18 successful nests representing five diurnal raptor species in the study area in 2005 (Table 16.9-4). Accurate counts of young were made at all of these nests. Additionally, some Great Horned Owl and Common Raven nests were successful, but productivity was not calculated for these species because researchers may have overlooked fledged young at nest sites (i.e., surveys were too late to count nestlings), thus underestimating production.

Red-tailed Hawk

The single nest of a Red-tailed Hawk in the study area was successful and produced three young (3.0 young per nest). The mean number of young per pair ranged from 0.9 to 1.8 young per nesting pair for a number of studies in the lower 48 states (Preston and Beane, 1993).

Golden Eagle

All three occupied Golden Eagle nests (100 percent) in the study area (Figure 16.9-4) were determined to be successful in 2005 (Table 16.9-4). Six young were produced at these nests, resulting in productivity rates of 2.0 young per successful nest and 2.0 young per occupied nest (Table 16.9-4). This small sample size does not allow meaningful comparisons, but the mean number of young per successful nest in other studies has ranged from 1.1 to 1.5 in interior and northern Alaska (Ritchie and Curatolo, 1982; Young et al., 1995).

Bald Eagle

Eight of the 24 occupied Bald Eagle nests (33 percent) found in the study area (Figure 16.9-5) were successful in 2005 (Table 16.9-4). Nesting success was 62 percent for nests on the Alaska Peninsula in 1970 (n = 38; Hehnke and White, 1978) and ranged from 65 to 88 percent for Katmai National Monument in the 1970s (e.g., n = 20; Troyer, 1979). Nesting success was lower (53 percent) for Bald Eagles nesting along the Lake Clark National Park/Cook Inlet Coastline (Bennett, 1996). Nesting success was determined to be 54 percent for 518 occupied nests on Kodiak National Wildlife Refuge in 1997 (Zwiefelhofer, 1997).

Eight successful nests produced a total of 12 young eagles, or 1.5 young per successful nest and 0.5 per occupied nest (Table 16.9-4). Ages of nestlings ranged from two weeks to six weeks during surveys in mid-July, suggesting a fairly protracted range of laying dates for Bald Eagles in the region. Overall, production was similar to (based on young per successful nest) or lower than (based on young per occupied nest) other populations in adjacent areas: 1.6 young per successful nest and 1.0 per occupied nest along the southern Alaska Peninsula (Hehnke and White, 1978); 1.5 young per successful and 0.8 per occupied nest along the Lake Clark National Park coastline (Bennett, 1996). Productivity was higher in Katmai National Monument; young per successful nest ranged from 1.7 to 2.3 between 1974 and 1979 (e.g., Troyer, 1979). The average productivity of successful and occupied nests for a number of Bald Eagle populations in North America was 1.6 and 0.9 young, respectively, in 1970 through 1982 (Stalmaster, 1987).

Osprey

All five (100 percent) occupied Osprey nests in the study area (Figure 16.9-5) were determined to be successful (Table 16.9-4). Comparatively, nesting success for Ospreys in the upper Tanana River in interior Alaska has averaged 54.8 percent over a recent 17-year period (Timm and Johnson, 2003). Osprey nests in the study area produced 10 young or 2.0 young per successful and per occupied nest. Productivity in the upper Tanana River area has ranged from less than 0.5 young per occupied nest to 1.5 young per occupied nest (Timm and Johnson, 2003). In study areas in Sweden and New England, productivity has ranged from 1.8 to 2.2 young per successful nest (Poole, 1989).

Peregrine Falcon

Only one of the three (33 percent) occupied Peregrine Falcon nests (Figure 16.9-5) was successful in the study area in 2005 (Table 16.9-4). This nest produced two young (2.0 young per successful nest). Although this is a small sample, nesting success for Peregrine Falcon populations in interior Alaska generally exceeded 50 percent. For example, success ranged from 55 to 94 percent (1973-1985) on the Yukon River (Ambrose et al., 1988). Productivity (young per successful nest) for Peregrine Falcons ranged from 1.9 to 3.2 young per successful nest on the Yukon River during the same period (Ambrose et al., 1988).

Other Raptors and Common Ravens

Very little information on nesting success or productivity of other raptors (e.g., Great Horned Owl) and Common Ravens was acquired. At least one Great Horned Owl nest was successful, but survey timing was too late to determine the number of young at the nest site. Most young ravens had fledged and left the vicinity of the nests before productivity surveys were undertaken.

16.9.7.3 Wintering Bald Eagles

Bald Eagles were recorded on aerial surveys designed to count wintering eagles in the study area in February and November 2005 and November and December 2006. A single, adult Bald Eagle was recorded near Knutson Bay in February 2005. In addition, waterfowl (mergansers and goldeneyes), potential prey of Bald Eagles, were recorded in the Newhalen River, and goldeneyes were recorded at one location in Pile Bay, Iliamna Lake, in February. Researchers counted 120 Bald Eagles in the study area on November 9 and 10, 2005, but only 33 Bald Eagles on November 13, 2006. In 2005, 63 percent of these eagles were in adult plumage; the remaining birds were subadults, including juvenile plumaged birds (less than 1 year old). In November 2006, 86 percent of Bald Eagles observed were adult plumaged birds. Most Bald Eagles (80 percent in 2005, 67 percent in 2006) were associated with open water along the Iliamna River, particularly in an approximately 10-kilometer-long reach above the bridge. The remaining eagles were recorded along the Newhalen River, the north shore of Iliamna Lake, and the Knutson River in 2005 and 2006. By early December 2006, Bald Eagles had generally left the study area: only 3 adults were observed along the Iliamna River on December 7.

Wintering Bald Eagles may occur uncommonly in the study area, particularly by mid-winter (mid-December through February). Substantial concentrations of Bald Eagles have been reported during fall near the mouth of Chekok Bay (Russell, 2004, pers. comm.), and observations in the Pebble study in early November may be considered a late-fall phenomenon, particularly because only a single Bald Eagle was recorded in late winter (February). Bald Eagles are probably more common along the coast throughout the winter and have been recorded along the Lake Clark National Park coastline during winter months (Bennett, 1996).

16.9.7.4 Habitat Suitability for Breeding Raptors

Woodland Habitats

Habitats for tree-nesting raptors are abundant in the study area, particularly east of the Newhalen River and below 400-meter elevations. Larger spruce and cottonwood trees, most suitable for the large nesting raptors such as Bald Eagles, are found along floodplains and associated river courses entering Iliamna Lake.

Cliff Habitats

Suitable and high-value habitats for cliff-nesting species are available along the southern front of the Alaska Range from the Newhalen River to the upper Iliamna River. Additional, scattered rock outcrops and cliffs occur along the shorelines of Iliamna Lake, islands in the eastern portion of the lake, and near small lakes between Pedro Bay and Pile Bay. Excellent habitats—based on nest records, physical attributes of the cliffs such as availability of suitable ledges, and raptor sign (whitewash, perches)—include the following:

- Hills between Upper Talarik Creek and Newhalen River.
- Canyon Creek above the point where it leaves the mountains.

- Southern exposures along Roadhouse and Knutson mountains.
- Cliffs along the Iliamna River and upper Chinkelyes Creek.

16.9.7.5 Survey Efficacy

Suitable cliff and woodland areas were thoroughly searched in both years in the study area. In particular, the inventory of cliff-nesting sites for Golden Eagle, Gyrfalcon, Peregrine Falcon, and Rough-legged Hawk was very thorough for discrete cliff faces and riparian areas in the study area. Areas used traditionally by these species (e.g., heavily white-washed ledges, stick nests) generally were obvious in these habitats.

Researchers were most effective at locating nests of tree-nesting species during surveys of woodlands along shorelines of lakes and rivers, where the primary tree-nesting species of interest in this study usually select nest sites. Exceptions might include woodland raptors, such as the Northern Goshawk or Great Horned Owl, which often locate their nests in more dense and complex woodlands. In 2004, surveys were conducted before any leaf-out of trees (late April) to increase the chance of recording early nesters, especially woodland raptors such as Northern Goshawks. This early survey probably underestimated occupancy of nests by other tree-nesting species, such as the Bald Eagle and Osprey, in 2004. This possible cause for underestimation of nest occupancy for other species, however, was “corrected” in 2005, when spring surveys were conducted at dates coinciding more with nesting chronologies for Bald Eagles and other large raptor species (mid-May).

Researchers observed only one Northern Goshawk—flying near a potential, but dilapidated, nest—during surveys in the study area, which is at the southern extent of the goshawk breeding range in southwestern Alaska (Squires and Reynolds, 1997). Woodland habitat in the study area, from a habitat-structure perspective, appears to be suitable for breeding goshawks. Unfortunately, little information on the density of Northern Goshawks or other woodland species in this region is available to improve an assessment.

16.9.8 Summary

Aerial surveys were conducted to gather information on the abundance, distribution, and breeding status of large cliff- and tree-nesting raptors in the study area in 2004, as well as to provide information on nesting success and productivity in 2005. Several raptor species were included in these surveys because of their legal or conservation status, sensitivity to disturbance, and traditional use of nesting territories. Large raptors, such as Bald and Golden eagles, Peregrine Falcon, Gyrfalcon, Osprey, and Northern Goshawk, were the primary focus of the raptor surveys.

At least 125 nests, representing eight species of raptors and Common Ravens, were identified in 2004 and 2005 in a broad study area associated with the transportation corridor for the Pebble Project. Bald and Golden eagle nests were most abundant, representing 43 and 19 percent, respectively, of nests found in 2005. Nests of Common Raven (15 percent in 2005) and Osprey (5 percent in 2005) were the next most abundant nests found. The remaining species had three or fewer nests located in the study area: Peregrine Falcon (3), Gyrfalcon (2), Rough-legged Hawks (2), Great Horned Owls (3), and Red-tailed Hawk (1). Unidentified nests (10 percent of the total in 2005) may have included additional nests of the species listed above, as well as nest substrates for some species that researchers expected to record but did not (e.g., Northern Goshawk). Generally, the conditions of the nests disallowed more specific identifications.

Nest sites were widely distributed throughout the study area, but areas of concentration were evident. Bald Eagles were most abundant along the Newhalen River and along reaches of streams close to the Iliamna Lake shoreline. Bald Eagle nests were less common along smaller lake shorelines. All Golden Eagle nests, often in clusters, were found on cliffs on southern exposures of the Alaska Range. Peregrine Falcon nests had not previously been recorded in the Lake Clark/Iliamna region, but researchers were not surprised to locate three active nests. The delisted *anatum* subspecies, which may be the race found in the study area, is recovering and increasing throughout its range. Additional suitable habitats appear to exist throughout the study area. Other species (Gyrfalcon, Rough-legged Hawk, Osprey, and Common Raven) have been recorded previously as breeding in the study area.

Nesting success and productivity were determined for five raptor species in the study area in 2005. Ospreys and Golden Eagles, although represented by only a few nests, had high nesting success and productivity compared to other populations in Alaska and North America. Bald Eagles, on the other hand, had lower nesting success (33 percent) than comparative populations in southern Alaska and North America. Productivity (young per successful nest), however, was similar to values for these other populations. A single Red-tailed Hawk nest, probably at the southwestern extent of it breeding range, was successful. Finally, only one of three occupied Peregrine Falcon nests produced young, which is lower than success rates for Peregrine Falcons nesting elsewhere in Alaska.

Bald Eagles were recorded in the study area in February and November 2005 and November and December 2006. Numbers ranged from a single adult Bald Eagle in February 2005 (Knutson Bay) to 120 eagles 9-10 November 2006 (Iliamna River and Newhalen Rivers and along Iliamna Lake shoreline). Numbers of eagles declined between November and early December in 2006 suggesting an exodus of most eagles by mid-winter.

Habitats for tree-nesting raptors are abundant in the study area, particularly east of the Newhalen River and below 400-meter elevations. The best habitats for large tree-nesting species, like Bald Eagles, occur in cottonwood stands most closely associated with the floodplains of major rivers like the Newhalen and Iliamna rivers. Suitable and high-value habitats for cliff-nesting species are found along the southern front of the Alaska Range. Good to excellent habitats occur in the hills between Upper Talarik Creek and the Newhalen River, along Canyon Creek and Knutson Mountain, and along the upper Iliamna River (including a few cliffs on Chinkelyes Creek). A few cliffs along the shoreline of Iliamna Lake are suitable, including those on islands in the eastern extent of the lake and those on some lakes between the Pile and Iliamna rivers.

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TABLES

TABLE 16.9-1
Dates of Aerial Surveys for Raptors in the Transportation-corridor Study Area, Bristol Bay Drainages, 2004-2006

Survey Type	Species of Interest	2004	2005	2006
Occupancy Survey	Tree-nesting species	April 22	May 6-7	
Occupancy Survey	Cliff-nesting species	May 24-26	May 21-25	
Productivity Survey	Early nesting species	—	July 1	
Productivity Surveys	Later nesting species	—	Mid-July, Mid-August	
Late Winter Survey	Bald Eagle	—	February 22	
Early Winter Survey	Bald Eagle	—	November 10	November 13
				December 7-8

TABLE 16.9-2
Status of Raptor Species and Common Ravens Observed during Aerial Surveys in the Transportation-corridor Study Area, Bristol Bay Drainages, April-May 2004 and May-August 2005

Common Name	Scientific Name	Status	References[a]
Northern Harrier	*Circus cyaneus*	Probably Breeding	1, 2, 3, 5
Northern Goshawk	*Accipiter gentilis*	Probably Breeding	This study, 4
Rough-legged Hawk	*Buteo lagopus*	Breeding	This study, 4
Red-tailed Hawk	*Buteo jamaicensis*	Breeding	This study
Golden Eagle	*Aquila chrysaetos*	Breeding	This study
Bald Eagle	*Haliaeetus leucocephalus*	Breeding	This study, 4
Osprey	*Pandion haliaetus*	Breeding	This study, 4
Merlin	*Falco columbarius*	Probably Breeding	This study, 5
Gyrfalcon	*Falco rusticolus*	Breeding	This study, 4
Peregrine Falcon	*Falco peregrinus*	Breeding	This study
Short-eared Owl	*Asio flammeus*	Probably Breeding	This study
Great Horned Owl	*Bubo virginianus*	Breeding	This study, 3
Common Raven	*Corvus corax*	Breeding	This study, 3

References:

a. 1) Cahalane, 1959; 2) Williamson and Peyton, 1962; 3) Racine and Young, 1978; 4) Russell, pers. comm.; 5) University of Alaska Museum, 2003.

TABLE 16.9-3
Numbers and Status of Raptor and Common Raven Nests in the Transportation-corridor Study Area, Bristol Bay Drainages, 2004 and 2005

	2004			2005		
Species	**Unoccupied**	**Occupied (%)**	**Total**	**Unoccupied**	**Occupied (%)**	**Total**
Rough-legged Hawk	1	0 (0)	1	1	1 (50)	2
Red-tailed Hawk	0	0	0	0	1 (100)	1
Golden Eagle	19	1 (5)	20	19	3 (14)	22
Bald Eagle	23	8 (26)	31	26	24 (48)	50
Osprey	0	2 (100)	2	1	5 (83)	6
Gyrfalcon	1	1 (50)	2	2	0 (0)	2
Peregrine Falcon	0	2 (100)	2	0	3 (100)	3
Great Horned Owl	0	0 (0)	0	0	3 (100)	3
Common Raven	3	4 (57)	7	9	6 (40)	15
Unidentified raptor [a]	6	0 (0)	6	11	0 (0)	11
TOTAL NESTS	**53**	**18 (25)**	**71**	**69**	**46 (40)**	**115**

Notes:

a. “Unidentified raptor” includes remnant stick nests on cliffs and some smaller stick nests in trees used by woodland species such as Northern Goshawks and Great Horned Owls.

TABLE 16.9-4
Nesting Success and Productivity of Raptor Nests in the Transportation-corridor Study Area, Bristol Bay Drainages, 2005[a]

Species	**No. Occupied Nests**	**No. Successful Nests**	**% Successful Nests**	**No. Young**	**Young/ Success. Nest**	**Young/ Occupied Nest**
Red-tailed Hawk	1	1	100	3	3.0	3.0
Golden Eagle	3	3	100	6	2.0	2.0
Bald Eagle	24	8	33	12	1.5	0.5
Osprey	5	5	100	10	2.0	2.0
Peregrine Falcon	3	1	33	2	2.0	0.7

a. One successful Great Horned Owl nest is not included in this table because an accurate count of young could not be determined.

FIGURES

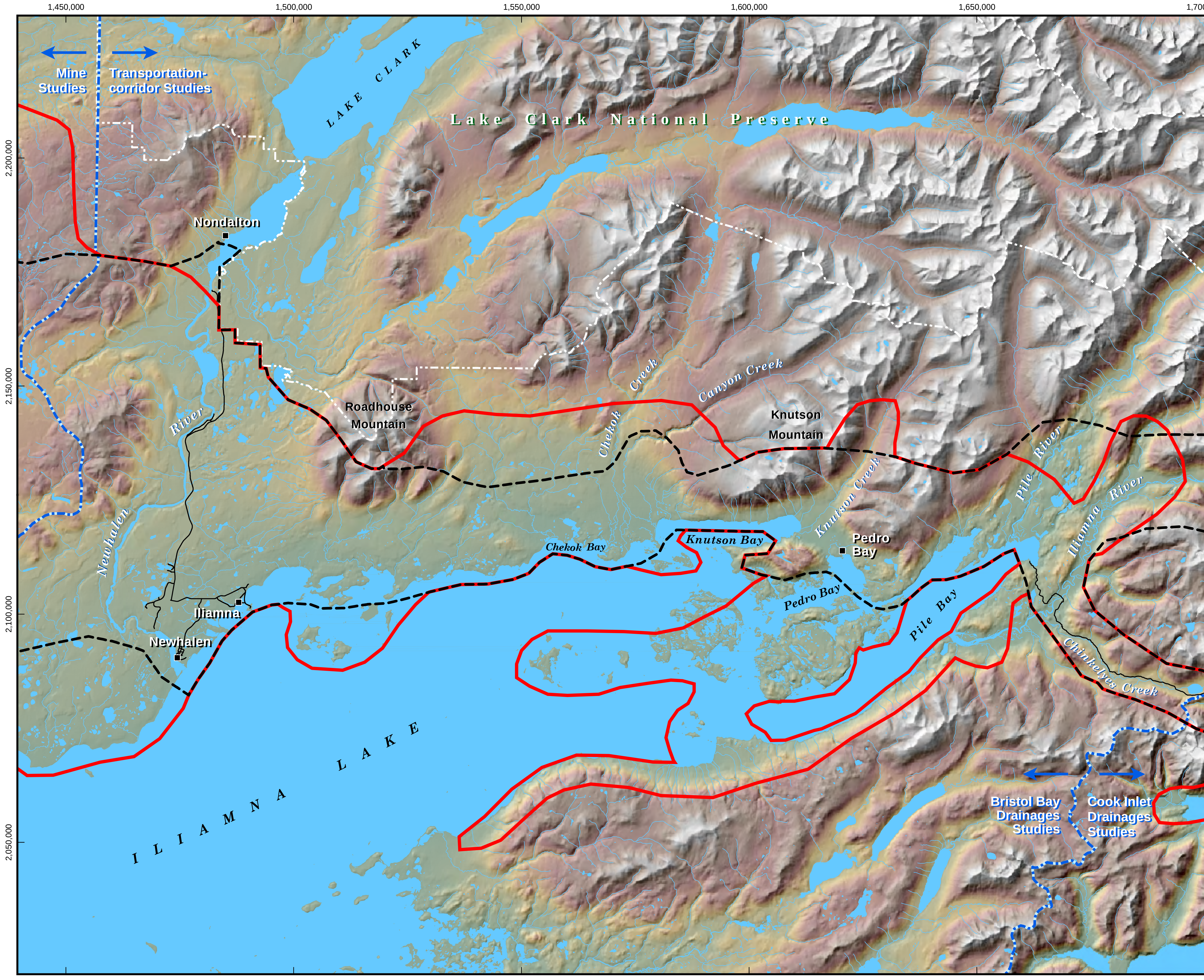

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Figure 16.9-1
Survey Areas for Raptors, Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

Legend

- 2004 Survey Area
- 2005 Survey Area
- Existing Road

Miles: 0 2 4 6 8 10

Kilometers: 0 2 4 6 8 10 12 14

N

Scale 1:260,000

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

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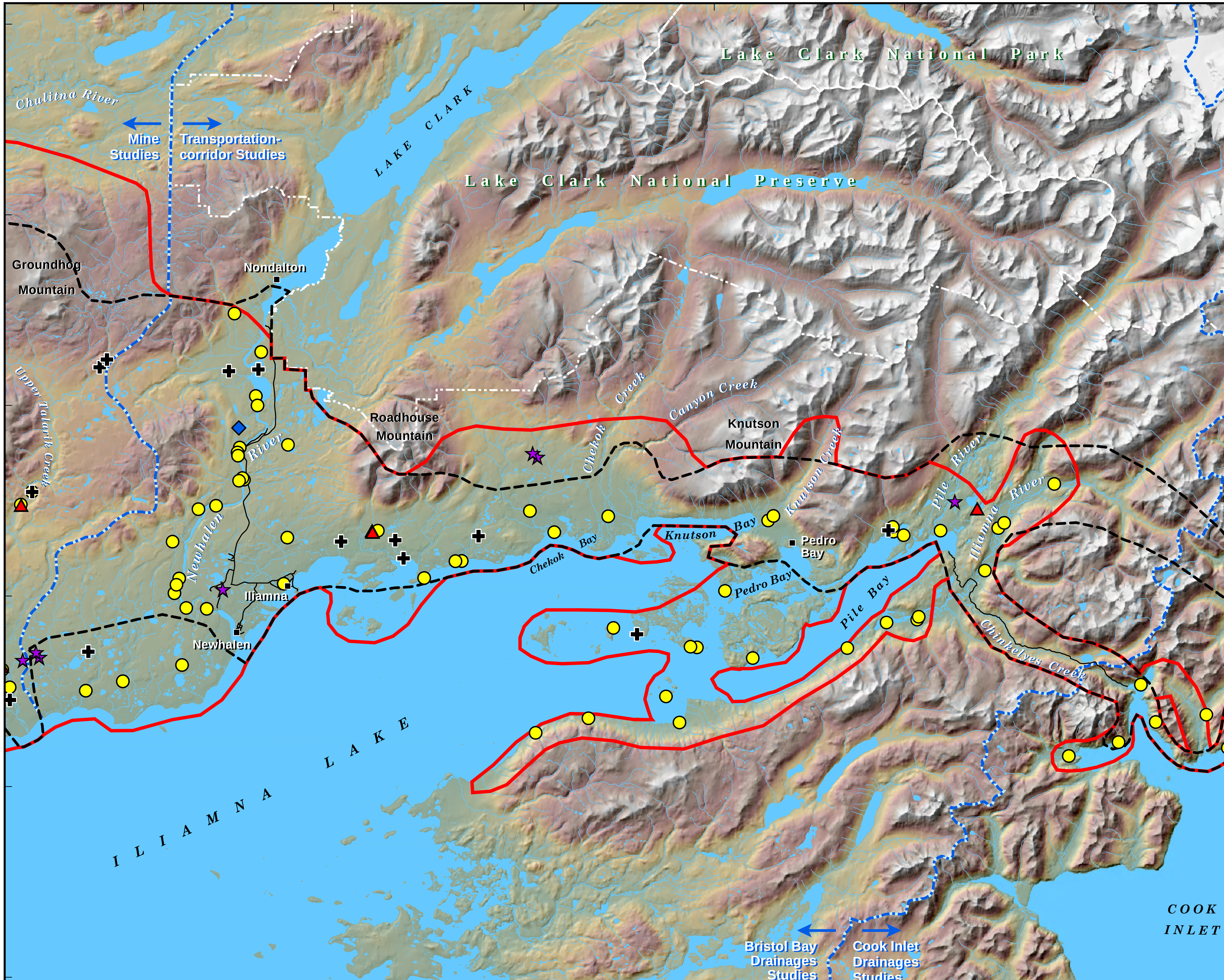
Version: 1	Author: ABR-AZC



![The Pebble Partnership logo]

Figure 16.9-2
Raptor Nest Distribution, (Osprey, Bald Eagle, Red-tailed Hawk, Great Horned Owl, Unidentified Raptor), Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

Legend

- Osprey
- Bald Eagle
- Red-tailed Hawk
- Great Horned Owl
- Unidentified Raptor
- 2004 Survey Area
- 2005 Survey Area
- Existing Road

Miles: 0 2 4 6 8 10
Kilometers: 0 2 4 6 8 10 12 14 16

N

Scale 1:320,000

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

File: 16-9-2_RaptTree04-05_Rd_PLP_EBD_v01.mxd	Date: July 1, 2010
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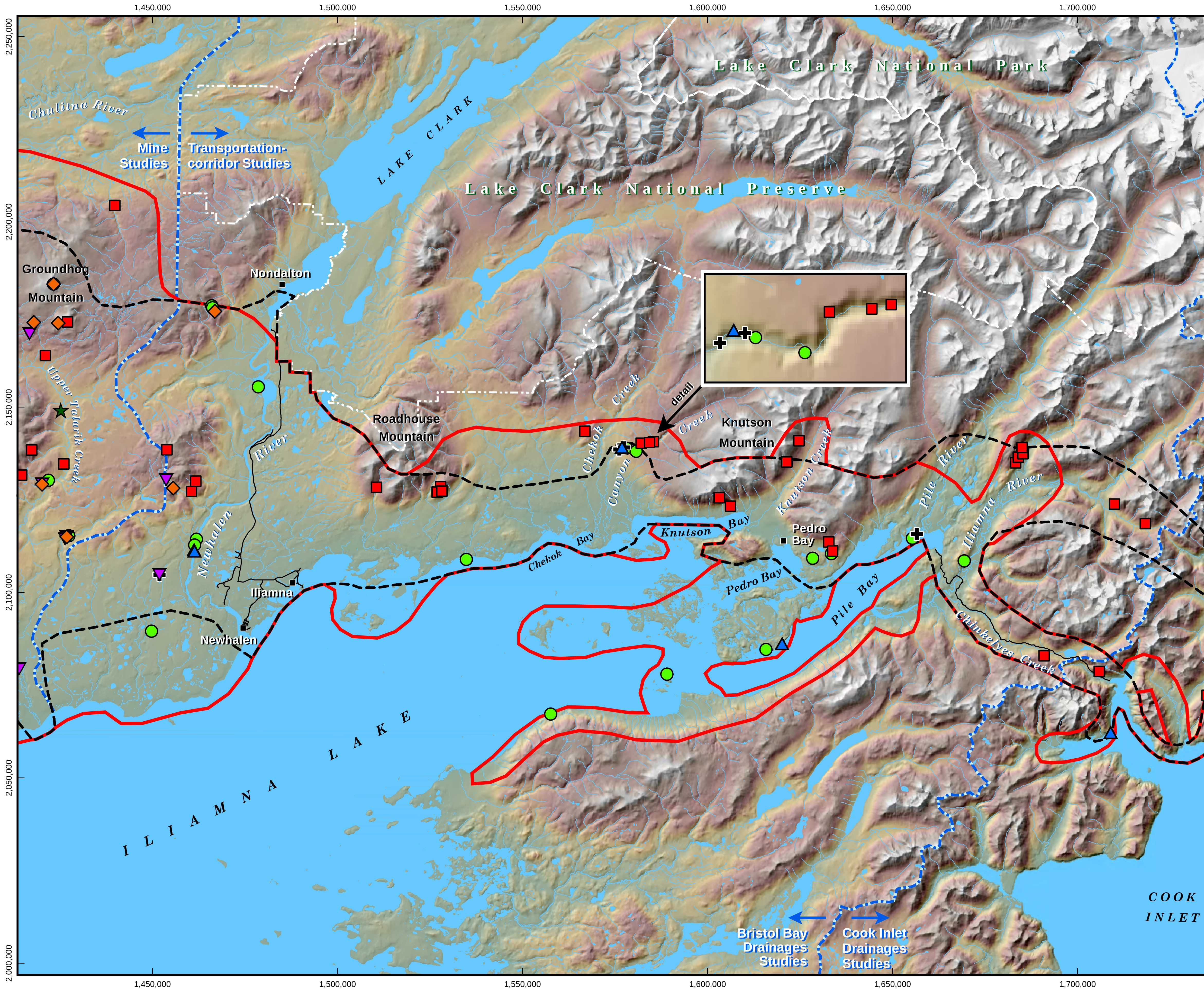

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Figure 16.9-3
Raptor Nest Distribution, (Golden Eagle, Rough-legged Hawk, Merlin, Peregrine Falcon, Gyrfalcon, Unidentified Raptor, Common Raven), Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

Legend

- Golden Eagle
- Rough-legged Hawk
- Merlin
- Peregrine Falcon
- Gyrfalcon
- Unidentified Raptor
- Common Raven

- 2004 Survey Area
- 2005 Survey Area
- Existing Road

Miles: 0 2 4 6 8 10

Kilometers: 0 2 4 6 8 10 12 14 16

N

Scale 1:320,000

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

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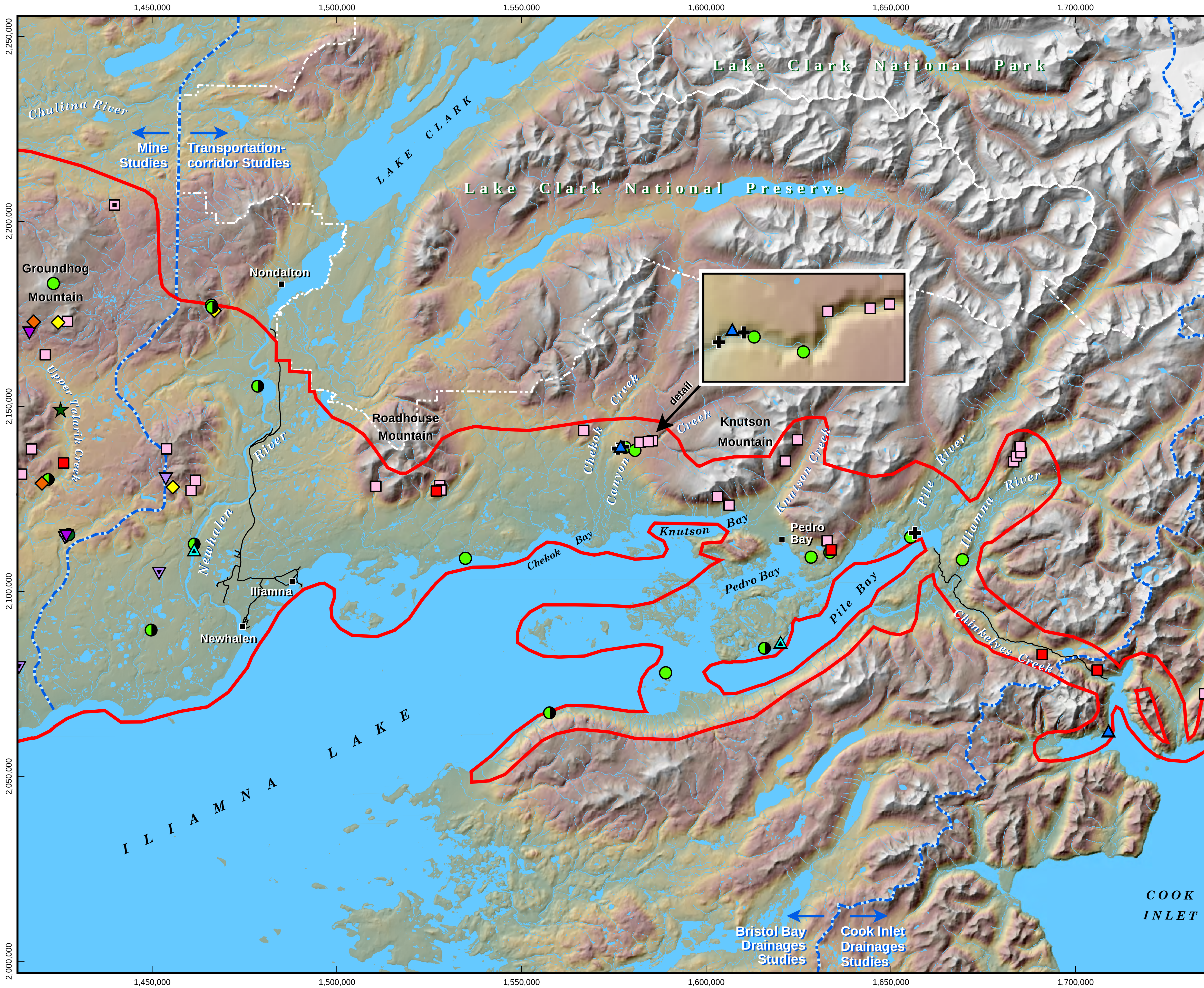

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Figure 16.9-4
Raptor Nest Distribution and Status (Golden Eagle, Rough-legged Hawk, Peregrine Falcon, Gyrfalcon, Unidentified Raptor, Common Raven), Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Legend

	Inactive	Occupied	Successful
Golden Eagle			
Rough-legged Hawk			
Merlin			
Peregrine Falcon			
Gyrfalcon			
Unidentified Raptor			
Common Raven			

Raptor Survey Area
Existing Road

Miles 0 2 4 6 8 10
Kilometers 0 2 4 6 8 10 12 14 16
N
Scale 1:320,000

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

File: 16-9-4_RaptCliff05_Rd_PLP_EBD_v01.mxd	Date: July 2, 2010
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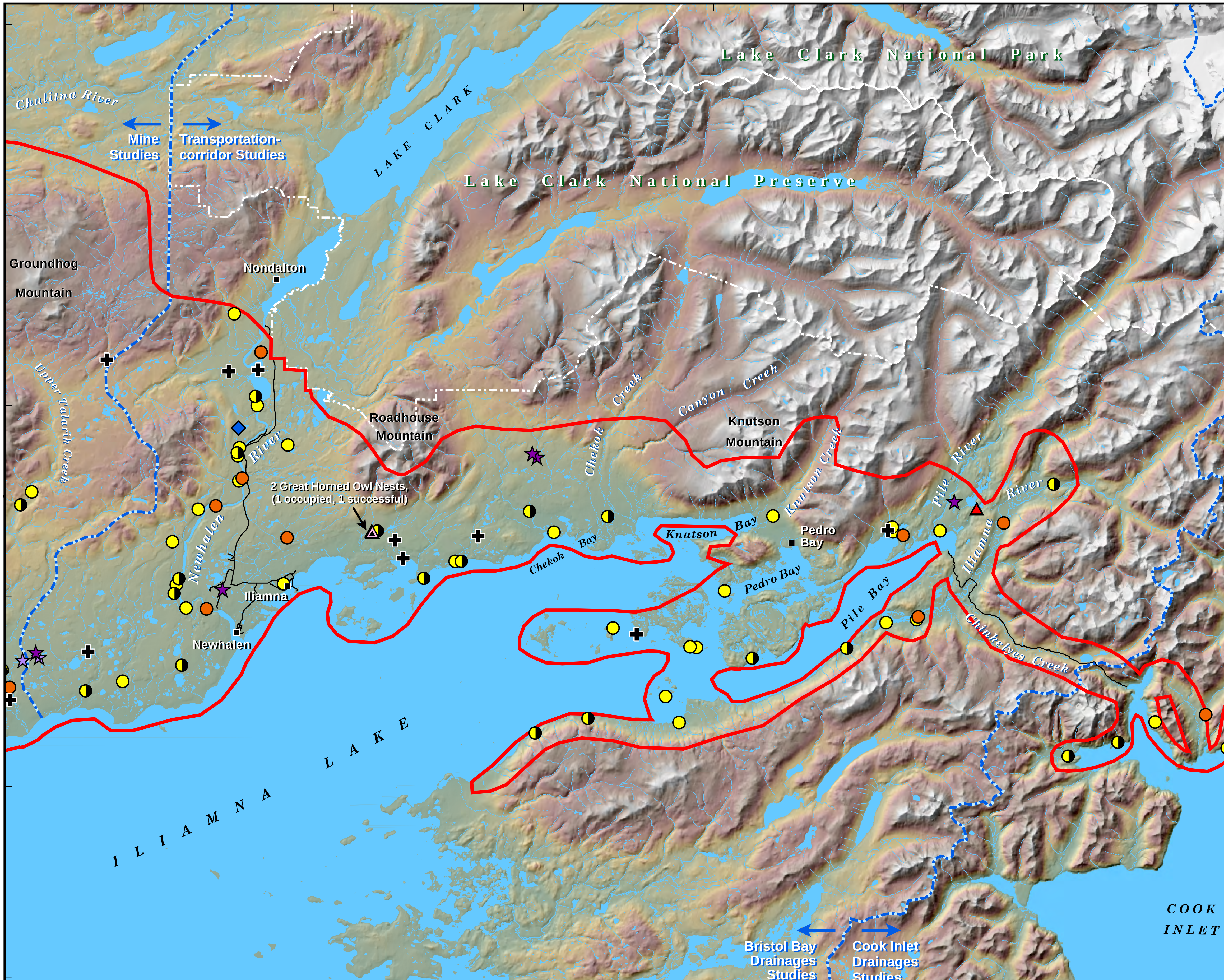

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Figure 16.9-5.
Raptor Nest Distribution and Status (Osprey, Bald Eagle, Red-tailed Hawk, Great Horned Owl, Unidentified Raptor), Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Legend

	Inactive	Occupied	Successful
Osprey	☆		★
Bald Eagle	●	◑	●
Red-tailed Hawk			◆
Great Horned Owl		▲	▲
Unidentified Raptor	✚		

Raptor Survey Area
Existing Road

Miles 0 2 4 6 8 10
Kilometers 0 2 4 6 8 10 12 14 16
N
Scale 1:320,000

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

File: 16-9-5_RaptTree05_Rd_PLP_EBD_v01.mxd	Date: July 2, 2010
Version: 1	Author: ABR-AZC

APPENDICES

APPENDIX 16.9A

SEASONAL OCCURRENCE AND RELATIVE ABUNDANCE OF RAPTORS IN THE LAKE CLARK/ILIAMNA REGION

APPENDIX 16.9A
Seasonal Occurrence and Relative Abundance of Raptors in the Lake Clark/Iliamna Region with Notes on Probable Status in the Transportation-corridor, Bristol Bay drainages Study Area

		Relative Abundance[a]				
		Lake Clark[b]				Transportation-corridor Study Area[c]
Common Name	**Scientific Name**	**Spring**	**Summer**	**Fall**	**Winter**	**Probable Status**
DIURNAL RAPTORS:						
Osprey	*Pandion haliaetus*	R	R, B	R		R, Breeding
Bald Eagle	*Haliaeetus leucocephalus*	C	C, B	C	R	C Breeding, U Winter
Northern Harrier	*Circus cyaneus*	C	U, B	C		U Breeding
Sharp-shinned Hawk	*Accipiter striatus*	U	U, B	U	R	R Visitor
Northern Goshawk	*Accipiter gentilis*	U	U, B	U	U	R Breeding
Red-tailed Hawk	*Buteo jamaicensis*	U	U, B	U		R Breeding
Rough-legged Hawk	*Buteo lagopus*	U		R		U Breeding
Golden Eagle	*Aquila chrysaetos*	U	U, B	U		U Breeding
American Kestrel[d]	*Falco sparverius*	R	R	R		AC
Merlin	*Falco columbarius*	U	U, B	U	CA	U Breeding
Peregrine Falcon	*Falco peregrinus*	R	R, B	R	CA	R Breeding
Gyrfalcon	*Falco rusticolus*	R	R, B	R	CA	U Breeding
OWLS:						
Great Horned Owl	*Bubo virginianus*	U	U, B	U	U	U Breeding
Snowy Owl	*Bubo scandiacus*			R	R	AC Migrant?
Northern Hawk-owl	*Surnia ulula*	R	R, B	R	R	R Breeding
Great Gray Owl	*Strix nebulosa*	R	R	R	R	R Breeding
Short-eared Owl	*Asio flammeus*	U	U, B	R	AC	U Breeding
Boreal Owl	*Aegolius funereus*	U	U, B	U	U	U Breeding
Northern Saw-whet Owl	*Aegolius acadicus*	U	U	U	U	Rare

Notes:

a. Relative abundance and breeding codes:
A=abundant, C=common, U=uncommon, R=rare, CA=casual, AC=accidental, and B= known nest records.

b. Main Source: National Park Service, Lake Clark National Park and Preserve Bird List (NPS, 2000).

c. This study and incidental observations from other aerial and ground wildlife studies (e.g., landbird, waterbird), and Williamson and Peyton, 1962.

d. Racine and Young, 1978.

16.10 Waterbirds—Transportation Corridor

16.10.1 Introduction

The results of the 2004 and 2005 surveys for waterbirds and a 2006 survey for post-breeding swans in the transportation-corridor, Bristol Bay drainages study area are presented in this section. Some waterbird surveys extended beyond the Bristol Bay drainages into the terrestrial and marine environments of the Cook Inlet drainages. Waterbird survey results for the terrestrial environment of the Cook Inlet drainages is presented in Chapter 41.4 and results for the marine environment in Chapter 44. The surveys for waterbirds in 2004 and 2005 focused on recording the distribution and abundance of all waterbird species—with an emphasis on waterfowl—during the breeding season (pre-nesting, nesting, molting, and brood-rearing) and during spring and fall migration. The survey for swans in 2006 located brood-rearing groups in the study area and determined whether they were Tundra and/or Trumpeter swans. The Iliamna Lake region of the northern Alaska Peninsula is an important migration route for many species of waterbirds (swans, geese, ducks, loons, shorebirds, and gulls) moving to and from breeding areas in western and northern Alaska (King and Lensink, 1971; Platte and Butler, 1995; Schuster, 2004; Conant and Groves, 2005). Important waterbird species that use the study area for breeding or staging include Tundra Swan, Common Loon, Harlequin Duck, Surf and Black scoters, Long-tailed Duck, and a diverse assemblage of dabbling and diving ducks (Williamson and Peyton, 1962; University of Alaska Museum, 2003). Swans and loons are key indicator species for environmental health of lakes and wetlands and Harlequin Ducks of productive riparian areas because they are sensitive to contaminants and they return to the same nesting territory year after year, often reusing nest sites (Limpert and Earnst, 1994; Mitchell, 1994; McIntyre and Barr, 1997; Robertson and Goudie, 1999; Zwiefelhofer, 2004). Harlequin Duck, Surf and Black scoters, and Long-tailed Duck are considered species of conservation concern in Alaska because Harlequin Ducks require specialized or unique habitats for breeding (BLM, 2004) and because breeding populations of Black Scoter and Long-tailed Duck have declined (Audubon Alaska, 2005). All three of these sea ducks are vulnerable to marine oil spills in their coastal wintering areas and other contaminants in their breeding areas.

16.10.2 Study Objectives

The objectives of the waterbird studies were to collect baseline data on the occurrence of swans, geese, ducks, loons, and gulls during the spring, summer, and fall seasons in the region of the possible transportation corridor for the Pebble Project. All species observed during surveys were recorded but special emphasis was placed on indicator species, (e.g., Tundra Swan and Harlequin Duck). This study had four specific objectives:

- Determine the distribution and abundance of waterbirds during spring and fall migration.
- Describe species composition of waterbirds using lakes, rivers, and wetlands during breeding and during spring and fall migration.
- Determine breeding areas for swans and Harlequin Ducks.
- Delineate important areas used by waterbirds during breeding and during spring and fall migration.

16.10.3 Study Area

Waterbird studies were conducted during breeding (pre-nesting, nesting, and brood-rearing) and during spring and fall migration within a 729-square-kilometer area in 2004 and an 885-square-kilometer area in 2005 in the transportation-corridor, Bristol Bay drainages study area (study area) (Figure 16.10-1). The selection of specific survey areas for each type of waterbird survey was based on what were considered suitable habitats for the species under investigation. Migration surveys covered all lakes and rivers in the study area, including some selected outlying areas that might be of regional importance (i.e., Newhalen River and bays of Iliamna Lake). Surveys for breeding waterfowl and swans included lakes, ponds, wetlands, and adjacent terrain in the study area. Surveys for pre-nesting and brood-rearing Harlequin Ducks followed all rivers and creeks in the study area

The study area extends for a distance of approximately 108 kilometers from the Summit Lakes area in the Chigmit Mountains east of Iliamna Lake to near the base of Ground Hog Mountain west of the Newhalen River. The study area, which traverses the northern shore of Iliamna Lake and three ecoregions of Alaska (Bristol Bay-Nushagak Lowlands, Alaska Range, and Interior Forested Lowlands and Uplands [Gallant et al., 1995]), is composed of a variety of woodland, tundra, and wetland habitats.

Habitats for waterbirds consist mostly of shallow ponds and wetlands, deep lakes, and meandering rivers in tundra and forest habitats. The ponds and wetlands provide feeding habitats for ducks and swans during nesting and brood-rearing. The deep lakes provide nesting and feeding habitats for Common Loons and feeding habitats for staging ducks during molting and migration. The tundra and wetland habitats adjacent to ponds and lakes provide nesting habitat for swans, ducks, and loons. Rivers and river-outlet areas on Iliamna Lake are important staging areas for waterbirds, especially during early spring when surrounding lakes are mostly frozen. Many dabbling and diving ducks, including Harlequin Ducks, nest and rear their young along rivers.

16.10.4 Previous Studies

Information specific to the use of the study area by waterbirds is limited to a reconnaissance-level survey during previous mining exploration in the area, regional waterfowl surveys adjacent to the area, and miscellaneous avian investigations near Iliamna Lake. During reconnaissance surveys of a possible road alignment for Cominco Alaska Exploration in August 1991, swans, geese, and ducks were noted as being present, but no formal survey for these species-groups was conducted and no location information was presented (Smith, 1991). However, known regional staging locations of waterfowl on the Kvichak and Naknek rivers derived from ADF&G maps were presented in the survey report (Smith, 1991).

Since 1957, U.S. Fish and Wildlife Service (USFWS) biologists have conducted annual surveys to estimate waterfowl populations in Alaska as part of the Alaska-Yukon Waterfowl Population Survey (e.g., Conant and Groves, 2004, 2005). The Bristol Bay region, 1 of 12 survey strata, encompasses an area of 50,000 square kilometers extending from the Ahklun Mountains on the west to the Aleutian Mountains on the east, and from Port Alsworth on the north to Port Heiden along Bristol Bay on the south. The mountains along the edge of the survey area give way to a vast basin of rolling hills and upland tundra, and eventually to a flat coastal plain. The study area is within the Bristol Bay waterfowl region, but the nearest sample transects are about 80 kilometers southwest of the deposit in predominantly coastal lowland habitat where lakes, ponds, and wetlands are extensive. Therefore, comparisons with these annual USFWS surveys are limited because of differences in habitat types between the two areas. In 1993 and 1994, an expanded waterfowl breeding-population survey was conducted over the entire Bristol Bay waterfowl region, which included transects within the study area, and waterbird density distribution maps were produced (Platte and Butler, 1995).

A few general bird studies have been conducted in the Lake Clark/Iliamna region and reported basic information on species occurrence, abundance, and habitat associations of waterbirds (e.g., Osgood, 1904; Gabrielson, 1944; Williamson and Peyton, 1962; Racine and Young, 1978; University of Alaska Museum, 2003; Ruthrauff et al., 2005). On the Alaska Peninsula south of the study area, spring and fall staging surveys have been conducted in the Port Moller area (Gill et al., 1981), along the Naknek River (Scharf, 1993; Meixell and Savage, 2004; Oligschlaeger and Schuster, 2004; Schuster, 2004), and along the southwestern coast of Alaska from the Yukon-Kuskokwim Delta to Unimak Island (Mallek and Dau, 2000, 2002). Tundra Swan productivity and migratory behavior have been studied south of the study area between the Kvichak River and Unimak Island (Wilk, 1984, 1987, 1988; Dau and Sarvis, 2002, Doster, 2002). Surveys for breeding Harlequin Ducks have been conducted in the Alaska Peninsula/Becharof National Wildlife Refuge (Savage, 2000) south of the study area and in other areas of southwestern Alaska (Morgart, 1998; MacDonald, 2003; Zwiefelhofer, 2004).

16.10.5 Scope of Work

The research and field work for this study were conducted during April through October 2004, April through October 2005, and September 2006. The study was performed by Robert J. Ritchie, Ann M. Wildman, and Jennifer H. Boisvert of ABR, Inc., Fairbanks and Anchorage, according to the approach described in Chapter 9 of the *Draft Environmental Baseline Studies, Proposed 2004 Study Plan* (NDM, 2004) and *Draft Environmental Baseline Studies, 2005 Study Plans* (NDM, 2005). The scope of work for waterbird studies in 2004 and 2005 included the following:

- Identifying areas used by waterbirds during spring and fall migration.
- Determining the density of breeding waterfowl.
- Locating and mapping swan nest sites.
- Determining the use of rivers by Harlequin Ducks during pre-nesting and brood-rearing.

In mid-July 2006, Northern Dynasty Mines approved swan productivity and species delineation surveys commencing in mid-September 2006. The scope of work included the following:

- Locating and mapping swan brood-rearing groups.
- Determining whether breeding swans were Trumpeter or Tundra swans.

16.10.6 Methods

16.10.6.1 Waterbird Spring and Fall Migration Surveys

Fixed-wing aircraft were used for waterbird surveys every seven to 10 days during spring and fall migration in 2004 and 2005. In 2004, four migration surveys were conducted in spring (between April 21 and May 23), and five surveys were conducted in fall (between September 2 and October 21; Table

16.10-1). More surveys were conducted during 2005 than in 2004 to better improve coverage of the spring and fall migration periods. In 2005, five migration surveys were conducted in spring (between April 20 and May 23), and seven surveys were conducted in fall (between August 18 and October 12). (A sixth spring survey had been planned for April 15, 2005, to document the first arrival of migrating swans and geese, but it was prevented by poor weather conditions.) The April 20, 2005 survey was a reconnaissance survey conducted only by the pilot to visit important staging locations, because weather prevented a biologist from getting to the area until April 24. The pilot was an experienced observer and counted the number of waterbirds by species-groups (i.e., swans, geese, ducks) at important staging locations identified during migration surveys in 2004.

Groups of lakes and sections of rivers were selected and were assigned unique identification numbers prior to field surveys. Selection criteria included geographic features and possible development plans. Within the study area, most lakes, rivers, and bays of northeastern Iliamna Lake were surveyed in 2004 and 2005 (Figure 16.10-2). A few lakes and the upper Iliamna River (20 kilometers) that were surveyed in 2004 were not surveyed in 2005. A few lakes also were added to the survey in 2005 that were not surveyed in 2004 (Figures 16.10-1 and 16.10-2). The lower 26 kilometers of the Iliamna River was surveyed during spring and fall in both years. Chinkelyes Creek and the Newhalen and Pile rivers were surveyed in spring of both years and during fall in 2005. Only a section of the Newhalen River was surveyed in fall 2004. Knutson Creek was surveyed only in spring 2004.

In 2005, reconnaissance surveys (two during spring and one during fall) were conducted of lakes between Upper Talarik Creek and the Newhalen River (Figures 16.10-1 and 16.10-2) because of a possible development option in that area. Additional surveys had been planned for fall, but none occurred because flying restrictions were placed over the area in late August to minimize disturbance to subsistence activities and continued through the remainder of the migration season. Reconnaissance surveys also were conducted of the southeastern shore of Iliamna Lake (Figures 16.10-1 and 16.10-2) because of possible barge operations on the lake.

Standard operating procedures for both years called for one observer and a pilot to conduct surveys in a Piper PA18 Super Cub. Exceptions included the first migration survey in April 2004 which was conducted with two observers and a pilot in a Cessna 206, and two fall surveys, one in 2004 and one in 2005, which were conducted with one observer using a Robinson 44 helicopter on one survey day and a Piper PA18 Super Cub on the other survey days. All surveys were flown at 60 meters above ground level and a speed of 100 to 145 kilometers per hour. During a survey, the aircraft circled or crossed lakes and flew along rivers parallel to the river course to allow observers to view waterfowl on the water and along the shore.

The observer recorded all waterbird data on a hand-held tape recorder, following the same methodology presented in Section 16.4.6.1 of this chapter. Data were summarized by species, species-group, lake group or river segment, and date of survey, also following the same methodology presented in Section 16.4.6.1 of this chapter. Any noteworthy incidental observations of raptors (e.g., Bald Eagle nests) or large mammals also were recorded on the tape recorder and with a GPS location.

16.10.6.2 Waterfowl Breeding-population Survey

Breeding-pair surveys were conducted in the study area on June 2, 2004, and May 27 and 28, 2005, using a Cessna 206 fixed-wing aircraft (Table 16.10-1). Surveys were flown at 45 meters above ground level at a speed of 145 kilometers per hour. Two observers, one on each side of the aircraft, surveyed 400 meters on either side of the aircraft along 31 pre-selected transects in 2004 and 68 in 2005, each 3.2 kilometers in length. Transects were spaced approximately 800 meters apart and were aligned to cover the largest possible number of waterbodies and wetlands in the study area (Figure 16.10-3). Observers recorded observations on hand-held tape recorders. Data recorded included transect number, species and number of birds, and observation type (e.g., male, pair, flock). The survey followed the current USFWS *Standard Operating Procedures for Aerial Waterfowl Breeding Ground Population and Habitat Surveys* (USFWS and CWS, 1987). All data were transcribed from tape recorders after completion of the survey following the same methodology presented in Section 16.4.6.2 of this chapter.

16.10.6.3 Swan Nesting Survey

Aerial surveys to locate swan nests were conducted in the study area on June 3, 2004, and May 28, 2005 (Table 16.10-1). Although swan nests were recorded during all avian surveys, the migration and breeding-pair surveys focused primarily on water surfaces and shorelines and did not provide adequate coverage for terrestrial habitats between lakes and ponds, where swans may nest. In contrast, the swan nesting survey was designed to cover both wetlands and the terrain surrounding wetlands (Figure 16.10.4). The surveys were flown in a Cessna 206 fixed-wing aircraft with a pilot and two observers, one on each side of the aircraft and followed same the methodology presented in Section 16.4.6.3 of this chapter.

The purpose of the swan productivity and species delineation survey in September 2006 was to search for swan broods and identify the swan species occurring in the study area. This survey also followed same the methodology presented in Section 16.4.6.3 of this chapter.

16.10.6.4 Harlequin Duck Pre-nesting and Brood-rearing Surveys

One aerial survey for pre-nesting Harlequin Ducks was flown on May 25 through 28, 2004, and two surveys were flown in 2005—one on May 23 through 26 and one on May 29 through 30 (Table 16.10-1). No aerial surveys for brood-rearing Harlequin Ducks were flown in 2004 in the study area. Two aerial surveys for brood-rearing Harlequin Ducks were conducted in 2005 on July 27 and 28, and August 12 and 14. Thirteen creeks and rivers were surveyed for pre-nesting Harlequin Ducks in the study area in 2004, and 14 were surveyed in 2005 (Figures 16.10-5 and 16.10-6). The coverage of the 2004 survey in most of the creeks and rivers studied was lengthened in 2005 to include all riverine habitat suitable for breeding Harlequin Ducks. Survey coverage of the creeks and rivers during brood-rearing in 2005 (Figure 16.10-7) was the same as during pre-nesting in 2005 (Figure 16.10-6). Surveys were flown following the same methodology presented in Section 16.4.6.4 of this chapter.

16.10.6.5 Loon Observations During Breeding

Surveys designed specifically for recording loons during the breeding season were not conducted in 2004 or 2005. Observations of loons and their nests and broods were recorded as part of the spring and fall migration surveys and the waterbird brood-rearing surveys. Occurrences of adult loons, nests, and broods were summarized by species and lake group.

16.10.7 Results and Discussion

Thirty-four species of waterbirds were observed during breeding, brood-rearing, and migration surveys in the study area (Table 16.10-2). Representatives from 11 taxa were recorded: geese (2 species), swans (1), ducks (18), loons (3), grebes (1), cormorants (1), cranes (1), shorebirds (1), gulls (4), terns (1), and jaegers (1). Fourteen species were confirmed to breed in the study area based on the presence of a nest or brood recorded during surveys. Another 11 species probably bred in the study area in 2004 and 2005, as indicated by their presence in the area during the breeding season, the availability of suitable nesting habitats, and the area being within their general breeding range. Nine species were seen only occasionally and in small numbers and were assumed to be migrants through the area (Table 16.10-2).

No waterbird species that is listed as federally endangered or threatened was observed in the Bristol Bay drainages portion of the transportation-corridor study area during surveys in 2004 and 2005 (USFWS, 2006). Some waterbird species that are not listed, however, are of conservation concern by governmental and non-governmental organizations because of apparent decreases in population abundance and/or population trends or because of a lack of data on population abundance and/or trends. Waterbird species of conservation concern are those that are classified as of concern by USFWS, the Bureau of Land Management, or ADF&G and/or are listed as of concern by non-governmental organizations focused on particular taxa (e.g., Partners in Flight, Alaska Shorebird Group) or by groups that use science extensively in conservation (e.g., Alaska Natural Heritage Program, Audubon Society). Species that occurred on at least two conservation lists are included as species of conservation concern. The rationale behind this approach to selecting species of conservation concern was that it relied primarily on information from groups of state and/or national experts in waterbird biology who used multiple criteria to determine the conservation status of each species.

Five species of waterbirds recorded during surveys in the study area are considered of conservation concern: Harlequin Duck, Surf Scoter, Black Scoter, Long-tailed Duck, and Red-throated Loon. A discussion of reasons why these five species are of conservation concern is presented in Chapter 17. Surveys for Harlequin Ducks found breeding pairs and/or broods in six different drainages (see Section 16.10.7.5). Surf and Black scoters and Long-tailed Ducks were seen in pairs on lakes in spring and in small staging flocks during spring and fall migration surveys (see Sections 16.10.7.1 and 16.10.7.2). Only one Red-Throated Loon was recorded in late August during a fall migration survey (see Section 16.10.7.2).

16.10.7.1 Waterbird Spring Migration Surveys

Temporal Patterns

The distribution and abundance of waterbirds in spring appeared to depend on the availability of open water and suitable staging habitats in the study area. Most lakes were 90 percent ice-covered during the first survey in late April in 2004 and 70 percent covered during the first survey in 2005. Early migrants, such as geese, swans, and dabbling ducks, were found concentrated in shallow areas on flooding rivers and in the few areas of open water on lakes and in bays of Iliamna Lake. Snowmelt on land and ice melt on lakes in the study area occurred earlier and faster in 2005 compared to 2004. By the second migration survey in early May 2004, most lakes, small and large, still had 50 to 90 percent ice cover, whereas only a few large, deep lakes contained that much ice during the same period in 2005 and all smaller lakes were ice-free. Although the presence of open water occurred earlier in 2005 compared to 2004, water levels in some staging areas were higher in 2005 because of rapid snowmelt; these high water levels may have precluded some geese, swans, and dabbling ducks from using those areas. By the last two surveys in mid- and late May in both years, most lakes were ice-free and waterbirds were dispersed throughout the study area. Most of these birds probably were breeders.

The timing of peak numbers of staging waterbirds differed between years for some species-groups and was the same for others (Tables 16.10-3 and 16.10-4). Geese and swan numbers peaked in late April in both years; researchers counted over 100 geese and over 500 swans in each year on those surveys. During the next survey in early May of both years, the number of swans (47 birds in 2004 and 66 in 2005) was eight to 11 times less than in late April. In 2004, only a few geese (28 birds) were found staging in the study area in early May, but in 2005, over 100 geese were counted at that time. No geese were seen after May 4 in 2004 and May 15 in 2005. The swans counted in the study area during the last surveys in May (23 birds in 2004 and 40 birds in 2005) were observed as single birds or as pairs on nesting territories. The timing of geese and swan staging in the study area was similar to that recorded on the Naknek River in 2004, where numbers also peaked in mid- to late April (Schuster, 2004).

Ducks were the most abundant species-group in the study area on every survey during spring (Tables 16.10-3 and 16.10-4), making up 58 to 88 percent of the birds on every survey in each year. In 2004, the peak number of ducks (1,578) occurred on May 3 and 4, and in 2005, the peak number of ducks (1,798) occurred on April 24 in the area surveyed in both years (excludes lakes between Upper Talarik Creek and the Newhalen River). This difference in timing between years may be because of the greater amount of open water on lakes and bays earlier in 2005 compared to 2004. In 2004, the number of ducks in the study area dropped with each subsequent survey in May, whereas in 2005, the number remained high and the count on May 21, 2005 (1,755 ducks), was similar to the peak count on April 24, 2005 (1,798 ducks). Large migratory flocks of up to 120 diving ducks, mostly scaup, scoters, and mergansers, were observed in late May 2005, while in late May 2004, only six flocks of no more than 25 scaup and mergansers each were seen.

Gulls (Bonaparte’s, Mew, and Glaucous-winged) arrived in late April and Arctic Terns in early May. The peak number of gulls and terns observed was similar between years (244 in 2004 and 212 in 2005), but this peak occurred on May 13 and 14 in 2004 and on May 3 and 4 in 2005 (Tables 16.10-3 and 16.10-4). The occupation of the lakes by loons occurred in early May in both years.

Spatial Patterns

A shallow, wide section of the Newhalen River known as “Three-mile Lake” was an important staging location for geese, swans, and ducks in both years (Figures 16.10-8 and 16.10-9). On April 21, 2004, 898 waterbirds (306 swans, 140 geese, and 452 ducks) were counted at Three-mile Lake. That total was the highest concentration of birds found in spring 2004 in the study area. On April 24, 2005, 403 waterbirds (174 swans, 73 geese, and 156 ducks) were seen there, fewer than in 2004, possibly because higher water levels on the Newhalen River in 2005 compared to 2004 flooded some feeding areas used by geese, swans, and dabbling ducks in 2004. The area of highest concentration of birds in 2005 was at a shallow, confined bay off Chekok Bay on Iliamna Lake, locally known as “Goose Cove” (Figure 16.10-9). On April 24, 2005, 634 waterbirds (304 swans, 50 geese, and 280 ducks) were counted there. In 2004 (Figure 16.10-8), fewer waterbirds (180 swans and 73 ducks) used this area in late April. Three-mile Lake and Goose Cove were the only areas where concentrations of swans were found during spring.

Other important staging locations in late April and early May of both years included the open water formed by river runoff discharging into the bays of Iliamna Lake, including Eagle, Fox, Pile, and Whistlewing bays and the mouth of the Newhalen River (Figures 16.10-8 and 16.10-9). Hundreds of dabbling and diving ducks, and a few geese were found at these locations. River mouths also were popular feeding locations for gulls and terns. The Iliamna and Newhalen rivers were used by many ducks during spring, particularly Mallards and mergansers. When rivers were running high, water flooded into wetlands near outlet areas at Iliamna Lake, and dabbling ducks concentrated there. Rivers throughout the region are recognized to be important waterfowl staging areas; the Naknek River is one of particular importance on the Alaska Peninsula because it often is the first ice-free large body of water (Schuster, 2004).

By mid-May, waterbirds were distributed more evenly throughout the study area. Waterbird concentrations of 100 to 176 birds were found on a few lakes in each year. In both years, flocks of diving ducks (scaup, scoters, goldeneyes, and mergansers) staged on Alexcy Lake and an adjoining lake to the south. The maximal number of birds counted on these lakes was 169 in 2004 and 168 in 2005. Two other areas where waterbirds were concentrated were at shallow lakes on river floodplains near Iliamna Lake. One lake was near the mouth of the Iliamna River and the other was at the head of Pile Bay east of the Pile River. Both areas were used by a diverse assemblage of waterbirds (swans, geese, dabbling ducks, mergansers, shorebirds, and gulls). For the remaining lakes, 10 to 19 percent of the survey lake groups had from 26 to 100 birds in both years, while most lake groups (71 to 74 percent) had less than 26 birds (Figures 16.10-8 and 16.10-9).

Taxonomic Patterns

Thirty-one species of waterbirds were recorded on migration surveys during spring 2004 and 30 species during spring 2005 in the study area. Both Greater White-fronted and Canada geese were recorded in mixed and single-species flocks of 10 to 80 birds, with a total count of 169 geese in late April 2004 and 123 in late April 2005 (Tables 16.10-3 and 16.10-4). Canada Geese were more common in 2004, while Greater White-fronted Geese were observed more often in 2005 (Appendices 16.10A and 16.10B). Other research indicates that Greater White-fronted and Canada geese staged in moderate numbers on the Naknek River in 2004 (Schuster, 2004).

Migrating swans staged in the study area in late April in both 2004 and 2005 (Tables 16.10-3 and 16.10-4). All staging swans are assumed to be Tundra Swans, which breed from the Iliamna Lake area west to the Bristol Bay region. A small population of swans breeds in the study area, and birds begin occupying nesting territories as soon as they become snow and ice-free. Nests were found during migration surveys beginning in early May in 2004 and 2005. During aerial surveys in the study area, researchers could not differentiate swan species (i.e., Trumpeter or Tundra). (For discussion on the relative occurrence of these species in the study area, see Section 16.10.7.4, Swan Nesting Survey.)

Dabbling ducks made up 60 to 80 percent of the ducks observed on the days when the peak number of birds was recorded (May 3 and 4 in 2004 and April 24 in 2005). American Wigeon, Mallard, Northern Shoveler, Northern Pintail, and Green-winged Teal were common dabbling ducks in both years, and a few Gadwall were seen only in 2005 (Appendices 16.10A and 16.10B). The highest numbers of diving ducks were recorded on May 13 and 14, 2004, and on May 21 through 23, 2005. Scaup were the most common diving ducks, followed by mergansers (Common and Red-breasted) and goldeneyes, which all staged in large flocks on lakes, rivers, and bays of Iliamna Lake. Other diving ducks recorded include Canvasback, Harlequin Duck, scoters (Surf, White-winged, and Black), Long-tailed Duck, and Bufflehead. The assemblage of ducks seen in the study area and their timing and abundance during spring appeared to be in accordance, in general, with what has been recorded for other areas of the Alaska Peninsula (Bellrose, 1976; Gill et. al., 1981; Meixell and Savage, 2004; Oligschlaeger and Schuster, 2004; Schuster, 2004).

Four species of gulls were found in the study area (Bonaparte's, Mew, Herring, and Glaucous-winged), and although each species is considered a breeder in the area, some probably were migrants or non-breeders that spent the summer and fall in the Iliamna Lake area. A few Glaucous-winged Gulls arrived in late April, but most appeared each year in early May along with Bonaparte's and Mew gulls (Appendices 16.10A and 16.10B). Arctic Terns are migrants, and a flock of approximately 100 birds was seen feeding near the mouth of the Newhalen River in 2004. Shorebirds were observed in both years starting in late April. Yellowlegs were common along the shores of Iliamna Lake, where many flocks of 20 or fewer medium-sized shorebirds were observed on May 3 and 4, 2004, contributing to a peak number of 112 shorebirds counted on those days (Appendices 16.10A). Small numbers of loons, grebes, cormorants, and Sandhill Cranes were observed during spring in one or both years (Tables 16.10-3 and 16.10-4), and most birds probably nested in the area.

16.10.7.2 Waterbird Fall Migration Surveys

Temporal Patterns

Similar to spring, ducks were the most abundant species-group recorded in the study area during fall (Tables 16.10-3 and 16.10-4). The number of ducks recorded on a fall survey ranged from 725 to 1,042 birds in 2004 and from 1,049 to 2,090 birds in 2005. Peak abundance was on October 6 and 7 in 2004 and on September 6 through 8 in 2005. No geese were recorded in the study area during fall migration, and no staging swans were found. The few swans observed in the study area during fall surveys were failed breeders or adults with young.

In both years, numbers of gulls (mostly Glaucous-winged Gulls) increased with each successive fall survey until the peak number occurred—on October 6 and 7, 2004, at 696 birds and on September, 6 through 8, 2005, at 1,490 (Tables 16.10-3 and 16.10-4). Loons observed in the study area during fall were breeders which began to depart the area in late September.

Spatial Patterns

During fall migration in 2004 and 2005 (Figures 16.10-10 and 16.10-11), waterbirds congregated in many of the same locations as during spring (Figures 16.10-8 and 16.10-9). In fall 2004 (Figure 16.10-10), hundreds of ducks staged at Three-mile Lake on the Newhalen River, Goose Cove off Chekok Bay, Whistlewing Bay, and on a lake connected to the southern part of Alexcy Lake. Peak abundance at each one of these locations occurred on September 13 when both dabbling and diving ducks were present in large flocks. In fall 2005 (Figure 16.10-11), hundreds of ducks staged at Three-mile Lake on the Newhalen River and on Alexcy Lake and an adjoining lake, but fewer waterbirds were found at Goose Cove and Whistlewing Bay than in 2004. Dabbling and diving ducks were found at Three-mile Lake, but mostly diving ducks (scaup, goldeneye, and merganser) were observed in the Alexcy Lake area. Another lake near Alexcy Lake and one near Whistlewing Bay had concentrations of 279 and 146 waterbirds, respectively. Large flocks of Mallards, scaup, and mergansers were present.

The highest concentration of waterbirds during fall 2004 occurred on September 23 in the eastern half of Knutson Bay, where 342 mergansers and 125 gulls were observed (Figure 16.10-10). Another concentration of 392 gulls, mostly Glaucous-winged Gulls, was found feeding on salmon carcasses on the lower half of the Iliamna River on October 6, 2004, and 120 gulls were observed at the mouth of Canyon Creek and in Fox Bay on September 13, 2004. Gulls also were observed in smaller concentrations in many of the bays of Iliamna Lake at river-outlet areas (e.g., Fox Bay). In fall 2005, large concentrations of Glaucous-winged Gulls were observed on the Iliamna River, in the eastern half of Knutson Bay, and in Pile Bay. On September 6, 1,650 waterbirds (1,234 gulls, 175 mergansers, 166 Mallards, 63 Green-winged Teal, 10 Harlequin Ducks, and 2 goldeneyes) were counted on the Iliamna River (Figure 16.10-11). Mergansers were not present in Knutson Bay in the large flocks observed in 2004, but they were common along the southeastern shore of Iliamna Lake.

Reconnaissance surveys were conducted along the southeastern shore of Iliamna Lake on four fall surveys between August 18 and September 14, 2005. From 220 to 314 birds were recorded on each survey (Figure 16.10-11), with mergansers and gulls making up 76 to 87 percent of all birds recorded.

Taxonomic Patterns

Nineteen species of waterbirds were recorded on migration surveys in the study area during fall 2004 and 25 species during fall 2005 (Appendices 16.10A and 16.10B). No geese were found in the study area during fall. Swans were recorded on every fall survey in 2004 and 2005, but no concentrations of swans were identified (Tables 16.10-3 and 16.10-4). In 2004, swan numbers were similar during all surveys in September (approximately 35 birds) and declined in October until only two were observed on October 21. In 2005, on August 18 and 19, 85 swans—including nine broods (18 adults and 23 young)—were counted; this survey included the area between the Newhalen River and Upper Talarik Creek. The remaining 44 swans were spread between Chekok Bay and Upper Talarik Creek mostly as singles or pairs; only one group of adults (three) was observed. In 2005, six swans were observed in the study area on the last migration survey on October 11. On the Naknek River in 1993, swans were observed up until October 20, which was a week before ponds and riverbanks began freezing (Scharf, 1993). Swan departure dates can vary annually depending on the time of freeze-up.

Mallards were the most abundant dabbling duck, and their numbers increased from September to October in 2004, with a peak of 178 birds on October 21 (Appendix 16.10A). In 2005, the number of Mallards peaked at 411 on September 6 (Appendix 16.10B), and the number counted in October was similar to that counted in October 2004. Mallards have the most prolonged fall migration of any duck and in 1993 were observed on the Naknek River as late as mid-November (Scharf, 1993). Other dabbling ducks in the study area were most abundant from late August to mid-September, which is consistent with the timing of staging on the Naknek River (Scharf, 1993). Dabbling ducks staged on shallow wetlands, creek outlets, and rivers. Similar to spring, scaup were the most common diving duck in the study area in both years during fall, followed by mergansers (Common and Red-breasted) and goldeneyes, and were found staging on deep lakes and protected bays.

Common Loons were most abundant in early September 2004 (32) and mid-August 2005 (25) (Appendices 16.10A and 16.10B). Most loons were seen as singles or pairs, but a few groups of three to five adults were recorded. No grebes were seen in 2004, but a few Red-necked Grebes were observed in 2005, including a flock of eight birds on September 29. No shorebird flocks were seen during fall in either year.

16.10.7.3 Waterfowl Breeding-population Survey

Waterfowl breeding-population surveys in the study area sampled 40.1 square kilometers in 2004 and 88.1 square kilometers in 2005. Seven species of ducks were recorded in 2004 and 10 species in 2005 (Table 16.10-5). Total duck density was slightly higher in 2005 (6.1 ducks per square kilometer) compared to 2004 (5.3 ducks per square kilometer). Species composition was similar in both years, except American Wigeon, Green-winged Teal, and Long-tailed Duck were observed only in 2005. Higher species richness and higher overall density in 2005 may partially reflect the larger survey area sampled.

Scaup were the most commonly observed duck in the study area in 2004 and 2005 (2.0 ducks per square kilometer and 2.6 ducks per square kilometer, respectively), followed by Mallard (1.6 ducks per square kilometer in 2004 and 1.5 ducks per square kilometer in 2005). In both years, densities of scaup and Mallard were at least two to three times higher than any other duck species, which all had densities 0.7 ducks or fewer per square kilometer. The densities of three duck species (Northern Shoveler, Northern Pintail, and goldeneyes) were similar in 2004 and 2005, but the densities of scoters and mergansers differed between years (Table 16.10-5). Scoter densities were seven times greater in 2005, while merganser densities were seven times greater in 2004. Fewer swans were recorded in 2004 (0.1 swans per square kilometer) compared to 2005 (0.3 swans per square kilometer).

Surveys conducted by the USFWS in the Bristol Bay region had mean densities of 20.8 ducks per square kilometer in 2004 and 19.4 ducks per square kilometer in 2005 (Conant and Groves, 2004, 2005), which were three to four times greater than duck densities in the study area. Biologists recorded 10 species of ducks in the study area compared to 12 species in the entire Bristol Bay region in both 2004 and 2005 (Conant and Groves, 2004, 2005). Species that were seen in Bristol Bay region, but not in the study area, during waterfowl population surveys included Gadwall (less than 0.1 ducks per square kilometer) and Blue-winged Teal (0 to 0.1 ducks per square kilometer; Conant and Groves, 2004, 2005). These species were uncommon during the Bristol Bay surveys, however, and comprised one percent or less of total birds recorded (Conant and Groves, 2004, 2005).

Scaup were the most commonly observed duck both in the study area and in the Bristol Bay region (Conant and Groves, 2004, 2005). Statewide trends have indicated an increase in tundra-nesting scaup (excluding the North Slope population) since the mid-1970s (Conant and Groves, 2005). Platte and Butler (1995) also found scaup to be common during a study of waterfowl distribution across the entire Bristol Bay region and noted concentrations in wetlands near the Newhalen River and north of Whistlewing and Eagle bays.

Differences in density and species composition between the Bristol Bay region and the study area may be a result of differences in the relative sizes of the survey areas and differences in habitat types. The study area covered 40.1 square kilometers in 2004 and 88.1 square kilometers in 2005, whereas the Bristol Bay survey area covered 238 square kilometers. The study area contains a mosaic of lakes and ponds between 50 and 225 meters in elevation in tundra, woodland, and forest habitats bordered by small mountains. The Bristol Bay survey area is mostly outwash and flood plains between 15 and 75 meters in elevation (Platte and Butler, 1995). Within the Bristol Bay region, some species—such as scaup and scoters—are distributed evenly across the survey area while others—such as Northern Pintail, Mallard, and Green-winged Teal—occur in smaller, disjunct patches (Platte and Butler, 1995). Another reason for differences in the densities of some waterfowl may be a difference in timing of the two surveys relative to the visible presence of dabbling and diving ducks during the breeding season. Dabbling ducks arrive on the breeding grounds and nest before diving ducks. The waterfowl breeding-population survey was planned to occur at a similar time to the USFWS surveys in the Bristol Bay region because the mine study area is within that region, but snow melt and lake thaw probably occurred earlier in the mine study area than in the Bristol Bay lowlands where the climate is cooler during spring. Consequently, the arrival of dabbling and diving ducks happened earlier in the mine study area than in the Bristol Bay lowlands and their visible presence at the time of each survey differed..

The density of nesting swans recorded in the study area during the waterfowl breeding-population survey was 0.1 and 0.3 swans per square kilometer in 2004 and 2005, respectively (Table 16.10-5). Similar densities were recorded by other studies on the Alaska Peninsula; however, most of these surveys were conducted more than five years earlier. Annual swan density was 0.3 swans per square kilometer in 1993 and 1994, when a waterfowl breeding-population survey was conducted over the entire Bristol Bay region, which included transects within the transportation-corridor study area (Platte and Butler, 1995). On the lower Alaska Peninsula, Dau and Sarvis (2002) conducted surveys in 2002 and reported densities of 0.2 swans per square kilometer at Izembek and 0.3 swans per square kilometer at Pavlof. The highest densities of swans (0.3 to 0.9 swans per square kilometer) on the lower Alaska Peninsula have been reported outside the study area along the Bristol Bay coast and in broad drainage basins between the Naknek and Meshik rivers (Wilk, 1988). High densities of Tundra Swans in Alaska’s lowlands are associated with an abundance of shallow waterbodies (King and Hodges, 1981).

16.10.7.4 Swan Nesting Survey

Swans were found nesting in the study area in 2004 and 2005 from the Pile River to Upper Talarik Creek (Figure 16.10-4). In 2004, two nests were found on the swan survey and an additional eight nests were found on other wildlife surveys (i.e., migration, breeding waterfowl, and mammal surveys). The swan surveys in 2004 covered only the western portion of the transportation-corridor study area, whereas the other wildlife surveys extended to the Pile River area (Figure 16.10-4). In 2005, the survey area was extended east to the Pile River and west to Upper Talarik Creek. Twenty-three swan nests were found in 2005, 12 during the swan survey and the remaining 11 during other surveys (i.e., raptor, migration, breeding waterfowl, and mammal surveys). A similar number of nests was found between the Newhalen and Pile rivers in 2004 (9 nests) and 2005 (8 nests). One nest site was occupied in both years, and four other nest sites recorded in 2005 were within 1 kilometer of where swans nested in 2004. In both years, most nests were found adjacent to wetlands, ponds, or lakes.

Tundra Swans are one of the first birds to arrive on nesting grounds in Alaska in spring (Limpert and Earnst, 1994). On the Alaska Peninsula, nesting habitats become available much earlier than in other major nesting areas because of early snowmelt and quickly moderating spring conditions (Wilk, 1987, 1988). Swans were first observed on nests in the study area on May 3 in 2004 and on May 7 in 2005. The first brood in 2005 was observed in late May during the waterfowl breeding-population survey. A pair of swans with cygnets was found on a lake between Upper Talarik Creek and the Newhalen River near Iliamna Lake. Nest initiation and incubation for that pair of swans must have started at the end of April (based on a 30-day incubation period). Snowmelt occurred earlier in 2005 than in 2004, particularly along Iliamna Lake, and the phenology of swan nest initiation and hatch can be highly correlated with the progression of ice and snowmelt in spring (Babcock et al., 2002). The timing of the swan surveys in both years probably was late for the phenology of nesting in the study area, however, because other wildlife surveys were conducted throughout May, most nests in the study area probably were detected. Some swan nests found on wildlife surveys in early May probably had failed by the time of the swan survey in late May, and this may be the reason that they were not detected during that survey.

Specific aerial surveys to identify and enumerate swan broods were not conducted in the study area in 2004 or 2005, but swan broods were recorded during fall migration surveys. In 2004, at least three swan broods were counted on each September migration survey. In 2005, the highest number of swan broods (8) was counted on August 18: three broods were found between the Pile and Newhalen rivers, and five broods were found between the Newhalen River and Upper Talarik Creek. The last observations of swan broods in the study area were on September 23 in 2004 and October 11 in 2005. Productivity surveys conducted on September 27 and 28, 2006, found four broods in the study area.

During aerial surveys in the study area in 2004 and 2005, researchers could not differentiate swan species (i.e., Trumpeter versus Tundra). Ground surveys for waterbird broods were conducted in the mine study area and researchers were able to get close enough to some swans there to identify them as Tundra Swans. No swans seen within close range in the mine study area were identified as Trumpeter Swans. However, while the habitat of the mine study area (tundra with little relief, wet meadows, and numerous shallow lakes with littoral, emergent vegetation) is typical of Tundra Swan nesting habitats (Wilk, 1988), either species could occur in the habitats of the transportation-corridor, Bristol Bay study area (tundra with shallow lakes and wet meadows, and open forests with many lakes, ponds, and wetlands with littoral, emergent vegetation).

In late September 2006, researchers in a helicopter searched the study area for swans and, when swans were found, circled them or landed to identify the swans to species. Out of 19 adult swans encountered in the study area, nine were identified as Tundra Swans, two as Trumpeter Swans, and eight could not be identified definitely to species. The Trumpeter Swan pair had one young and was seen near the Pile River. The nearest Tundra Swan observation (at Chekok Creek) was 28 kilometers from the Trumpeter Swans. All of these sightings were near where nests were recorded in 2004 and 2005, and no nests were found in either year between these two areas (Figure 16.10-4). The nine Tundra Swans seen on the survey occurred from Chekok Creek to the Newhalen River, and the eight swans of unknown species were seen west of the Newhalen River.

During a faunal inventory of birds in the Iliamna Lake area in May and June 1958 and June 1959, researchers reported seeing a few swans in flight and identified them as Tundra Swans based on size alone, but recognized that both species could occur in the area (Williamson and Peyton, 1962). In June 2003, a University of Alaska class spent a week conducting field work near Iliamna Village and identified a Trumpeter Swan pair and young at Pike Lake near the Iliamna airport (University of Alaska Museum, 2003). Other pairs of Trumpeter Swans also were identified at lakes west of there.

The study area is on the eastern edge of the breeding range for Tundra Swans and the western edge for Trumpeter Swans. Population surveys for Tundra Swans have been conducted on the Alaska Peninsula south of Iliamna Lake between the Naknek River and Port Moller (Wilk, 1984; Doster, 2002), and surveys for Trumpeter Swans have occurred along western Cook Inlet from the Susitna River to Iniskin Bay (Conant et al., 2001). Both Trumpeter and Tundra swan populations have increased substantially since 1965 (Conant and Groves, 2005), and nesting ranges overlap in some areas (Bryant et al., 2005). In northwestern interior Alaska, recent studies have found sympatric nesting of Trumpeter and Tundra swans (Bryant et al., 2005). Both swan species there used similar nesting habitats, except that Trumpeter Swans preferred lakes with peninsulas and islands, while Tundra Swans preferred round or oval lakes (Bryant et al., 2005). Based on the Pebble Project surveys, the current division between the breeding range for Trumpeter and Tundra swans appears to be between Chekok Creek and the Pile River, but it also is possible that the nesting range between Trumpeter and Tundra swans could overlap in this area. Trumpeter and Tundra swans are known to hybridize in captivity and may also hybridize in the wild (King, pers. comm., 2004).

16.10.7.5 Harlequin Duck Pre-nesting and Brood-rearing Surveys

During pre-nesting surveys, Harlequin Ducks were found on six of the 13 rivers surveyed in 2004 (Figure 16.10-5) and on five of the 14 rivers surveyed in 2005 (Figure 16.10-6). Twenty-six Harlequin Ducks were observed on 147.9 kilometers of river (0.2 ducks per kilometer) in 2004 (Table 16.10-6). In 2005, researchers counted 49 ducks on 207.8 kilometers of river (0.2 ducks per kilometer) on the first pre-nesting survey and 16 ducks (0.1 ducks per kilometer) on the second survey (Table 16.10-7). In both years, pairs were found on the Newhalen River, Eagle Bay Creek, Canyon Creek, and the Iliamna River. Researchers observed one pair each on Eagle Bay and Canyon creeks in 2004 and 2005. In 2004, one pair also was found on the Iliamna River, while in 2005, 15 pairs and a single male were observed there on the first survey. On the Newhalen River, one single male, one single female, and three pairs were counted in 2004 and three single males and five pairs on the first survey in 2005. Additionally, in 2004, a single male was observed on Chinkelyes Creek and a flock of 10 males and 1 female were found at the mouth of Knutson Creek. In 2005, a single male was seen on the Pile River during the first pre-nesting survey. On the second pre-nesting survey in 2005, Harlequin Ducks were observed only on the Newhalen and Iliamna rivers, and the numbers were less than during the first pre-nesting survey (Figure 16.10-6).

No brood-rearing survey for Harlequin Ducks was conducted in the study area in 2004. In 2005, two brood-rearing surveys were conducted, one in late July and one in mid-August. Only single females were seen on the first brood-rearing survey: two females on the Iliamna River and three females on Chinkelyes Creek (Table 16.10-7). On the second brood-rearing survey, researchers counted a total of 33 Harlequin Ducks in five broods on 207.8 kilometers of river, giving a linear density of 0.2 ducks per kilometer (Table 16.10-7). A single brood was found on each of the Newhalen, Iliamna, and Pile rivers and two broods were found on Stonehouse Lake (Figure 16.10-7). Twenty-four young were counted in the five broods, for a mean brood size of 4.8 young per brood (range = 1 to 12 young per brood).

Linear densities of pre-nesting Harlequin Ducks in the study area were generally lower than those reported for surveys done within the past 10 years in other areas of southwest Alaska (Morgart, 1998; MacDonald, 2003; Zwiefelhofer, 2004). Linear densities ranged from 1.5 to 2.3 ducks per kilometer in Togiak National Wildlife Refuge (MacDonald, 2003) and from 1.3 to 1.7 ducks per kilometer in the Kilbuck Mountains (Morgart, 1998). The density within the study area was calculated for all the rivers and creeks flown during the survey, but Harlequin Ducks were found on less than half of those creeks in both 2004 and 2005. Recalculating densities for only those segments on which Harlequin Ducks actually occurred in each year produced a linear density of 0.3 ducks per kilometer during pre-nesting in 2004 and 0.5 ducks per kilometer on the first pre-nesting survey in 2005. Similar densities (0.4 ducks per kilometer) were found in two watersheds surveyed in Kodiak National Wildlife Refuge in 2004 (Zwiefelhofer, 2004).

Although the overall density of Harlequin Ducks was low in the study area during brood-rearing, the density for the four individual creek segments where ducks were observed on the second survey was 0.4 ducks per kilometer, similar to the density during pre-nesting. At Togiak National Wildlife Refuge, densities of Harlequin Ducks were lower during brood-rearing (0.6 to 0.8 ducks per kilometer) than during pre-nesting (1.5 to 2.3 ducks per kilometer; MacDonald, 2003), but some broods may have been capable of flight at the time of the brood surveys and, therefore, may have been missed. The mean brood size of 4.8 young per brood in the study area was higher than that found in recent years in other areas of southwest Alaska: 3.1 to 4.0 young per brood in Kodiak National Wildlife Refuge (Zwiefelhofer, 2004), 3.4 to 3.8 young per brood in Togiak National Wildlife Refuge (MacDonald, 2003), 4.3 young per brood in Alaska Peninsula/Becharof National Wildlife Refuge (Savage, 2000), and 4.4 young per brood in the Kuskokwim Mountains (McCaffery, 1996).

Eighty-three percent of the Harlequin Duck groups recorded in the study area during pre-nesting in 2004 and 2005 were found on swift-flowing sections of clear-water streams. During brood-rearing, one brood was found in swift water and four broods were found in placid water—two of the latter were on a lake. Of the five broods, three were in clear water and two were in glacial-affected water. Fast, clear-water rivers with mid-stream islands are preferred nesting and brood-rearing habitats of Harlequin Ducks (Bengtson, 1966; Crowley, 1994; Robertson and Goudie, 1999). Harlequin Ducks forage entirely on animal prey, including stream invertebrates and fish roe (Bengtson, 1972; Vermeer, 1983; Fischer and Griffin, 2000). The presence of broods on many of the creeks and rivers in the study area indicate that, at present, the characteristics of these streams meet the requirements of breeding Harlequin Ducks. Harlequin Ducks are an indicator species of high-quality and productive riparian habitats (MacDonald, 2003; Zwiefelhofer, 2004).

During aerial surveys for brood-rearing Harlequin Ducks in 2005, broods of all waterfowl species were recorded for the rivers surveyed in the study area. Nine species of duck broods (excluding Harlequin Ducks) were seen on rivers: four species of dabbling ducks and five species of diving ducks (Table 16.10-8). Diving ducks (scaups, scoters, Long-tailed Ducks, and Common and Red-breasted mergansers) comprised 74 percent of 42 duck broods seen. Red-breasted Merganser was the most commonly found diving-duck brood (52 percent of all divers), followed by Common Merganser, unidentified scaup, unidentified scoter, and Long-tailed Duck. The remaining 26 percent of the broods observed were American Wigeon, Mallard, Northern Pintail, and Green-winged Teal, with a similar number of broods recorded for each species (Table 16.10-8). The most broods were seen on Chekok Bay Creek (9 broods), Iliamna River (9), and Newhalen River (8). In other studies, Red-breasted Merganser was the most common duck observed on rivers during brood-rearing surveys for Harlequin Ducks in the Kilbuck Mountains and in Togiak National Wildlife Refuge (Morgart, 1998; MacDonald, 2003).

16.10.7.6 Loon Observations during Breeding

Common, Pacific, and Red-throated loons were recorded in the study area during spring and fall migration surveys. Red-throated Loons appeared to be migrants or uncommon breeders because they were sighted only twice. One adult was seen in early fall (August 18, 2005) near the mouth of the Newhalen River during a migration survey, and another adult was found on a small lake south of Negro Lake on June 2, 2005, during landbird breeding surveys. During earlier avian surveys, Red-throated Loons were considered uncommon in the Lake Clark/Iliamna Lake region (Osgood, 1904; Racine and Young, 1978), but scattered breeding records exist, including a brood observed in 1959 by Williamson and Peyton (1962). Red-throated Loons were more numerous on the Alaska Peninsula south and west of Iliamna Lake (Cahalane, 1944; Gill et al., 1981).

Pacific Loons are uncommon breeders in the study area and were observed only in spring. A pair of adults was seen on each of three different lakes between the village of Iliamna and Chekok Creek, and a single adult was observed on Iliamna Lake near Chekok Creek. Early avian surveys considered Pacific Loons to be abundant in the Lake Clark/Iliamna Lake region (Osgood, 1904; Gabrielson, 1944; Williamson and Peyton, 1962; Racine and Young, 1978), although Cahalane (1944) observed that they were absent from the interior of the Alaska Peninsula near Katmai National Monument (now Katmai National Park and Preserve), even where suitable habitat exists. In June 2003, a University of Alaska class spent a week conducting field work near Iliamna Village and did not report any Pacific Loons (University of Alaska Museum, 2003).

Common Loons were the most numerous loon in the study area and were observed repeatedly during spring and fall migration surveys on many large lakes. Breeding Common Loons occupy nest lakes as soon as enough water has formed around the edge to allow them to take off and land. Common Loons were able to occupy nest lakes in the transportation-corridor study area between May 3 and 13 in both 2004 and 2005, and they left the nest lakes between September 14 and 23 in 2004 and September 14 and 30 in 2005. Common Loons were seen on 21 lake groups in 2004 and 36 lake groups in 2005 between Upper Talarik Creek and the Iliamna River (Figure 16.10-12). No nests were found in the study area in 2004 and 2005, but five broods were recorded in each year on eight different lakes, most of which were near the Newhalen or Iliamna rivers (Figure 16.10-12). One brood in 2005 was found in Pile Bay. In 2004, a brood also was seen in a large lake between Upper Talarik Creek and the Newhalen River. Only one brood in each year had two young, the remaining broods had one young. Broods were observed in the study area from late August to mid-September of both years.

In Alaska, the highest densities of Common Loons occur in the lake regions of Bristol Bay and Kenai Peninsula (Groves et al., 1996). The Iliamna Lake region is located on the eastern edge of the Bristol Bay nesting grounds and has many lakes within its mosaic of forest and tundra habitats that can support Common Loons (Williamson and Peyton, 1962). Common Loons were not reported during some earlier avian surveys in the region (Osgood, 1904; Hurley, 1931; Cahalane, 1944), but Gabrielson (1944) observed many adults on the Kvichak River in mid-July 1940. Common Loons have been classified as uncommon in Lake Clark National Park (Racine and Young, 1978) and in the Iliamna Lake area (Williamson and Peyton, 1962). Williamson and Peyton (1962) felt that Common Loons should have been more prevalent in 1958 and 1959 given the large number of apparently suitable nesting lakes with abundant fish in the Iliamna Lake area.

Pacific and Common loons differ in many of their breeding requirements, although some overlap occurs. Common Loons prefer large, clear lakes with fish that usually have extensive complex shorelines (Barr, 1973, 1996; McIntyre and Barr, 1997). Reported territory sizes range from 0.2 to 0.8 square kilometers (Barr, 1973; Kerekes et al., 1994). Their diet is primarily live fish, and their foraging habitats are usually littoral zones with good underwater visibility within the nest lake (McIntyre and Barr, 1997). In contrast, Pacific Loons are generalists that occupy a variety of lakes ranging from shallow to relatively large, deep lakes (0.1 to 0.9 square kilometers; Russell, 2002). Their diet consists mainly of fish and aquatic invertebrates, and during the breeding season they may forage in their nest pond or on nearby lakes, rivers, and nearshore marine waters (Russell, 2002).

Lakes that meet the selection criteria for nesting Common Loons are common in the study area, and the numbers of nesting Common Loons probably are limited by the number of lakes that meet the size, complexity, water quality, prey availability, and territorial requirements.

16.10.8 Summary

Ponds, lakes, rivers, and wetlands in the study area supported a diverse assemblage of waterbirds in 2004 and 2005 during breeding and during spring and fall migration. Thirty-four species were observed in the transportation-corridor study area, 14 of which were recorded as breeding based on the presence of a nest or a brood. Breeding waterbirds included representatives from five taxa: swans, ducks, loons, cranes, and gulls.

Waterbirds used lakes and rivers for staging throughout the study area during spring and fall migration. During spring, swans, geese, and dabbling ducks (American Wigeon, Mallard, Northern Shoveler, Northern Pintail, Green-winged Teal) arrived in late April to early May and fed in mixed-species flocks on rivers and open water on lakes and the bays of Iliamna Lake created by river runoff. The highest concentrations of swans, geese, and ducks were found in an area of the Newhalen River known as Three-mile Lake and at Goose Cove, a small cove off of Chekok Bay. Other popular areas for dabbling ducks included Eagle, Fox, and Pile bays and shallow lakes in the floodplain of the Iliamna River and at the head of Pile Bay. Diving ducks (scaups, scoters, Long-tailed Ducks, Buffleheads, goldeneyes, and mergansers) arrived in mid- to late May and staged in large flocks at Whistlewing Bay, Alexcy Lake, and on the Iliamna and Newhalen rivers.

During fall migration, concentrations of waterbirds occurred at many of the same locations where they were found in spring, including Three-mile Lake on the Newhalen River, Goose Cove off Chekok Bay, Whistlewing Bay, Alexcy Lake and an adjoining lake, and the Iliamna River. Additionally, concentrations of gulls and mergansers were found on Iliamna Lake at Knutson and Pile bays and along the south shore of the lake. No groups of swans or geese staged in the study area during fall; only brood-rearing groups and adult swans as singles or pairs were observed. Thousands of ducks and gulls were recorded during fall surveys, with duck abundance remaining high during the entire period from mid-August to mid-October and gull abundance peaking in mid- to late September.

Swans were common breeding birds between Chekok Creek and the Newhalen River, where eight and nine nests were found in 2004 and 2005, respectively. An additional 15 nests were found in 2005 between Upper Talarik Creek and the Newhalen River north of Iliamna Lake. Some swans returned to the same territories in 2005, and one returned to the same nest site used in 2004. Swans in the study area were observed on nests in early May, and one brood was observed in late May, indicating that some swans started incubating in late April. Most swans found in September 2006 were identified as Tundra Swans; however one pair with one young near the Pile River was identified as Trumpeter Swans.

Pairs of Harlequin Ducks were found on pre-nesting surveys in both years on Canyon Creek, the east branch of Eagle Creek, and the Iliamna and Newhalen rivers. Additionally, single males were observed on Chinkelyes Creek and at the mouth of Knutson Creek in 2004, and on the Pile River in 2005. Twelve single males and six pairs were recorded in 2004, and five single males and 22 pairs were recorded in 2005; 15 of the pairs in 2005 were found on the Iliamna River. No brood-rearing surveys were conducted in the study area in 2004. In 2005, broods were found on Stonehouse Lake and on the Newhalen, Pile, and

Iliamna rivers. Nine females and 24 young were counted in five broods on August 12 and 14, and mean brood size was 4.8 young per brood.

Common Loons were found on large, deep lakes between Upper Talarik Creek and the Iliamna River from early May to late September in 2004 and 2005. Five broods were recorded in each year; these 10 broods were found on eight different lakes, most of which were near the Newhalen or Iliamna rivers. Pacific and Red-throated loons were uncommon in the study area and no nests or broods were observed.

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16.10.10 Glossary

Phenology—the study of the seasonal timing of life cycle events (changes in plants and animals)

Sympatric—describing different species or populations that live in the same geographical area

Littoral—the region of the shore of a lake or sea or ocean

Taxa—a taxonomic category or group, such as a phylum, order, family, genus or species

TABLES

TABLE 16.10-1
Waterbird Surveys Conducted in the Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

Year/ Survey Type	**Target Species**	**Purpose**	**Survey Date**	**Aircraft**	**Altitude (meters)**	**Method**
2004						
Aerial	Waterfowl	Spring Migration	Apr 21	C206	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 3-4	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 13-14	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 22-23	Cub	60	Lake-to-Lake
Aerial	Harlequin Duck	Pre-nesting	May 25-28	H500	45	Stream
Aerial	Waterfowl	Breeding	Jun 2	C206	45	Transect
Aerial	Swans	Nesting	Jun 3	C206	150	Transect
Aerial	Waterfowl	Fall Migration	Sep 2-3	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 13-14	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 23-24	Cub/R44	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Oct 6-7	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Oct 21	Cub	60	Lake-to-Lake
2005						
Aerial	Waterfowl	Spring Migration	Apr 20[a]	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	Apr 24	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 3-4	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 13-15	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Spring Migration	May 21-23	Cub	60	Lake-to-Lake
Aerial	Harlequin Duck	Pre-nesting	May 23-26	B206/R44	45	Stream
Aerial	Waterfowl	Breeding	May 27-28	C206	45	Transect
Aerial	Swans	Nesting	May 28	C206	150	Transect
Aerial	Harlequin Duck	Pre-nesting	May 29-30	B206/R44	45	Stream
Aerial	Harlequin Duck	Brood-rearing	Jul 27-28	R44	45	Stream
Aerial	Harlequin Duck	Brood-rearing	Aug 12, 14	R44	45	Stream
Aerial	Waterfowl	Fall Migration	Aug 18-19	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Aug 27-29	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 6-8	Cub/R44	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 13-14	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Sep 29-30	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Oct 6-7	Cub	60	Lake-to-Lake
Aerial	Waterfowl	Fall Migration	Oct 11-12	Cub	60	Lake-to-Lake

Notes:

a. Reconnaissance survey conducted by pilot only.

TABLE 16.10-2
Status of Waterbird Species Observed during Aerial and Ground Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2004-2005

Common Name	Scientific Name	Status
Greater White-fronted Goose	*Anser albifrons*	Migrant
Canada/Cackling Goose[a]	*Branta* spp.	Migrant
Unidentified swan[b]	*Cygnus* spp.	Confirmed Breeder
Gadwall	*Anas strepera*	Migrant
American Wigeon	*Anas americana*	Confirmed Breeder
Mallard	*Anas platyrhynchos*	Confirmed Breeder
Northern Shoveler	*Anas clypeata*	Probable Breeder
Northern Pintail	*Anas acuta*	Confirmed Breeder
Green-winged Teal	*Anas crecca*	Confirmed Breeder
Canvasback	*Aythya valisineria*	Migrant
Ring-necked Duck	*Aythya collaris*	Probable Breeder
Unidentified scaup[c]	*Aythya* spp.	Confirmed Breeder
Harlequin Duck	*Histrionicus histrionicus*	Confirmed Breeder
Surf Scoter	*Melanitta perspicillata*	Migrant
White-winged Scoter	*Melanitta fusca*	Migrant
Black Scoter	*Melanitta nigra*	Probable Breeder
Long-tailed Duck	*Clangula hyemalis*	Confirmed Breeder
Bufflehead	*Bucephala albeola*	Probable Breeder
Unidentified goldeneye[d]	*Bucephala* spp.	Probable Breeder
Common Merganser	*Mergus merganser*	Confirmed Breeder
Red-breasted Merganser	*Mergus serrator*	Confirmed Breeder
Red-throated Loon	*Gavia stellata*	Migrant
Pacific Loon	*Gavia pacifica*	Probable Breeder
Common Loon	*Gavia immer*	Confirmed Breeder
Red-necked Grebe	*Podiceps grisegena*	Probable Breeder
Double-crested Cormorant	*Phalacrocorax auritus*	Probable Breeder
Sandhill Crane	*Grus canadensis*	Confirmed Breeder
Unidentified yellowlegs[e]	*Tringa* spp.	Probable Breeder
Bonaparte's Gull	*Larus philadelphia*	Probable Breeder
Mew Gull	*Larus canus*	Confirmed Breeder
Herring Gull	*Larus argentatus*	Probable Breeder
Glaucous-winged Gull	*Larus glaucescens*	Confirmed Breeder
Arctic Tern	*Sterna paradisaea*	Migrant
Parasitic Jaeger	*Stercorarius parasiticus*	Migrant

Notes:

a. Canada Geese (*Branta canadensis*) probably are the primary *Branta* spp. in the transportation-corridor, Bristol Bay drainages study area, but Cackling Geese (*B. hutchinsii*) may be present.

b. Tundra Swans (*Cygnus columbinanus*) probably are the primary swan species in the transportation-corridor, Bristol Bay drainages study area, but Trumpeter Swans (*C. buccinator*) may be present.

c. Greater Scaup (*Athya marila*) probably are the primary scaup species in the transportation-corridor, Bristol Bay drainages study area, but Lesser Scaup (*A. affinus*) may be present.

d. Barrow's Goldeneye (*Bucephela islandica*) and Common Goldeneye (*B. clangula*) were not distinguished between during field data collection; both may be present.

e. Greater Yellowlegs (*Tringa melanoluca*) probably are the primary yellowlegs species in the transportation-corridor, Bristol Bay drainages study area, but Lesser Yellowlegs (*T. flavipes*) may be present.

TABLE 16.10-3
Numbers of Waterbirds by Species-group Observed during Spring and Fall Migration Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2004

	Spring				Fall				
Species-group	**Apr 21**	**May 3-4**	**May 13-14**	**May 22-23**	**Sep 2-3**	**Sep 13-14**	**Sep 23-24**	**Oct 6-7**	**Oct 21**
Geese	169	28	0	0	0	0	0	0	0
Swans	503	47	27	23	33	37	37	11	2
Ducks	939	1,578	1,294	686	748	996	757	1,042	725
Loons	1	7	10	8	32	8	3	2	0
Grebes	0	1	0	0	0	0	0	0	0
Cormorants	0	2	0	7	4	2	3	4	0
Cranes	0	1	0	0	5	6	0	0	0
Shorebirds	13	112	40	7	0	0	0	0	0
Gulls/Terns	8	120	244	50	81	296	406	696	118
Jaegers	0	0	1	0	0	0	0	0	0
TOTAL	**1,633**	**1,896**	**1,616**	**781**	**903**	**1,345**	**1,206**	**1,755**	**845**

TABLE 16.10-4
Numbers of Waterbirds by Species-group Observed during Spring and Fall Migration Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

	Spring					Fall						
Species-group	**Apr 20[a]**	**Apr 24**	**May 3-4**	**May 13-15[b]**	**May 21-23[b]**	**Aug 18-19[b]**	**Aug 27-29**	**Sep 6-8**	**Sep 13-14**	**Sep 29-30**	**Oct 6-7**	**Oct 11-12**
Geese	84	123	105	10	0	0	0	0	0	0	0	0
Swans	225	535	66	34	40	85	20	17	20	18	18	6
Ducks	737	1,798	1,408	1,613	2,060	1,239	1,218	2,090	1,186	1,182	1,049	1,161
Loons	0	0	9	19	37	27	25	18	18	4	1	1
Grebes	0	0	0	0	0	0	0	0	3	8	0	1
Cormorants	0	0	0	9	1	4	7	2	0	3	2	0
Shorebirds	1	28	11	25	61	1	0	0	0	0	0	0
Gulls/Terns	0	71	212	174	185	208	655	1,490	1,076	1,090	446	503
Jaegers	0	0	0	0	1	0	0	0	0	0	0	0
TOTAL	**1,047**	**2,555**	**1,811**	**1,884**	**2,385**	**1,564**	**1,925**	**3,617**	**2,303**	**2,305**	**1,516**	**1,672**

Notes:

a. Reconnaissance survey conducted by pilot only.

b. Includes the survey lakes from Iliamna Lake to 2 kilometers inland between Upper Talarik Creek and the Newhalen River (Figure 16.10-2).

TABLE 16.10-5
Numbers and Densities of Waterfowl Observed during Breeding-population Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

Year/ Species	**Males**	**Pairs**	**Grouped Birds**[a]	**Indicated Total No. Birds**[b]	**Visibility Correction Factor**[c]	**Corrected Total No. Birds**[d]	**Density**[e] **(birds/ km^2)**	**Composition (% of total)**
2004								
Mallard	6	2	0	16	4.01	64	1.6	30
Northern Shoveler	0	1	0	2	3.79	8	0.2	4
Northern Pintail	1	0	0	2	3.05	6	0.2	3
Unidentified scaup[f]	4	9	20	42	1.93	81	2.0	38
Unidentified scoter	0	1	0	2	1.17	2	0.1	1
Unidentified goldeneye	2	1	0	6	3.61	22	0.5	10
Unidentified merganser	1	2	16	22	1.27	28	0.7	13
TOTAL DUCKS						**211**	**5.3**	**100**
Unidentified swan[f]	1	2	0	5	1	5	0.1	
2005								
American Wigeon	0	3	0	6	3.84	23	0.3	4
Mallard	7	6	6	32	4.01	128	1.5	24
Northern Shoveler	0	1	0	2	3.79	8	0.1	1
Northern Pintail	1	1	5	9	3.05	27	0.3	5
Green-winged Teal	0	1	0	2	8.36	17	0.2	3
Unidentified scaup[f]	6	24	64	118	1.93	228	2.6	42
Unidentified scoter	0	9	32	50	1.17	59	0.7	11
Long-tailed Duck	0	1	0	2	1.87	4	<0.1	1
Unidentified goldeneye	2	3	0	10	3.61	36	0.4	7
Unidentified merganser	3	1	0	8	1.27	10	0.1	2
TOTAL DUCKS						**539**	**6.1**	**100**
Unidentified swan[f]	3	11	0	25	1	25	0.3	

Notes:

a. Grouped birds are those that occurred in flocks; no assumptions as to the number of pairs were made.

b. Indicated Total No. Birds = (number of males in groups [<5 birds] x 2) + (number of pairs x 2) + number of birds in groups >4 birds.

c. Visibility Correction Factor developed by USFWS (Conant and Groves, 2004).

d. Corrected Total No. Birds = Indicated Total No. Birds x Visibility Correction Factor.

e. Density based on corrected total number of birds in a 40.1-square-kilometer (km^2) sample area in 2004 and a 88.1-km^2 sample area in 2005.

f. Males and single birds not doubled in calculating indicated total number of birds.

TABLE 16.10-6
Numbers of Harlequin Ducks Observed during Pre-nesting Aerial Surveys, Transportation- corridor, Bristol Bay Drainages Study Area, May 25-28, 2004

Location	Single Male	Single Female	Pairs	Total Birds[a]
Canyon Creek	0	0	1	2
Chekok Creek East	0	0	0	0
Chekok Bay Creek	0	0	0	0
Chinkelyes Creek	1	0	0	1
Eagle Bay Creek East	0	0	1	2
Eagle Bay Creek West	0	0	0	0
Iliamna River	0	0	1	2
Knutson Creek	10	1	0	11
Newhalen River	1	1	3	8
Pile River	0	0	0	0
Roadhouse Creek	0	0	0	0
Stonehouse Lake Creek	0	0	0	0
West Newhalen Branch	0	0	0	0
TOTAL	**12**	**2**	**6**	**26**

Notes:

a. Total = (number of single males) + (number of single females) + (number of pairs x 2).

TABLE 16.10-7
Numbers of Harlequin Ducks Observed during Pre-nesting and Brood-rearing Aerial Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Survey/ Location	Pre-nesting				Brood-rearing			
	Single Male	Single Female	Pairs	Total Birds[a]	Females	Young	Total Birds	No. Broods
First Survey[b]								
Canyon Creek	0	0	1	2	0	0	0	—
Chekok Creek East	0	0	0	0	0	0	0	—
Chekok Creek West	0	0	0	0	0	0	0	—
Chekok Bay Creek	0	0	0	0	0	0	0	—
Chinkelyes Creek	0	0	0	0	3	0	3	—
Eagle Bay Creek East	0	0	1	2	0	0	0	—
Eagle Bay Creek West	0	0	0	0	0	0	0	—
Iliamna River	1	0	15	31	2	0	2	—
Knutson Creek	0	0	0	0	0	0	0	—
Newhalen River	3	0	5	13	0	0	0	—
Pile River	1	0	0	1	0	0	0	—
Roadhouse Creek	0	0	0	0	0	0	0	—
Stonehouse Lake Creek	0	0	0	0	0	0	0	—
West Newhalen Branch	0	0	0	0	0	0	0	—
TOTAL	**5**	**0**	**22**	**49**	**5**	**0**	**5**	**—**
Second Survey[c]								
Canyon Creek	0	0	0	0	0	0	0	0
Chekok Creek East	0	0	0	0	0	0	0	0
Chekok Creek West	0	0	0	0	0	0	0	0
Chekok Bay Creek	0	0	0	0	0	0	0	0
Chinkelyes Creek	0	0	0	0	0	0	0	0
Eagle Bay Creek East	0	0	0	0	0	0	0	0
Eagle Bay Creek West	0	0	0	0	0	0	0	0
Iliamna River	2	0	5	12	1	4	5	1
Knutson Creek	0	0	0	0	0	0	0	0
Newhalen River	0	0	2	4	5	1	6	1
Pile River	0	0	0	0	1	3	4	1
Roadhouse Creek	0	0	0	0	0	0	0	0
Stonehouse Creek	0	0	0	0	2	16	18	2
West Newhalen Branch	0	0	0	0	0	0	0	0
TOTAL	**2**	**0**	**7**	**16**	**9**	**24**	**33**	**5**

Notes:

a. Total = (number of single males) + (number of single females) + (number of pairs x 2).

b. Pre-nesting survey was flown on May 23-25 and brood-rearing survey on July 28-29.

c. Pre-nesting survey was flown on May 29-30 and brood-rearing survey on August 12 and 14.

TABLE 16.10-8
Numbers of Waterfowl Broods (Excluding Harlequin Ducks) Observed on Rivers during Brood-rearing Aerial Surveys for Harlequin Ducks, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Location	American Wigeon	Mallard	Northern Pintail	Green-winged Teal	Unidentified scaup	Unidentified scoter	Long-tailed Duck	Common Merganser	Red-breasted Merganser	Unidentified Merganser	Total
Canyon Creek	0	0	0	0	0	0	0	0	2	0	2
Chekok Creek East	0	0	0	0	0	0	0	1	1	0	2
Chekok Creek West	0	1	0	0	0	0	0	0	0	0	1
Chekok Bay Creek	1	2	1	1	0	0	1	0	3	0	9
Chinkelyes Creek	0	0	0	0	0	0	0	1	1	0	2
Eagle Bay Creek East	0	0	0	0	0	0	0	0	0	0	0
Eagle Bay Creek West	0	0	1	1	1	1	0	0	1	0	5
Iliamna River	0	0	0	0	1	0	0	1	5	2	9
Knutson Creek	0	0	0	0	0	0	0	0	0	0	0
Newhalen River	2	0	0	0	0	0	0	2	2	2	8
Pile River	0	0	0	0	0	0	0	2	0	0	2
Roadhouse Creek	0	0	0	0	0	0	0	0	0	0	0
Stonehouse Lake Creek	0	0	0	0	0	0	0	0	0	0	0
West Newhalen Branch	0	0	1	0	0	0	0	0	1	0	2
TOTAL	**3**	**3**	**3**	**2**	**2**	**1**	**1**	**7**	**16**	**4**	**42**

FIGURES

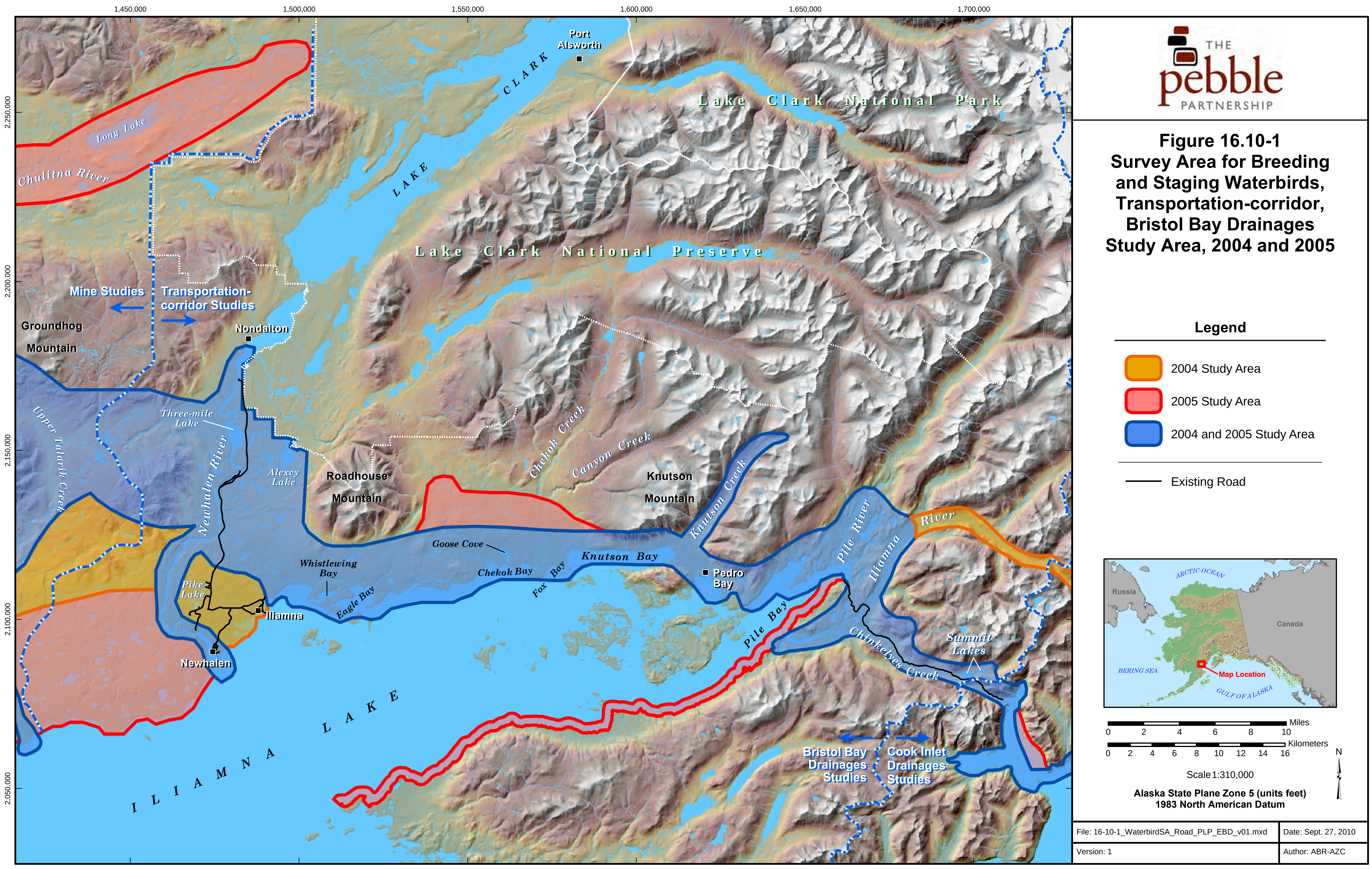


Figure 16.10-1 Survey Area for Breeding and Staging Waterbirds, Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

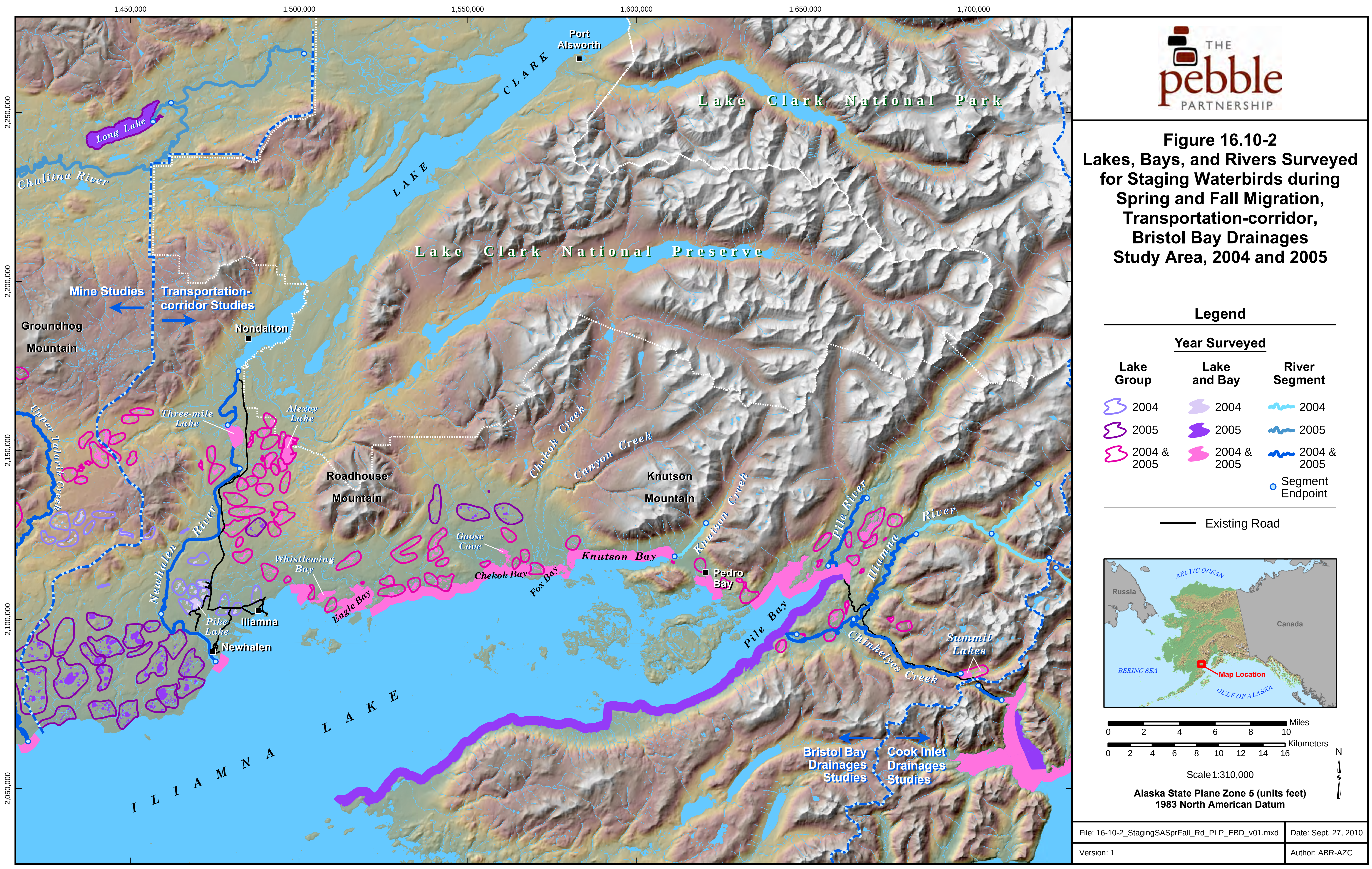


Figure 16.10-2
Lakes, Bays, and Rivers Surveyed for Staging Waterbirds during Spring and Fall Migration, Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

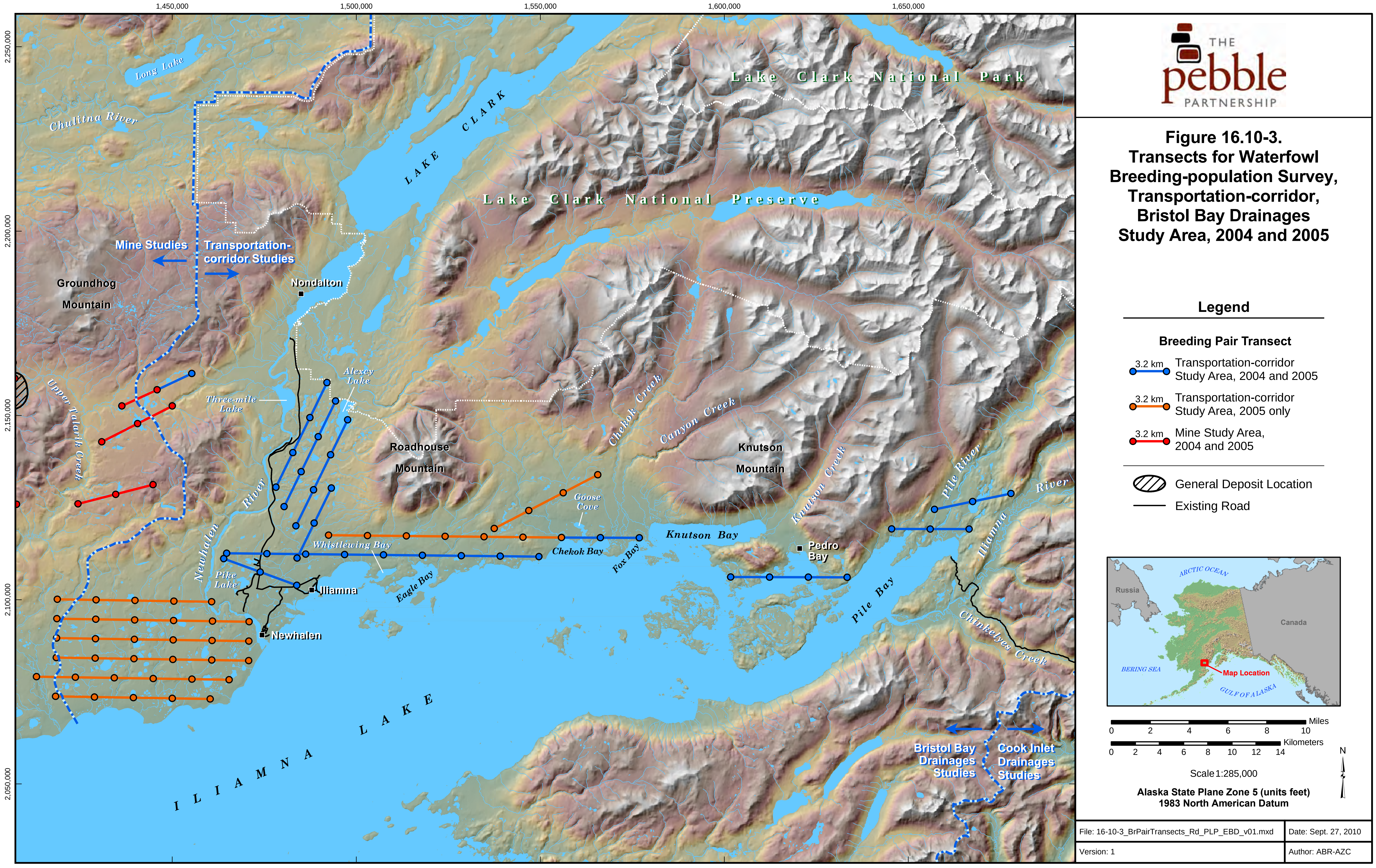
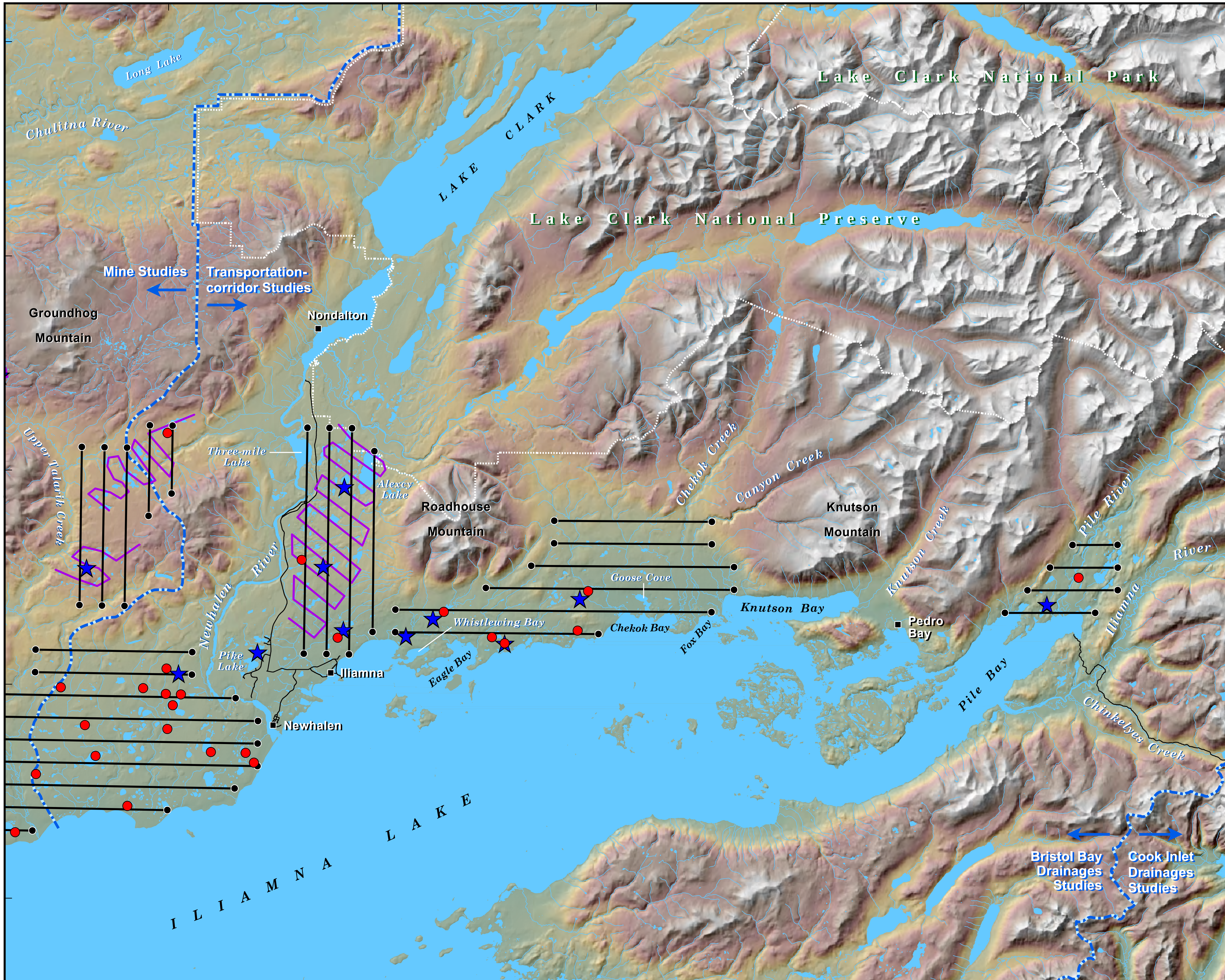


Figure 16.10-3. Transects for Waterfowl Breeding-population Survey, Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

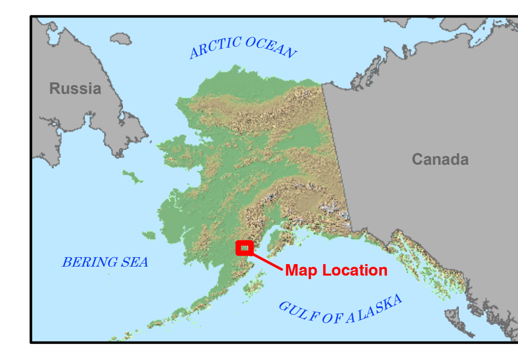


THE pebble PARTNERSHIP

Figure 16.10-4
Swan Nesting Locations, Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

Legend

- 2004 Nest
- 2005 Nest
- 2004 Survey Transect
- 2005 Survey Transect
- Existing Road



Miles: 0 2 4 6 8 10

Kilometers: 0 2 4 6 8 10 12 14

N

Scale 1:285,000

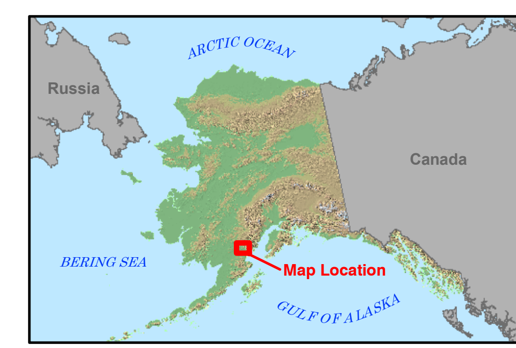
Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: 16-10-4_SwanNesting_Road_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC

Figure 16.10-5
Harlequin Duck Pre-nesting Locations, Transportation-corridor, Bristol Bay Drainages Study Area, 2004

Legend

- Pairs (# pairs >1)
- Males (# birds >1)
- Female
- Survey Stream
- Existing Road



Miles: 0 2 4 6 8 10

Kilometers: 0 2 4 6 8 10 12 14

N

Scale 1:285,000

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

File: 16-10-5_HADUPreNest04_Rd_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC

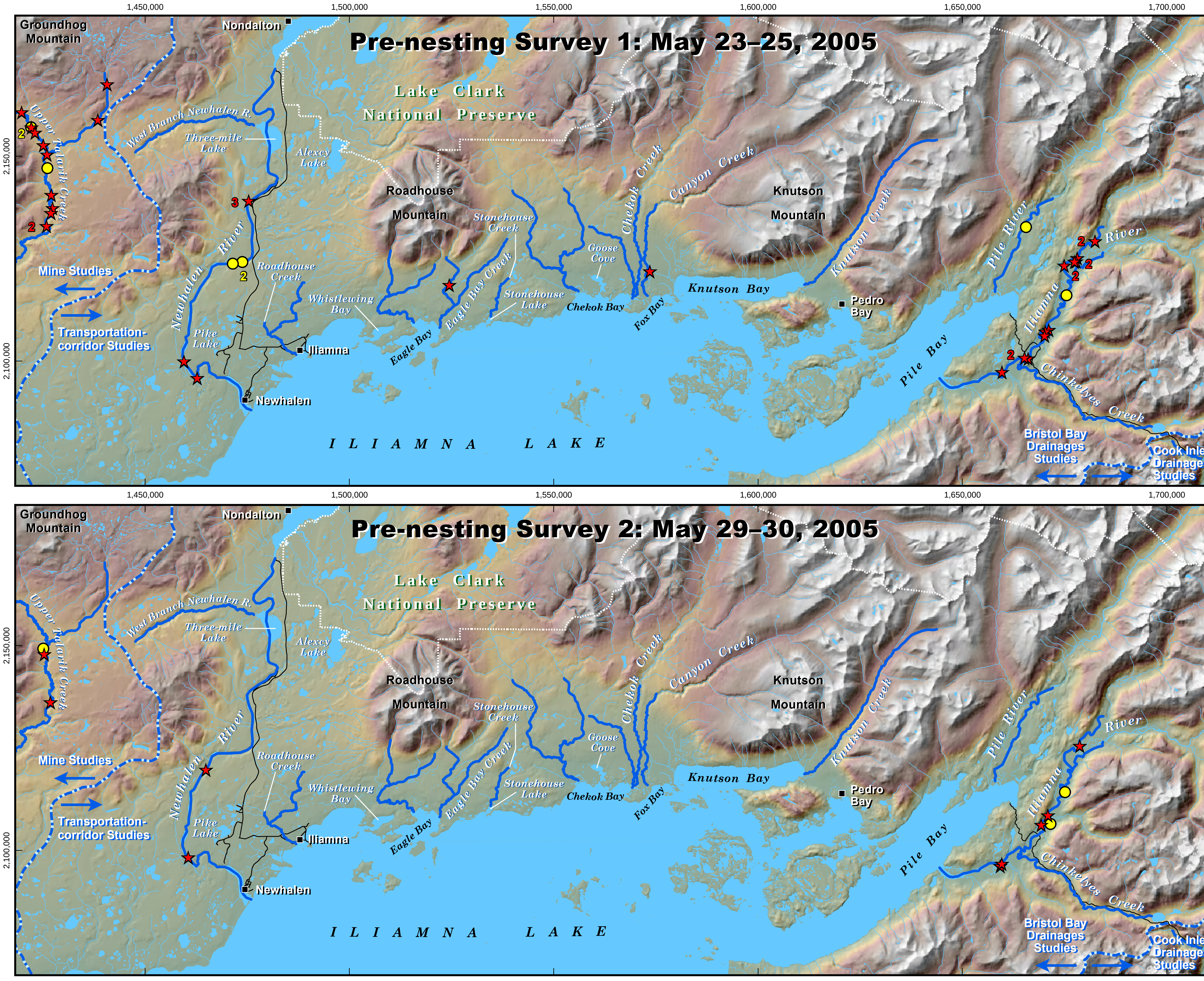


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Figure 16.10-6
Harlequin Duck
Pre-nesting Locations,
Transportation-corridor,
Bristol Bay Drainages Study Area,
2005

Legend

- Pairs (# pairs >1)
- Males (# birds >1)
- Survey Stream
- Existing Road

Miles: 0 2 4 6 8 10

Kilometers: 0 2 4 6 8 10 12 14

N

Scale 1:290,000

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

File: 16-10-6_HADUPreNest05_Rd_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC

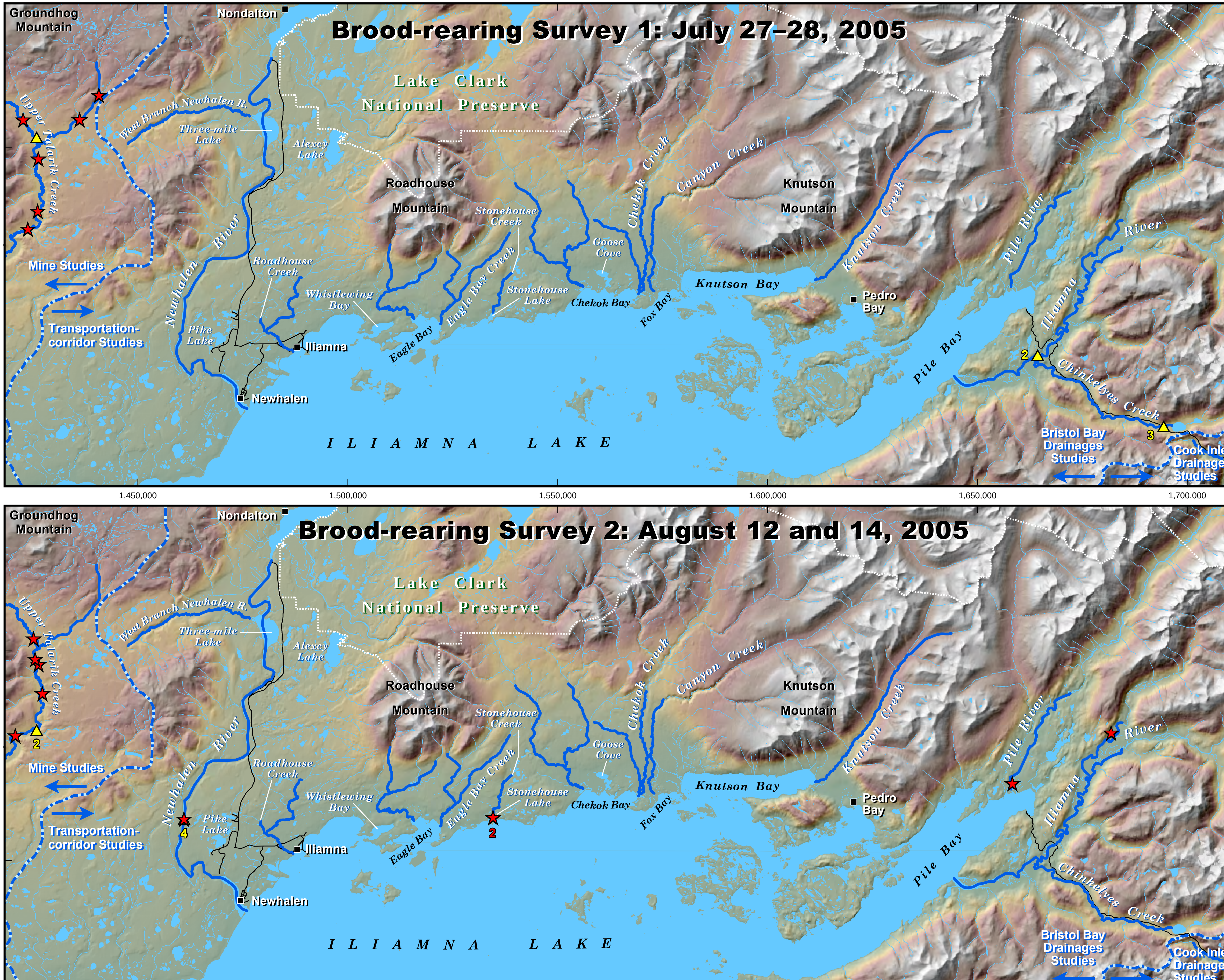

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Figure 16.10-7
Harlequin Duck
Brood-rearing Locations,
Transportation-corridor,
Bristol Bay Drainages Study Area,
2005

Legend

- Broods (# broods >1)
- Females (# birds >1)
- Survey Stream
- Existing Road

Miles: 0 2 4 6 8 10

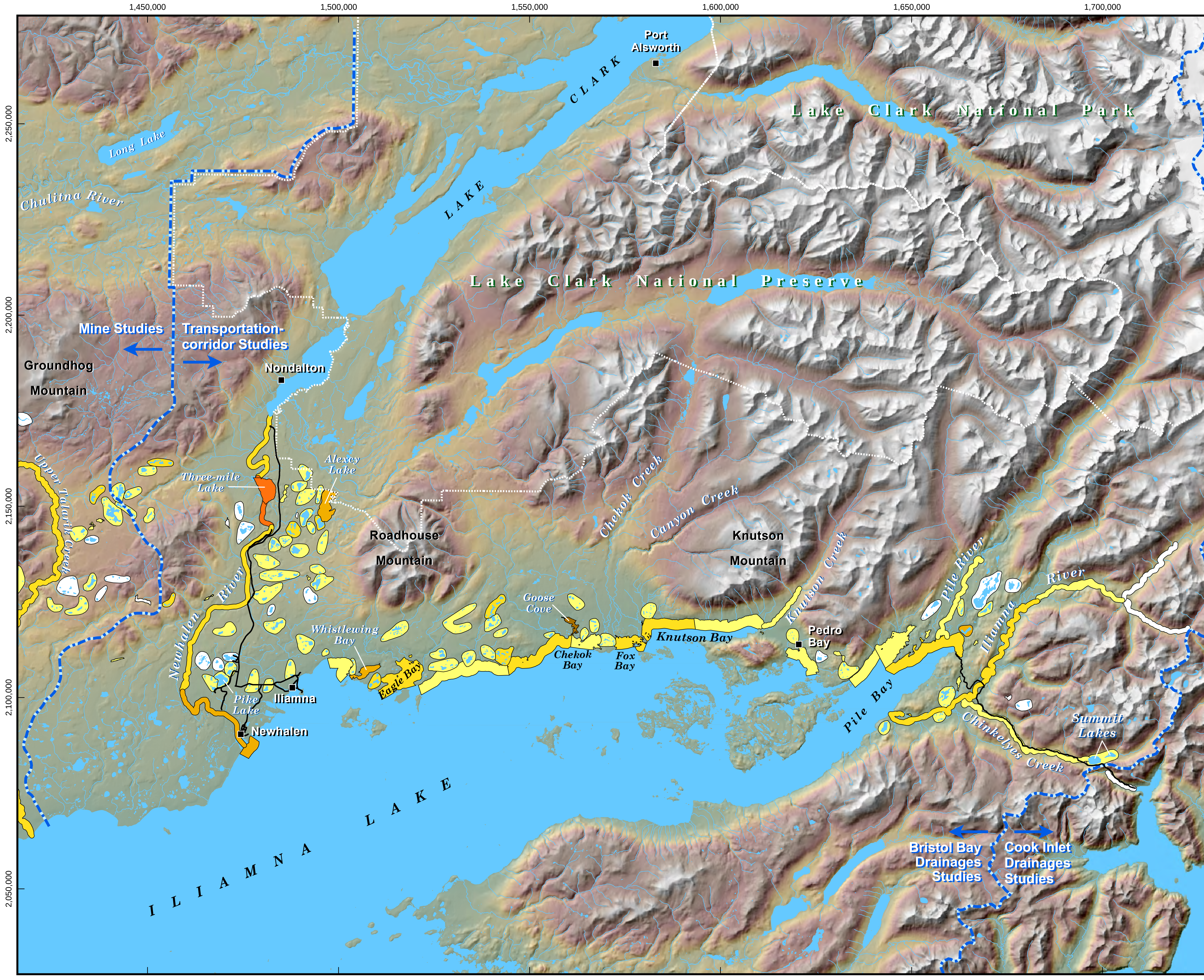
Kilometers: 0 2 4 6 8 10 12 14

Scale 1:290,000

N

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

File: 16-10-7_HADUBrdRear05_Rd_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC



![The Pebble Partnership logo]

Figure 16.10-8
Distribution and Abundance (Maximal Number) of Staging Waterbirds during Spring Migration, Transportation-corridor, Bristol Bay Drainages Study Area, 2004

Legend

Maximal Number of Birds

- 0
- 1 – 25
- 26 – 100
- 101 – 250
- 251 – 500
- 501 – 1000

Existing Road

Miles: 0 2 4 6 8 10

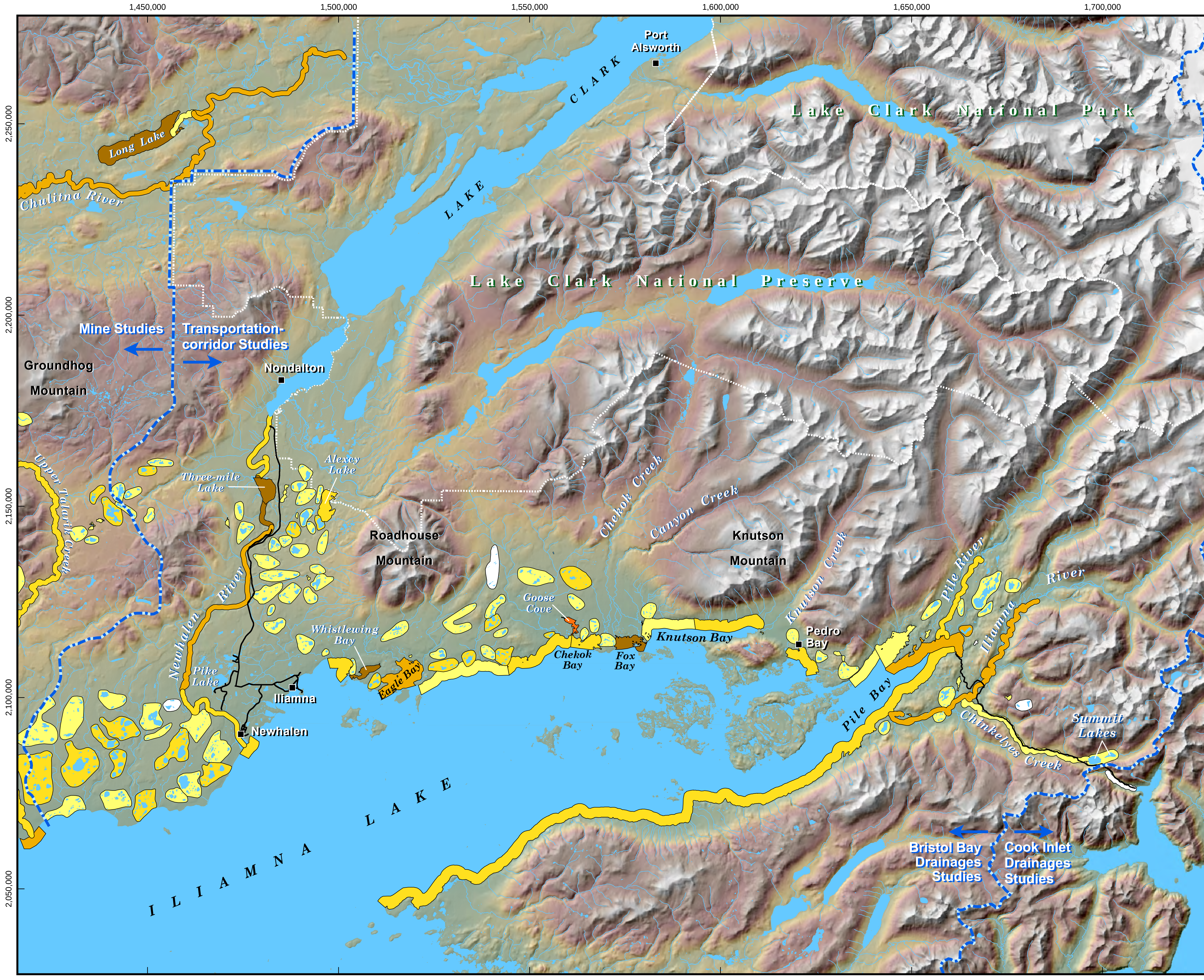
Kilometers: 0 2 4 6 8 10 12 14 16

N

Scale 1:310,000

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

File: 16-10-8_MigrDistSpr04_Rd_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC



![The Pebble Partnership]

Figure 16.10-9
Distribution and Abundance (Maximal Number) of Staging Waterbirds during Spring Migration, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Legend

Maximal Number of Birds

- 0
- 1 – 25
- 26 – 100
- 101 – 250
- 251 – 500
- 501 – 1000

Existing Road

Miles: 0 2 4 6 8 10

Kilometers: 0 2 4 6 8 10 12 14 16

N

Scale 1:310,000

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

File: 16-10-9_MigrDistSpr05_Rd_PLP_EBD_v01.mxd	Date: Sept. 27, 2010
Version: 1	Author: ABR-AZC

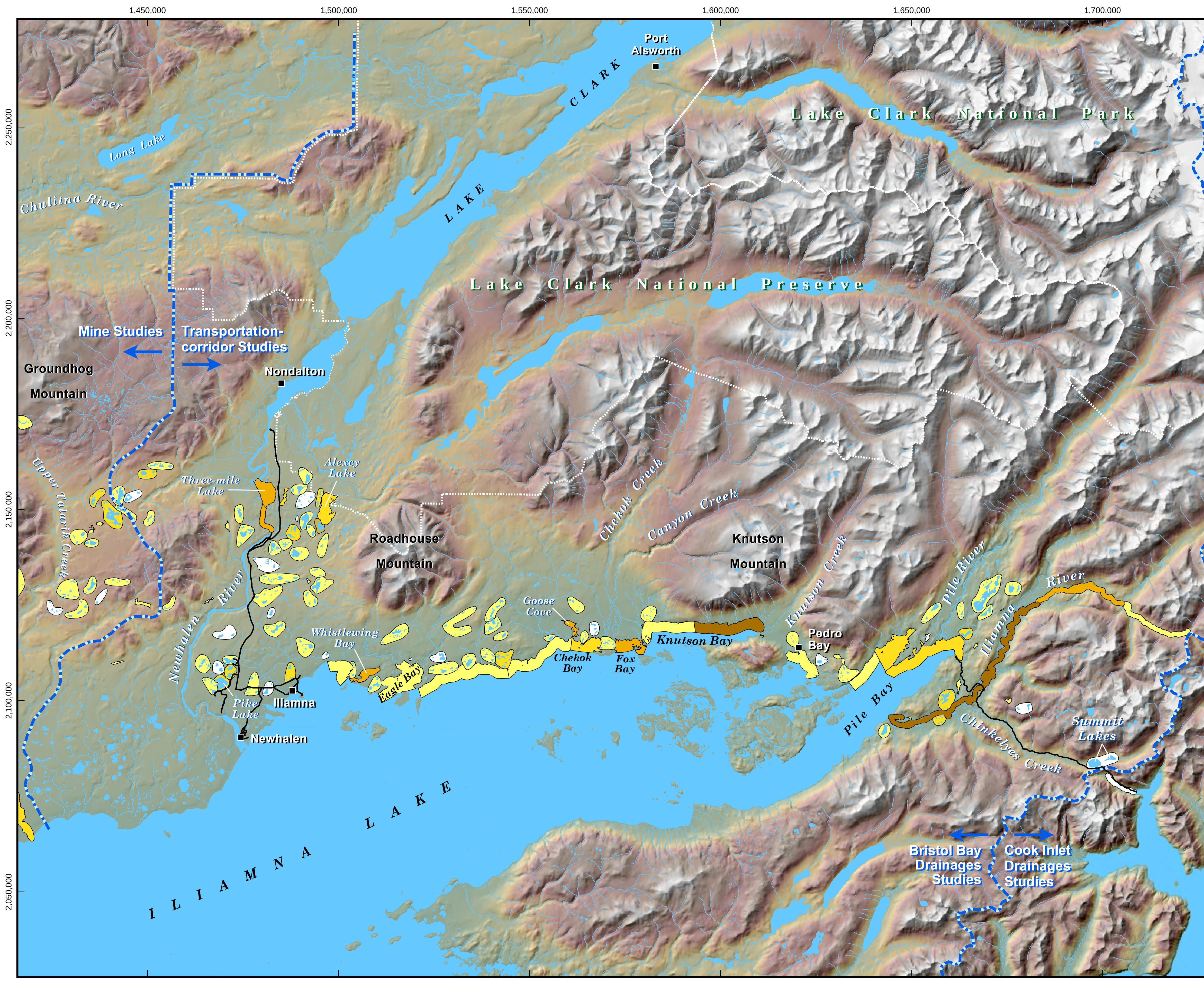


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Figure 16.10-10
Distribution and Abundance (Maximal Number) of Staging Waterbirds during Fall Migration, Transportation-corridor, Bristol Bay Drainages Study Area, 2004

Legend

Maximal Number of Birds

- 0
- 1 – 25
- 26 – 100
- 101 – 250
- 251 – 500

Existing Road

Miles: 0 2 4 6 8 10

Kilometers: 0 2 4 6 8 10 12 14 16

N

Scale 1:310,000

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

File: 16-10-10_MigrDistFall04_Rd_PLP_EBD_v01.mxd	Date: Sept. 28, 2010
Version: 1	Author: ABR-AZC

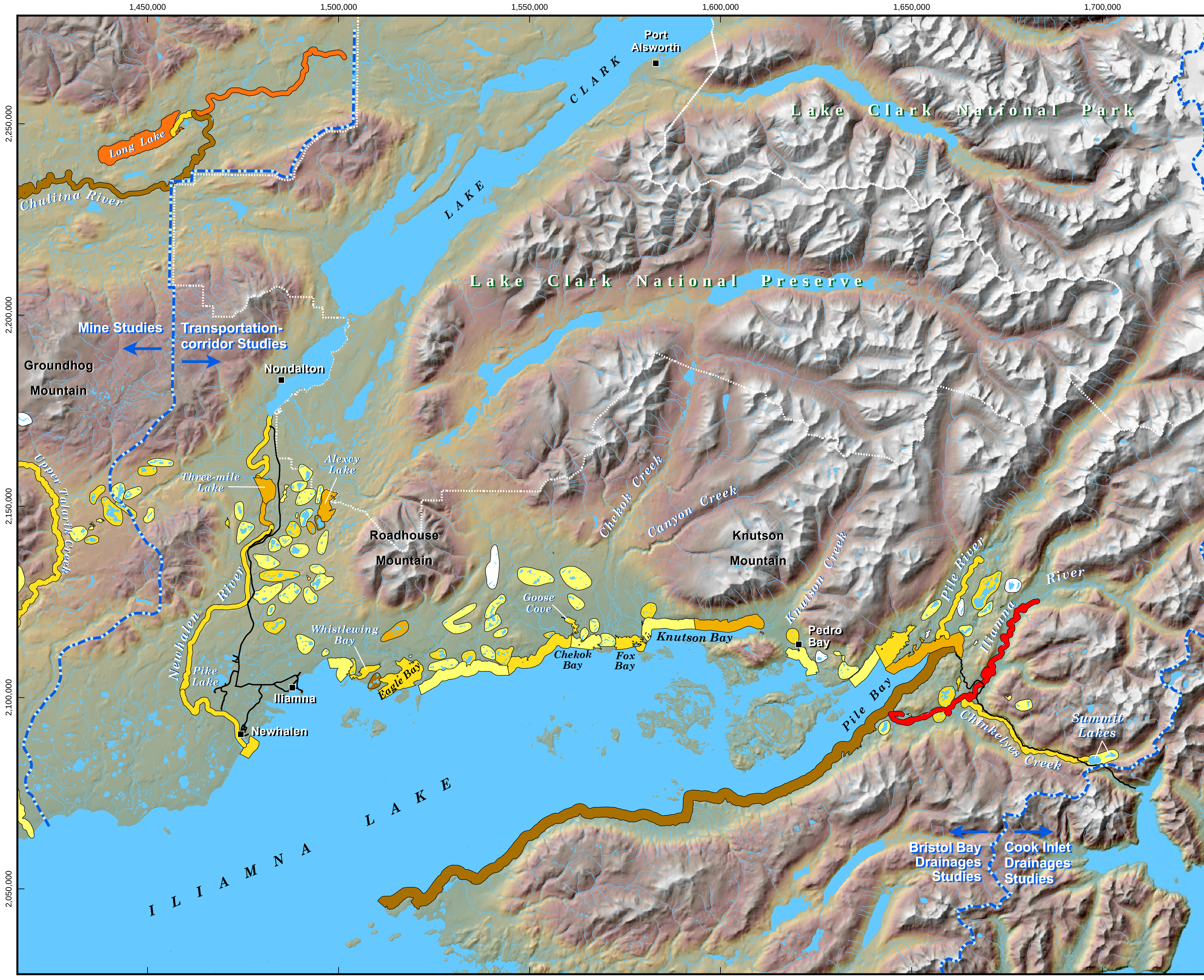

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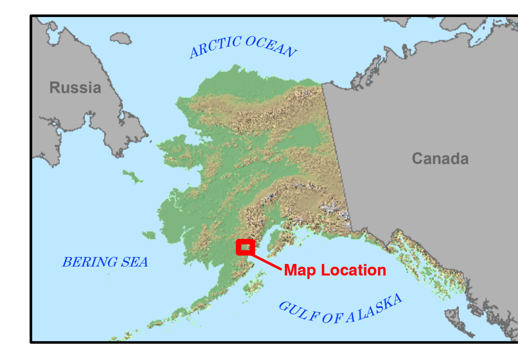
Figure 16.10-11
Distribution and Abundance (Maximal Number) of Staging Waterbirds during Fall Migration, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Legend

Maximal Number of Birds

- 0
- 1 – 25
- 26 – 100
- 101 – 250
- 251 – 500
- 501 – 1000
- 1001 – 2000

Existing Road



Miles: 0 2 4 6 8 10

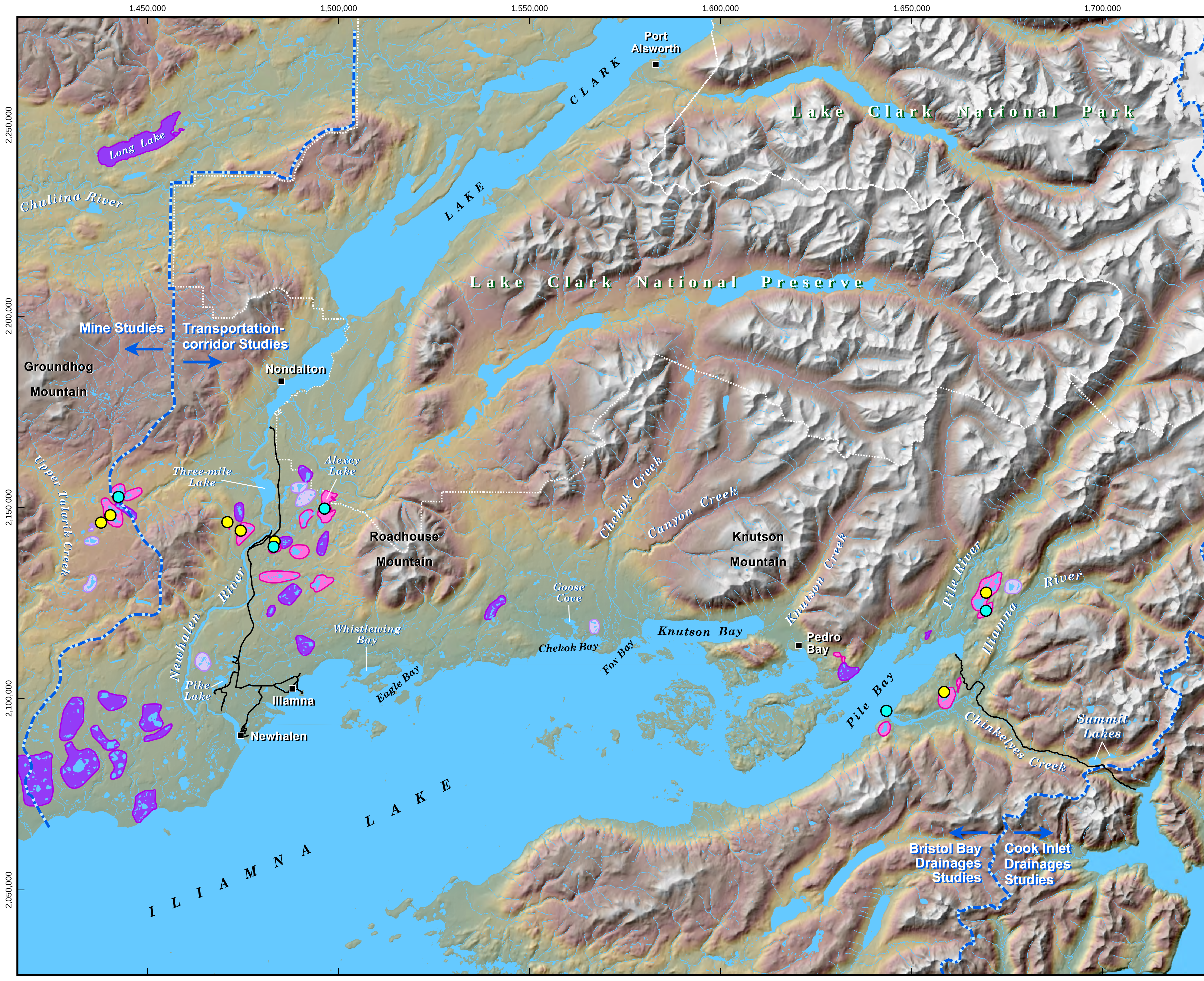
Kilometers: 0 2 4 6 8 10 12 14 16

N

Scale 1:310,000

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

File: 16-10-11_MigrDistFall05_Rd_PLP_EBD_v01.mxd	Date: Sept. 28, 2010
Version: 1	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.10-12
Common Loon Locations, Transportation-corridor, Bristol Bay Drainages Study Area, 2004 and 2005

Legend

Common Loon Brood

2004
2005

Lake Group with Adult Common Loons

2004
2005
2004 and 2005

Existing Road

Miles
0 2 4 6 8 10

Kilometers
0 2 4 6 8 10 12 14 16

N

Scale 1:310,000

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

File: 16-10-12_COLO_0405_Rd_PLP_EBD_v01.mxd	Date: Sept. 28, 2010
Version: 1	Author: ABR-AZC

APPENDICES

APPENDIX 16.10A

NUMBERS OF WATERBIRDS OBSERVED DURING SPRING AND FALL MIGRATION SURVEYS, TRANSPORTATION-CORRIDOR, BRISTOL BAY DRAINAGES STUDY AREA, 2004

APPENDIX 16.10A
Numbers of Waterbirds (by Species-group and Species) Observed during Spring and Fall Migration Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2004

	Spring				Fall				
Species-group/ Species	**Apr 21**	**May 3-4**	**May 13-14**	**May 22-23**	**Sep 2-3**	**Sep 13-14**	**Sep 23-24**	**Oct 6-7**	**Oct 21**
Waterfowl									
Greater White-fronted Goose	20	16	0	0	0	0	0	0	0
Canada/Cackling Goose	69	0	0	0	0	0	0	0	0
Unidentified goose	80	12	0	0	0	0	0	0	0
Unidentified swan	503	47	27	23	33	37	37	11	2
American Wigeon	4	164	125	24	21	0	1	5	0
Mallard	120	188	75	151	34	89	74	171	178
Northern Shoveler	0	51	0	2	0	0	0	0	0
Northern Pintail	117	180	45	55	8	30	1	0	0
Green-winged Teal	0	161	33	13	0	28	0	20	5
Unidentified dabbling duck	0	5	2	10	65	105	0	0	0
Canvasback	0	1	0	0	0	0	0	0	0
Unidentified scaup	14	198	457	138	204	216	170	300	79
Harlequin Duck	0	0	0	4	0	0	0	0	0
Surf Scoter	0	2	4	0	0	0	0	0	0
White-winged Scoter	0	0	0	0	0	0	5	0	0
Black Scoter	0	0	17	0	0	5	19	5	0
Unidentified scoter	0	0	0	0	17	0	0	0	0
Long-tailed Duck	0	0	8	0	5	0	0	0	0
Bufflehead	0	74	24	2	0	0	0	0	0
Unidentified goldeneye	18	77	110	66	34	19	0	5	41
Common Merganser	47	37	23	15	0	0	0	98	152
Red-breasted Merganser	0	60	43	5	15	0	0	141	111
Unidentified merganser	157	165	259	182	97	72	390	231	46
Unidentified diving duck	8	0	2	6	9	29	17	10	0
Unidentified duck	454	215	67	13	239	403	80	56	113
Waterfowl Total	1,611	1,653	1,321	709	781	1,033	794	1,053	727
Loons/Grebes									
Pacific Loon	0	0	0	2	0	0	0	0	0
Common Loon	1	7	10	6	32	8	3	2	0
Red-necked Grebe	0	1	0	0	0	0	0	0	0
Loon/Grebe Total	1	8	10	8	32	8	3	2	0

	Spring				Fall				
Species-group/ Species	**Apr 21**	**May 3-4**	**May 13-14**	**May 22-23**	**Sep 2-3**	**Sep 13-14**	**Sep 23-24**	**Oct 6-7**	**Oct 21**
Cormorants									
Double-crested Cormorant	0	1	0	7	0	0	3	4	0
Unidentified cormorant	0	1	0	0	4	2	0	0	0
Cormorant Total	0	2	0	7	4	2	3	4	0
Cranes									
Sandhill Crane	0	1	0	0	5	6	0	0	0
Shorebirds									
Unidentified yellowlegs	13	33	6	4	0	0	0	0	0
Large shorebird	0	8	3	1	0	0	0	0	0
Medium shorebird	0	30	28	1	0	0	0	0	0
Small shorebird	0	41	3	1	0	0	0	0	0
Shorebird Total	13	112	40	7	0	0	0	0	0
Gulls/Terns/Jaegers									
Bonaparte's Gull	0	24	12	9	0	0	0	0	0
Mew Gull	0	39	30	4	0	0	0	1	0
Glaucous-winged Gull	8	37	35	19	81	196	176	570	118
Unidentified gull	0	0	7	3	0	100	225	125	0
Arctic Tern	0	20	160	15	0	0	5	0	0
Parasitic Jaeger	0	0	1	0	0	0	0	0	0
Gull/Tern/Jaeger Total	8	120	245	50	81	296	406	696	118
TOTAL	1,633	1,896	1,616	781	903	1,345	1,206	1,755	845

APPENDIX 16.10B

NUMBERS OF WATERBIRDS OBSERVED DURING SPRING AND FALL MIGRATION SURVEYS, TRANSPORTATION-CORRIDOR, BRISTOL BAY DRAINAGES STUDY AREA, 2005

APPENDIX 16.10B
Numbers of Waterbirds (by Species-group and Species) Observed during Spring and Fall Migration Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

	Spring					Fall						
Species-group/ Species	**Apr 20**[a]	**Apr 24**	**May 3-4**	**May 13-15**[b]	**May 21-23**[b]	**Aug 18-19**[b]	**Aug 27-29**	**Sep 6-8**	**Sep 13-14**	**Sep 29-30**	**Oct 6-7**	**Oct 11-12**
Waterfowl												
Greater White-fronted Goose	0	40	67	8	0	0	0	0	0	0	0	0
Canada/Cackling Goose	0	33	38	2	0	0	0	0	0	0	0	0
Unidentified goose	84	50	0	0	0	0	0	0	0	0	0	0
Unidentified swan	225	535	66	34	40	85	20	17	20	18	18	6
Gadwall	0	0	0	8	2	0	0	0	0	0	1	0
American Wigeon	0	60	74	97	89	141	111	57	16	43	5	20
Mallard	0	219	101	187	130	140	98	411	149	79	183	155
Northern Shoveler	0	10	16	65	21	54	14	47	0	0	0	23
Northern Pintail	0	158	44	90	68	31	58	7	20	2	1	0
Green-winged Teal	0	171	59	22	10	78	68	137	23	6	3	4
Unidentified dabbling duck	0	437	270	0	0	10	0	0	46	0	0	10
Ringed-neck Duck	0	0	0	0	0	0	0	0	0	0	1	0
Unidentified scaup	0	15	62	480	517	315	239	561	199	582	454	411
Harlequin Duck	0	1	10	28	28	27	0	15	30	3	0	16
Surf Scoter	0	0	0	14	63	1	0	35	0	0	0	1
White-winged scoter	0	0	0	6	93	0	0	25	10	0	0	0
Black Scoter	0	0	0	0	16	0	0	0	6	0	0	0
Unidentified scoter	0	0	0	55	191	0	1	0	0	0	0	0
Long-tailed Duck	0	0	0	0	3	2	0	0	0	0	0	0
Bufflehead	0	14	8	1	1	0	28	40	0	8	13	4
Unidentified goldeneye	0	68	136	125	112	79	162	153	80	83	84	252

	Spring					Fall						
Species-group/ Species	**Apr 20[a]**	**Apr 24**	**May 3-4**	**May 13-15[b]**	**May 21-23[b]**	**Aug 18-19[b]**	**Aug 27-29**	**Sep 6-8**	**Sep 13-14**	**Sep 29-30**	**Oct 6-7**	**Oct 11-12**
Common Merganser	0	132	0	2	84	18	0	0	25	2	55	7
Red-breasted Merganser	0	5	0	24	308	0	0	6	18	0	221	0
Unidentified merganser	0	180	423	395	282	328	438	596	419	336	0	226
Unidentified diving duck	0	1	0	5	4	12	1	0	2	0	0	16
Unidentified duck	737	327	205	9	38	3	0	0	143	38	14	16
Waterfowl Total	1,046	2,456	1,579	1,657	2,100	1,324	1,238	2,107	1,206	1,200	1,067	1,167
Loons/Grebes												
Red-throated Loon	0	0	0	0	0	1	0	0	0	0	0	0
Pacific Loon	0	0	0	2	3	0	0	0	0	0	0	0
Common Loon	0	0	9	17	32	25	25	18	18	4	1	1
Unidentified loon	0	0	0	0	2	1	0	0	0	0	0	0
Red-necked Grebe	0	0	0	0	0	0	0	0	3	8	0	1
Loon/Grebe Total	0	0	9	19	37	27	25	18	21	12	1	2
Cormorants												
Double-crested Cormorant	0	0	0	0	0	4	7	2	0	1	2	0
Unidentified cormorant	0	0	0	9	1	0	0	0	0	2	0	0
Cormorant Total	0	0	0	9	1	4	7	2	0	3	2	0
Shorebirds												
Unidentified yellowlegs	1	28	11	19	43	0	0	0	0	0	0	0
Medium shorebird	0	0	0	3	0	0	0	0	0	0	0	0
Small shorebird	0	0	0	3	18	1	0	0	0	0	0	0
Shorebird Total	1	28	11	25	61	1	0	0	0	0	0	0

Species-group/ Species	Spring					Fall						
	Apr 20[a]	Apr 24	May 3-4	May 13-15[b]	May 21-23[b]	Aug 18-19[b]	Aug 27-29	Sep 6-8	Sep 13-14	Sep 29-30	Oct 6-7	Oct 11-12
Gulls/Terns/Jaegers												
Bonaparte's Gull	0	1	9	6	14	0	0	0	0	0	0	0
Mew Gull	0	9	14	21	34	0	0	8	0	0	0	1
Herring Gull	0	0	0	4	0	0	0	0	0	0	0	0
Glaucous-winged Gull	0	39	68	83	59	208	301	338	494	571	424	209
Unidentified gull	0	22	95	15	30	0	354	1144	582	519	22	293
Arctic Tern	0	0	26	45	48	0	0	0	0	0	0	0
Unidentified jaeger	0	0	0	0	1	0	0	0	0	0	0	0
Gull/Tern/Jaeger Total	0	71	212	174	186	208	655	1,490	1,076	1,090	446	503
TOTAL	1,047	2,555	1,811	1,884	2,385	1,564	1,925	3,617	2,303	2,305	1,516	1,672

Notes:

a. Reconnaissance survey conducted by pilot only.

b. Includes the survey lakes from Iliamna Lake to 2 kilometers inland between Upper Talarik Creek and the Newhalen River (Figure 16.10-2).

16.11 Breeding Landbirds and Shorebirds—Transportation Corridor

16.11.1 Introduction

The results of the 2005 breeding landbird and shorebird surveys conducted in the transportation-corridor, Bristol Bay drainages study area are presented in this section. This work focuses on assessing the baseline conditions for breeding landbirds and shorebirds in the area of the possible transportation corridor for the Pebble Project in the Bristol Bay drainages. Only observations of landbirds and shorebirds are reported here. Observations of waterbirds and raptors recorded in the study area during the survey effort for landbirds and shorebirds are reported in Section 16.10 (waterbirds) and Section 16.9 (raptors). This report summarizes the work conducted during the 2005 breeding season, documenting the landbird and shorebird species observed, their abundance, and their use of the mapped habitats in the study area. The mapping of wildlife habitats in the study area is presented in Section 16.6 (habitat mapping and habitat-value assessments).

16.11.2 Study Objectives

The primary objective of this work was to collect baseline data on breeding landbirds and shorebirds along the transportation corridor in the Bristol Bay drainages region. Researchers recorded all species observed in the field, paying special attention to species of conservation concern. The specific objectives of this study were to:

- Identify the assemblage of landbird and shorebird species that use the study area during the breeding season.
- Quantify the abundance of each species.
- Determine which habitats in the study area are important for breeding landbirds and shorebirds.

16.11.3 Study Area

The transportation-corridor, Bristol Bay drainages study area in which point-count surveys were conducted in 2005 was 108 kilometers long and 610 meters wide, and comprised approximately 66 square kilometers (Figure 16.11-1).

The study area runs from the Summit Lakes area in the Chigmit Mountains east of Iliamna Lake to near the base of Ground Hog Mountain west of the Newhalen River and traverses the northern shore of Iliamna Lake. The terrain in the area is predominantly characterized by gentle slopes, but some steeper mountainous slopes occur in localized areas. Steeper terrain occurs especially along Chinkelyes Creek in the Chigmit Mountains east of Pile Bay and at the base of Knutson and Roadhouse Mountains. Subalpine areas of white spruce (*Picea glauca*) woodland with upland dwarf scrub and graminoid-herb openings are common at higher elevations, especially to the east towards Cook Inlet. Well-drained areas at higher elevations are dominated by upland dwarf scrub. Low- and tall-scrub habitats occur in upland, lowland, and riverine areas. Low scrub is typically dominated by willows (*Salix* spp.), and tall scrub is dominated by alder (*Alnus* spp.), willows, or both. Extensive areas of mixed white spruce/Kenai birch (*Betula kenaica*) forest occur throughout the survey area and are almost always open forests with a substantial low- and/or tall-scrub understory of alders and willows. Along the floodplains of the larger streams and rivers, which run into Iliamna Lake, open riverine forests of poplar (*Populus balsamifera and Populus trichocarpa*) and mixed white spruce/poplar forests occur. Many forest openings are dominated by mesic lowland low scrub or wetter lowland scrub bog, but dwarf-scrub openings also occur at more well-drained sites and higher elevations. West of Roadhouse Mountain, towards the mine study area, extensive areas of upland white spruce woodland exist with an understory of low and dwarf scrub and fruticose lichens.

16.11.4 Previous Studies

A search of the published and unpublished biological literature for the region surrounding the transportation-corridor, Bristol Bay drainages study area did not reveal any studies of breeding landbirds and shorebirds that apply directly to the study area. A number of avifaunal studies, however, have been conducted within a broader region surrounding the study area (Figure 16.11-2) and provide general information on the relative abundance and distribution of breeding landbirds and shorebirds. Previous studies have been conducted in the Bristol Bay region (Hurley, 1931, 1932); the Iliamna Lake area (Williamson and Peyton, 1962); the northern Alaska Peninsula (Osgood, 1904; Gibson, 1970; Gill et al., 1981); the Katmai region (Cahalane, 1944, 1959); Katmai and Lake Clark national parks (Bennett, 1996a, 1996b; Gill et al., 1999; Gill and Tibbitts, 2003; Ruthrauff et al., 2007); Ugashik Bay (Gibson and Kessel, 1983); the Becharof Lake area (Dewhurst et al., 1996a; Moore and Leeman, 1996); the Mother Goose Lake area (Dewhurst et al., 1996b; Egan and Adler, 2001); or consider birds broadly in southwestern Alaska (Kessel and Gibson, 1978; Bennett, 1996c). None of these studies, however, is directly comparable to surveys conducted in the transportation-corridor, Bristol Bay drainages study area because of differences in survey methods, timing of surveys, habitats surveyed, field effort (e.g., number of point-counts conducted), and/or geographical or elevational extent of the surveys. The most important of these factors is variability in the survey coverage of different habitats, which can result in a different set of landbird and shorebird species being recorded in different studies and in differences in abundance within species. The conclusions that can be drawn from comparisons of the work done in the transportation-corridor, Bristol Bay drainages study area to these other regional studies therefore are limited.

16.11.5 Scope of Work

Surveys for breeding landbirds and shorebirds were conducted in the transportation-corridor, Bristol Bay drainages study area during June 2005. Charles T. Schick and Jennifer H. Boisvert, of ABR, Inc., Anchorage, Alaska, conducted the study according to the approach described in the *Draft Environmental Baseline Studies, 2005 Study Plans* (NDM, 2005). This work included the following activities:

- Allocating point-count sample plots based on aerial photosignature type, which allowed sampling of the important breeding-bird habitats in the study area.
- Performing early morning point-counts at each sample location.
- Recording habitat-use information (when possible) for all species observed at each point-count location.
- Recording observations and habitat-use information for less common species and/or species of conservation concern when in transit between point-count locations.

16.11.6 Methods

16.11.6.1 Field Surveys and Habitat-use Analyses

Surveys for breeding landbird and shorebirds in the transportation-corridor, Bristol Bay drainages study area followed the methods outlined in the 2005 study plan (NDM, 2005). Researchers used variable circular-plot point-count methods (Ralph et al., 1995; Buckland et al., 2001). These survey methods were designed primarily to detect singing male passerine birds defending territories and have become the standard method for surveying breeding landbirds in remote terrain in Alaska (USGS, 2006). These methods also have recently been adopted for inventories of breeding shorebirds in Alaska (Ruthrauff et al., 2007; ASG, 2006).

Researchers selected point-count locations for sampling among the available habitats in the study area using true-color aerial photography (from Aero-Metric, September 2004). A formal stratified-random sampling of points within each vegetation or habitat type, using a GIS, would have been preferable, but this was not possible given the lack of a fine-scale vegetation or habitat map for the area at the time the surveys were conducted. A completely random allocation of sample points across the survey area also could have been attempted, but this would have resulted in an over-sampling of the most common habitat types and an under-sampling, or omission, of less common habitats. Instead, researchers used the prominent photosignatures on the aerial photography as the sampling strata. Sample points were located in a haphazard fashion within each photosignature (by a vegetation ecologist with no knowledge of bird-habitat associations), subject to the restriction of maintaining a minimum distance of 500 meters between sample points. This sampling scheme resulted in a selection of point-count locations that was unbiased with respect to the distribution of birds on the landscape. Sample points were selected to satisfy two criteria:

- To allocate points within all prominent photosignatures evident on the aerial photography.
- To establish an adequate spatial representation of points along the study area.

The first criterion was established to help meet one of the primary objectives of this work, which was to assess habitat associations of breeding landbirds and shorebirds. For the second criterion, sample points were spread broadly across the survey area, and replicated within each photosignature to try to capture any spatial variability in habitat use by breeding birds.

Researchers conducted point-counts in the study area from June 1 through 14, 2005. Survey timing was selected to coincide with the peak breeding period for landbirds in southwestern Alaska. Many shorebirds start breeding activities earlier in May in southwest Alaska, but shorebirds were still present and vocal during the surveys. Many were agitated and giving alarm vocalizations in the presence of humans and may have been tending broods. Therefore, the habitat-association information acquired for shorebirds in the study area will still indicate which habitats are used for breeding (especially brood-rearing). All field point-count surveys and habitat-use analyses were conducted as described for the landbird and shorebird studies in the mine study area (see Section 16.5.6.1).

16.11.6.2 Species of Conservation Concern

To determine which landbird and shorebird species occurring in the transportation-corridor, Bristol Bay drainages study area currently are listed as species of conservation concern, researchers consulted bird-conservation lists from federal and state management agencies, conservation organizations, and bird working-groups that directly address the conservation concerns for Alaskan birds (Table 16.11-1). Species of conservation concern in the transportation-corridor study area were selected as described for the mine study area (see Section 16.5.6.2). Additional information on bird species of conservation concern in the transportation-corridor study area is presented in Chapter 17 (threatened and endangered species and species of conservation concern). For each species of conservation concern recorded in the transportation-corridor study area, additional research reports were reviewed to provide background ecological information on the reasons for conservation concern (see Section 16.11.7).

16.11.7 Results and Discussion

Point-count locations were spread, as much as possible, along the full length of the linear transportation-corridor, Bristol Bay drainages study area to adequately sample the spatial variability in habitat types occurring within the area (Figure 16.11-1). Researchers conducted 154 point-counts and recorded 1,831 individual birds in the study area in 2005. One-hundred sixty-seven birds were recorded as incidental and in-transit observations in the study area (Appendix 16.11A).

Breeding landbirds and/or shorebirds were recorded in each of the 12 habitat types sampled (Table 16.11-2); 25 wildlife habitats were mapped in the study area (see Section 16.6), but not all mapped habitats were sampled with point-count surveys. Many of the unsampled habitats were in upland and alpine physiographic areas at the edges of the corridor study area or were riverine or lacustrine waterbody types not targeted for point-count surveys.

The number of bird species (species richness) observed in each of habitat ranged from two to 30 and the average number of birds recorded per count in each habitat ranged from 0.7 to 7.8 (these figures were calculated using focal observations only; Table 16.11-2). The most productive breeding habitats, in terms of bird abundance (using focal observations per point count as the measure of abundance), were Riverine Moist Mixed Forest, Riverine Low Willow Scrub, Upland and Lowland Moist Mixed Forest, Upland and Lowland Spruce Forest, Upland Moist Tall Alder Scrub, and Upland Moist Low Willow Scrub. In each of these six habitats, more than five birds were observed per count; in the remaining habitats, fewer than four birds were recorded per count. One habitat (Upland and Lowland Moist Mixed Forest) supported the highest numbers of breeding-bird species (30) while three other habitats (Upland and Lowland Spruce Forest, Riverine Moist Mixed Forest, and Lowland Ericaceous Scrub Bog) supported intermediate numbers of species (15 to 24). The remaining habitats supported nine or fewer species each. Many of the habitat types with the highest species richness also had high bird abundance, as measured by observations per count (Table 16.11-2).

16.11.7.1 Species Richness and Abundance by Species-Group

Including the incidental and in-transit observations recorded outside the point-count periods, researchers identified 53 species of landbirds and shorebirds, combined, in the transportation-corridor, Bristol Bay drainages study area during 2005 (Tables 16.11-3 and 16.11-7). Of these 53 species, most (46 species) were landbirds, primarily passerines; the remaining seven species were shorebirds.

Considering only those 47 species observed systematically during point-count surveys in the study area, passerines were clearly the dominant group of landbirds, with 32 species recorded; other landbird species-groups observed included four species of corvids/shrikes, three woodpeckers, and three species of ptarmigan/grouse (Figure 16.11-3). Five shorebird species were detected during point-counts in the study area.

In terms of abundance, warblers were by far the most abundant birds observed during point-counts in the study area (more than 650 individuals; Figure 16.11-4). Thrushes and waxwings, and sparrows and allies (including juncos) were the second and third most abundant species-groups. Other common species-groups were finches and kinglets. Flycatchers, woodpeckers, swallows, corvids and shrikes, chickadees and allies (including nuthatches), and sandpipers also were observed in the study area, but in small numbers. Very few ptarmigan, plovers, or blackbirds were recorded. It is likely all the abundant and common species were identified during the surveys, although some uncommon or rare species using the area may not have been detected. It is well known that the occurrence and numbers of both landbirds and shorebirds can fluctuate widely among years at any one location, and some rare species may go undetected in a single year of study.

The numbers of landbird and shorebird species observed in the transportation-corridor, Bristol Bay drainages study area can be compared to numbers documented in other studies on the upper Alaska Peninsula and in western Cook Inlet (Figure 16.11-2). To standardize the comparisons, the numbers of species are restricted to only those observations made during point-counts. In the transportation-corridor, Bristol Bay drainages study area, 42 landbird and five shorebird species were recorded, and in Lake Clark National Park (LCNP), 46 landbird and 14 shorebird species were recorded (Ruthrauff et al., 2007). The transportation-corridor, Bristol Bay drainages study area is just south of the LCNP boundary and encompasses habitats similar to those found in LCNP (e.g., riverine, lowland and upland forests, dwarf-scrub tundra, and low and tall scrub). However, the LCNP surveys were conducted over a more extensive geographical area and elevational gradient (e.g., more open upland and alpine areas were included), whereas in this study the sampling was concentrated in forested areas (Table 16.11-2). The greater habitat diversity sampled in LCNP likely accounts for the greater bird-species richness found there, particularly for shorebirds, which selectively use open habitats for breeding. In Katmai National Park (KNP) on the upper Alaska Peninsula, 35 landbird and 11 shorebird species were documented during point-count surveys (Ruthrauff et al., 2007). As with the surveys by Ruthrauff et al. (2007) in LCNP, the KNP surveys were conducted over a large geographic area, but in KNP more open habitats and fewer forested areas were sampled, which is a likely explanation for the greater number of shorebird species and the fewer number of landbird species recorded there relative to this study. In other point-count-based studies of breeding birds conducted on the upper Alaska Peninsula, fewer landbird species were detected. At Becharof National Wildlife Refuge, 19 landbird species were recorded (Moore and Leeman, 1996), and at Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge, 20 landbird species were observed during point-counts (Dewhurst et al., 1996b; Egan and Adler, 2001). The smaller numbers of breeding landbird species observed at these Alaska Peninsula sites relative to the transportation-corridor, Bristol Bay drainages area are likely due primarily to smaller study areas and the reduced habitat diversity (less forested sites) sampled at the Alaska Peninsula sites. The numbers of shorebird species recorded in these Alaska Peninsula studies (seven at Becharof Lake and four at Mother Goose Lake) are comparable to the number (five) recorded in this study.

16.11.7.2 Landbird Occurrence

Researchers observed 42 landbird species (Table 16.11-3) and calculated a mean of 11.6 birds observed per sample point during the point-count surveys in the transportation-corridor, Bristol Bay drainages study area in 2005. Most birds observed were assumed to be nesting in the area, based on observations of nests or repeated observations of display activities, territorial behavior, or alarm/skulking reactions typical of nesting landbirds. Landbird species richness and abundance were both higher in the transportation-corridor, Bristol Bay drainages study area than in the mine study area (Section 16.5). In the mine study area, only 26 landbird species were observed during point-counts, and a mean of 10.2 birds per sample point was calculated over two seasons of study. The greater species richness and abundance of landbirds in the transportation-corridor, Bristol Bay drainages study area undoubtedly is because of the greater habitat diversity and geographical extent surveyed there.

The most frequently observed species (those with at least 70 point-count observations) were considered to be abundant in the transportation-corridor, Bristol Bay drainages study area. Ten species (Wilson's Warbler, Orange-crowned Warbler, Swainson's Thrush, Yellow-rumped Warbler, Golden-crowned Sparrow, Dark-eyed Junco, Ruby-crowned Kinglet, American Robin, Varied Thrush, and Hermit Thrush) were categorized as abundant (Table 16.11-4). Three of these species (Wilson's Warbler, Orange-crowned Warbler, and Swainson's Thrush) were especially abundant and accounted for 33 percent of the point-count observations. Sixteen other species were less frequently observed in the study area (recorded between 10 and 52 times on point-counts) and were considered common in the area. These species are Blackpoll Warbler, White-crowned Sparrow, Common Redpoll, Yellow Warbler, Fox Sparrow, Gray-cheeked Thrush, Savannah Sparrow, Olive-sided Flycatcher, White-winged Crossbill, Northern Waterthrush, Tree Swallow, Gray Jay, Boreal Chickadee, American Tree Sparrow, Alder Flycatcher, and Lincoln's Sparrow. The remaining species were recorded fewer than 10 times on point-counts and were considered uncommon. The average occurrences of landbird species in the study area ranged from 0.006 for Spruce Grouse, Rock Ptarmigan, and Arctic Warbler to 1.351 for Wilson's Warbler (Table 16.11-4).

Landbird abundance in the transportation-corridor, Bristol Bay drainages study area can be compared with landbird abundance found in similar studies of breeding birds conducted on the upper Alaska Peninsula and in western Cook Inlet (Table 16.11-5). Average-occurrence values are used in the comparison table to standardize abundance data across studies in which different numbers of point-counts were conducted. Point-count-based studies of landbirds were conducted at Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge (Dewhurst et al., 1996b; Egan and Adler, 2001), at Becharof Lake in Becharof National Wildlife Refuge (Moore and Leeman, 1996), and in Katmai and Lake Clark national parks (Ruthrauff et al., 2007) (Figure 16.11-2). Differences among these studies in the sizes of study areas and the habitats surveyed make the comparisons approximate, but with these caveats in mind, the comparisons are still instructive.

The most commonly recorded landbird species in the transportation-corridor, Bristol Bay drainages study area, Wilson's Warbler, also was the most common species recorded at Mother Goose Lake (Table 16.11-5). Similarly, Wilson's Warbler was the second most common species recorded at Becharof Lake and the third most common species in KNP. The next most common species recorded in the transportation-corridor, Bristol Bay drainages study area, Orange-crowned Warbler, was the fourth most common species at Mother Goose Lake, the sixth most common species at Becharof Lake, and the seventh most common species in KNP. Golden-crowned Sparrow was the fifth most common species in the transportation-corridor, Bristol Bay drainages study area and was similarly common at Becharof Lake and KNP, where it was the most commonly recorded species; at Mother Goose Lake, Golden-crowned Sparrow was the sixth most common species observed. Comparisons in abundance across these studies for the other landbird species, however, showed less similarity. This likely is due to the fact that in the transportation-corridor, Bristol Bay drainages study, most of the point-count sampling focused on forested habitats, whereas forests largely were not present at Mother Goose Lake and Becharof Lake; more forested habitats were sampled in KNP but there still was a focus on sampling more open habitats in the KNP study. Comparisons of abundance between the transportation-corridor, Bristol Bay drainages study and the LCNP study similarly yielded few commonalities. For example, a different set of especially common species was found in this study (Wilson's Warbler, Orange-crowned Warbler, Swainson's Thrush, Yellow-rumped Warbler) compared to what was found in LCNP (Golden-crowned Sparrow, Common Redpoll, Dark-eyed Junco, American Tree Sparrow). Again, this likely is a result of differences in the intensity of sampling of habitats in the two studies.

The average-occurrence values for Becharof Lake and Mother Goose Lake are slightly higher than those found in the transportation-corridor, Bristol Bay drainages study. Average occurrences for landbirds in the transportation-corridor, Bristol Bay drainages study area ranged from 0.006 to 1.351, at Becharof Lake they ranged from 0.020 to 1.879, and at Mother Goose Lake from 0.007 to 3.057 (Table 16.11-5). For Mother Goose Lake, the next highest average occurrence below the exceptionally high 3.057 for Wilson's Warblers was 1.723. Average occurrences of landbirds at KNP and LCNP were lower, ranging from 0.002 to 0.868 (KNP) and 0.002 to 0.628 (LCNP), as compared to a range of 0.006 to 1.351 recorded in the transportation-corridor, Bristol Bay drainages study. The lower abundance values in KNP and LCNP most likely are due to more points being surveyed (468 and 417 in KNP and LCNP, respectively, compared to 154 in the transportation-corridor, Bristol Bay drainages study), and to the point-count sampling being conducted over a greater geographical area and elevational range in KNP and LCNP studies. This causes a dilution effect, in which the average occurrences calculated for each species in the KNP and LCNP studies are reduced by the inclusion of a larger number of point-counts conducted in habitats where, for example, many forest-adapted landbird species do not occur (e.g., open upland and alpine areas). In contrast, in the transportation-corridor, Bristol Bay drainages study area, there likely is a concentration effect occurring because many of the same habitats are repeatedly surveyed (by design).

Of the five landbird species of conservation concern recorded in the transportation-corridor, Bristol Bay drainages study area (Olive-sided Flycatcher, Gray-cheeked Thrush, Varied Thrush, Blackpoll Warbler, and Rusty Blackbird; see Sections 16.11.7.4 and 16.11.7.8 below for more information on these species), only two species, Gray-cheeked Thrush and Varied Thrush, were recorded also on the upper Alaska Peninsula. (The ranges of the other three species do not extend southward onto the Alaska Peninsula.) Gray-cheeked Thrushes were found at Becharof Lake and Mother Goose Lake but not in KNP (Table 16.11-5). Gray-cheeked Thrushes were more abundant at Becharof Lake and Mother Goose Lake than in the transportation-corridor, Bristol Bay drainages study area, which is not surprising given that this species prefers scrub habitats and much of the sampling in the transportation-corridor, Bristol Bay drainages study area was focused on forested habitats. Varied Thrushes were recorded in KNP but in much lower abundance than in the transportation-corridor, Bristol Bay drainages study area. Each of the five landbird species of conservation concern recorded in the transportation-corridor, Bristol Bay drainages study area also was recorded in LCNP. Each of these species, however, had lower average-occurrence values in LCNP, and as discussed above, this reduced abundance likely is an artifact of the larger number of points sampled and the greater geographical extent and greater elevational range surveyed in LCNP.

16.11.7.3 Landbird Habitat Associations

Average-occurrence figures (numbers of birds observed per point-count), derived from focal observations only, were used to evaluate habitat use of landbirds in the transportation-corridor, Bristol Bay drainages study area. Using an average measure of abundance for each species in each habitat eliminates the bias that occurs in comparing total numbers of birds observed among habitats when unequal numbers of point-counts are conducted in different habitats (see Section 16.5.6.1).

In the transportation-corridor study area, the greatest numbers of breeding landbird species were found in forested habitats. Between 22 and 30 species (56 to 77 percent of the 39 landbird species recorded as focal observations) were observed in three forest types: Riverine Moist Mixed Forest, Upland and Lowland Spruce Forest, and Upland and Lowland Moist Mixed Forest (Table 16.11-6). Other non-forested habitats that supported intermediate numbers (seven to 13) of breeding landbird species were Lowland Ericaceous Scrub Bog, Lowland Low and Tall Willow Scrub, Riverine Low Willow Scrub, Upland Moist Tall Alder Scrub, Upland Moist Low Willow Scrub, and Upland Moist Dwarf Scrub. The other sampled tall-scrub and meadow habitats in the study area supported far fewer landbird species (one to three; Table 16.11-6).

The most abundant landbird species in the transportation-corridor, Bristol Bay drainages study area (Wilson’s Warbler) often breeds in low- and tall-scrub habitats in Alaska, but in the transportation-corridor study area, a relatively large number of observations of this species were recorded in forested habitats as well as low and tall scrub (Table 16.11-6). Another abundant species that typically occurs in scrub habitats (Golden-crowned Sparrow) also was commonly found in forests and low- and tall-scrub habitats in the study area. This likely is due to the preponderance of low and tall scrub in the understory of the predominantly open forests in the study area. Open forest types in Alaska are known to provide suitable breeding habitats for many landbird species (Williamson and Peyton, 1962; Kessel, 1998; Andres et al., 1999; Benson, 2004), primarily because of the diversity of vegetation structure present (Kessel, 1998).

The other abundant species in the study area (Orange-crowned Warbler, Swainson’s Thrush, Yellow-rumped Warbler, Dark-eyed Junco, Ruby-crowned Kinglet, American Robin, Varied Thrush, and Hermit Thrush) also commonly used forested areas and sometimes scrub habitats as well (Table 16.11-6). The sixteen common species in the study area (Blackpoll Warbler, White-crowned Sparrow, Common Redpoll, Yellow Warbler, Fox Sparrow, Gray-cheeked Thrush, Savannah Sparrow, Olive-sided Flycatcher, White-winged Crossbill, Northern Waterthrush, Tree Swallow, Gray Jay, Boreal Chickadee, American Tree Sparrow, Alder Flycatcher, and Lincoln’s Sparrow) were most often observed in forests and/or low- and tall-scrub habitats as would be expected from their habitat preferences (Table 16.11-6).

Although habitat use varied among species, the more abundant species tended to be more general in their habitat use. The 10 abundant landbird species observed in the study area used the widest array of habitats (three to 10 habitats per species; Table 16.11-6). The 16 common species in the area used one to six habitats and the remaining uncommon species used one to three habitats.

An assessment of the value of all available habitats in the transportation-corridor, Bristol Bay drainages study area for a subset of landbird species that are of conservation concern or management concern (for sport and subsistence hunting) is presented in Section 16.6.

16.11.7.4 Landbird Species of Conservation Concern

No landbirds that breed in Alaska are listed as federally endangered or threatened, or as proposed or candidate species (USFWS, 2006). A number of landbird species in the state, however, are listed as conservation-priority species by government agencies and non-governmental organizations that consider bird-conservation issues in Alaska and several of these species occur in the transportation-corridor, Bristol Bay drainages study area (Table 16.11-1). Using the criteria defined for this study to assess which species are of conservation concern (see Section 16.5.6.2), researchers determined that five (11 percent) of the 46 landbird species recorded in the transportation-corridor, Bristol Bay drainages study area are of conservation concern for Alaska (Table 16.11-1, Figure 16.11-3). Four of these five species (Olive-sided Flycatcher, Gray-cheeked Thrush, Varied Thrush, and Blackpoll Warbler) were confirmed to nest in the study area, or were inferred to do so based on behavioral observations. The fifth species, Rusty Blackbird, was observed only three times and nesting was not confirmed. The conservation concerns for these five species are outlined below.

Olive-sided Flycatcher

An analysis of Breeding Bird Survey (BBS) data for Olive-sided Flycatchers showed a consistent and widespread decline of 3.5 percent per year between 1966 and 2004 in breeding populations across the U.S. and Canada (Sauer et al., 2005). This suggests the worldwide population may have declined by as much as 70 percent over that period. In Alaska, breeding populations declined 2.3 percent per year between 1980 and 2004 (Sauer et al., 2005). Likely mortality factors on the breeding grounds in boreal forests in North America include deforestation, including salvage harvests, and forest-fire suppression activities (Altman and Sallabanks, 2000). Habitat alteration in the Cook Inlet area of Alaska, where human development is most active, is of concern (BPIFWG, 1999). However, the bulk of the mortality in this species is suspected to occur on the wintering grounds (BPIFWG, 1999; Altman and Sallabanks, 2000). Olive-sided flycatchers winter in Central America and most extensively in South America, where intensive tropical deforestation is suspected to be the primary factor driving the population declines. This species is considered highly vulnerable to the effects of deforestation during winter because of its preference for undisturbed tropical broadleaf forest (Petit et al., 1995). Olive-sided Flycatcher is listed as a species of conservation concern for Alaska on six of the eight agency or working group lists that consider landbird conservation issues in the state (Table 16.11-1).

Olive-sided Flycatchers were considered common in the transportation-corridor, Bristol Bay drainages study area (Table 16.11-4) and were found in coniferous and mixed forests in upland and lowland settings (Table 16.11-6; see also Section 16.6).

Gray-cheeked Thrush

The Gray-cheeked Thrush is of conservation concern because there are indications, from an analysis of BBS data, that declines in breeding populations in eastern North America occurred from 1978 to 1988 (Sauer and Droege, 1992). A longer time-period analysis of BBS data for Canada only, where this species is more common, shows a statistically significant population decline of 8.8 percent per year from 1967 to

2000 (although these results apply only to a small portion of the breeding range; Dunn, 2005). Similar population-trend data for Alaska are not available (Sauer et al., 2005). On their tropical wintering grounds (largely South America east of the Andes), this species is considered vulnerable to deforestation of broadleaf forests (Petit et al., 1993). Because Gray-cheeked Thrushes breed largely in relatively remote and undisturbed boreal forest and arctic environments where population threats are minimal, it is possible that declines in breeding populations may be driven primarily by the effects of tropical deforestation on the wintering grounds. Still, there are concerns that breeding populations in Alaska should be maintained because a large percentage of the species' global breeding range is concentrated in Alaska (BPIFWG, 1999). Gray-cheeked Thrush is listed as a species of conservation concern for Alaska on four of the eight agency or working group lists that consider landbird conservation issues in the state (Table 16.11-1).

Gray-cheeked Thrushes are known to commonly use upland, often mountainous, scrub habitats in Alaska during the breeding season and they were found to be common in the transportation-corridor, Bristol Bay drainages study area (Table 16.11-4); they occurred most frequently in Upland Moist Tall Alder Scrub and were less common in Riverine Moist Mixed Forest and Upland and Lowland Spruce Forest (Table 16.11-6; see also Section 16.6).

Varied Thrush

The Varied Thrush is considered vulnerable to forestry management practices because its primary habitat is coniferous forests on the North American west coast and in Alaska (BPIFWG 1999). The species also breeds less commonly in tall-scrub habitats in areas of western Alaska where forests are not present. BBS data indicate statistically significant declines of 1.1% per year for Varied Thrush populations in western North America from 1980 to 2004; no significant declines have been found in Alaskan populations over the same time period (Sauer et al., 2005). The primary concern for this species in Alaska is focused on monitoring and maintaining breeding populations in the state (BPIFWG 1999). A few Varied Thrushes winter in southcentral Alaska coastal forests, but most winter in coastal forests of southeastern Alaska, British Columbia, and in coastal and inland forests in several western lower 48 states where they also are considered vulnerable to deforestation activities (Luke, 2000). The Varied Thrush is listed as a species of conservation concern for Alaska on two of the eight agency or working group lists that consider landbird conservation issues in the state (Table 16.11-1).

Varied Thrushes were considered abundant in the transportation-corridor, Bristol Bay drainages study area (Table 16.11-4) and were found frequently in coniferous and mixed forests in upland, lowland, and riverine areas, and in Upland Moist Tall Alder Scrub (Table 16.11-6; see also Section 16.6).

Blackpoll Warbler

An analysis of BBS data for Blackpoll Warblers showed breeding populations across North America declining 9.5 percent per year between 1980 and 2004 (Sauer et al., 2005). Population numbers had increased from 1966 to 1979, but declined thereafter (Sauer et al., 2005). An analysis of data from Alaska also indicated a decline in breeding populations, in this case 3.0 percent per year, between 1980 and 2004 (Sauer et al., 2005). On the wintering grounds in South America, the species is considered highly vulnerable to the removal of tropical forests (Petit et al., 1993, 1995), and there are suggestions that heavy mortality can occur during trans-oceanic fall migration flights because of tropical storms (Butler, 2000). Because Blackpoll Warblers in Alaska breed largely in relatively remote and undisturbed boreal forest regions (areas with few population threats), the implication is that declines in breeding populations may be driven primarily by the combined effects of mortality during migration and tropical deforestation on the wintering grounds. Conservation concerns in Alaska are that breeding populations should be maintained because a large percentage of the species' global breeding range is concentrated in Alaska (BPIFWG, 1999). The Blackpoll Warbler is listed as a species of conservation concern for Alaska on six of the eight agency or working group lists that consider landbird conservation issues in the state (Table 16.11-1).

Blackpoll Warblers were considered common in the transportation-corridor, Bristol Bay drainages study area (Table 16.11-4) and were observed in several different habitats; they were most frequently recorded in Riverine Moist Mixed Forest and Riverine Tall Alder or Willow Scrub, and were less common in forests in upland and lowland areas, and in lowland scrub and bog habitats (Table 16.11-6; see also Section 16.6).

Rusty Blackbird

An analysis of BBS data for Rusty Blackbirds indicated a steep decline of 10.3 percent per year between 1966 and 2004 in breeding populations across the U.S. and Canada (Sauer et al., 2005). Using BBS and other population data, Greenberg and Droege (1999) estimated that populations in North America had declined by 90 percent. In Alaska, breeding populations have declined 5.2 percent per year between 1980 and 2004 (Sauer et al., 2005). The causes of the population declines in this species are uncertain, but impacts are suspected on both the breeding and wintering grounds. Alteration of boreal forest wetlands from human activities (deforestation and peat extraction) and the drying of boreal forest wetlands thought to be the result of global warming are both possible impacts to breeding habitats (Avery, 1995). Habitats in Alaska are believed to be largely intact (Greenberg, 2003), but permafrost degradation and drying wetlands from global warming may be altering habitats in some areas. Impacts on the wintering grounds in eastern North America include the documented loss of forested wetlands in the eastern U.S. (estimated at more than 80 percent reduction from pre-settlement records; Greenberg and Droege, 1999) and possibly more recent direct mortality from agricultural control efforts aimed at other blackbird species. The Rusty Blackbird is listed as a species of conservation concern for Alaska on four of the eight agency or working group lists that consider landbird conservation issues in the state (Table 16.11-1).

Rusty Blackbirds were considered uncommon in the transportation-corridor, Bristol Bay drainages study area (Table 16.11-4), where only three observations were recorded. The observations of this species are not shown in Table 16.11-6 because they were recorded in nonfocal habitats; all observations, however, were made in Upland and Lowland Moist Mixed Forest (see also Section 16.6).

16.11.7.5 Shorebird Occurrence

Shorebirds were not abundant in the transportation-corridor, Bristol Bay drainages study area. Only seven species were observed (Table 16.11-7), and two were not recorded during point-counts (Solitary Sandpiper and Spotted Sandpiper were recorded only as incidental and in-transit observations, respectively). For the five species recorded during point-counts (Table 16.11-8), researchers calculated a mean of 0.3 birds per point-count. In comparison, in the mine study area, 14 shorebird species were observed and a mean of 1.1 birds per point-count was calculated (see Section 16.5). Most shorebirds observed in the transportation-corridor, Bristol Bay drainages study area were assumed to be nesting in the area, based on observations of nests or broods, observations of display activities, or alarm/mobbing reactions typical of nesting shorebirds. The reduced species richness and abundance of shorebirds in the transportation-corridor, Bristol Bay drainages study area likely occur because the study area in general lacks large expanses of open habitats and because the linear study area was routed primarily in forested habitats and, where possible, avoided habitats that many shorebirds use for breeding in southwestern Alaska (e.g., open graminoid and low- and dwarf-scrub habitats; ASG, 2004).

None of the shorebird species recorded in the transportation-corridor, Bristol Bay drainages study area were considered to be abundant. The only species considered common (with 15 or more point-count observations) were Greater Yellowlegs and Wilson’s Snipe; these two species comprised 92 percent of all point-count observations of shorebirds (Table 16.11-8). Three species (American Golden-Plover, Pacific Golden-Plover, and Lesser Yellowlegs) were considered uncommon and were recorded fewer than 10 times during the point-count sampling. Solitary Sandpiper and Spotted Sandpiper were each recorded only once, as incidental and in-transit observations, respectively. The average occurrences of shorebird species in the study area also were low, ranging from 0.006 for Pacific and American Golden-Plover to 0.182 for Greater Yellowlegs (Table 16.11-8).

As with the assessment of landbird abundance, the abundance of shorebirds in the study area can be compared with shorebird abundance in three areas on the upper Alaska Peninsula and one in western Cook Inlet (Table 16.11-9). To standardize abundance data across studies in which different numbers of point-counts were conducted, the comparisons use average-occurrence values. Point-count-based studies in which shorebirds were observed were conducted at Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge (Dewhurst et al., 1996b; Egan and Adler, 2001), at Becharof Lake in Becharof National Wildlife Refuge (Moore and Leeman, 1996), and in Katmai and Lake Clark national parks (Ruthrauff et al., 2007). As noted above in the comparisons of landbird abundance, there are differences among these studies in the sizes of study areas and the habitats surveyed that make the comparisons of shorebird abundance approximate. Notwithstanding these caveats, the comparisons are still instructive.

The two most common shorebird species in the transportation-corridor, Bristol Bay drainages study area in 2005 (Greater Yellowlegs and Wilson’s Snipe) also were the two most common species recorded at Mother Goose Lake, Becharof Lake, and in KNP on the Alaska Peninsula (Semipalmated Plover was tied with Wilson’s Snipe as the second most common species at Becharof Lake). In LCNP, Wilson’s Snipe was the second most common species, and Lesser Yellowlegs (instead of Greater Yellowlegs) was the most common shorebird species. In earlier studies in the Iliamna Lake region, Williamson and Peyton (1962) indicated that Greater Yellowlegs were relatively abundant and common breeders in the Iliamna area, but that Common Snipe (now treated as Wilson’s Snipe) were uncommon. The average occurrences for shorebirds in the transportation-corridor, Bristol Bay drainages study area (ranging from 0.006 to 0.182) were lower than those for Becharof Lake (which ranged from 0.020 to 0.374; Table 16.11-9). The abundances of shorebirds in KNP (0.002 to 0.147) were similar to those in transportation-corridor, Bristol Bay drainages study area (0.006 to 0.182). In contrast, the abundances of shorebirds at Mother Goose Lake and in LCNP (average occurrences ranging from 0.007 to 0.085 and from 0.003 to 0.096, respectively) were lower than those for the transportation-corridor, Bristol Bay drainages study area. Shorebird species composition and abundance varied among the different studies, likely due primarily to differences in the habitats surveyed.

Of the two shorebird species of conservation concern recorded in the study area (American Golden-Plover and Solitary Sandpiper; see Sections 16.11.7.7 and 16.11.7.8 below for more information on these species), neither was recorded at Becharof Lake or Mother Goose Lake on the Alaska Peninsula (Table

16.11-9). American Golden-Plovers were observed in KNP, however, and both species were recorded on the surveys in LCNP. In both KNP and LCNP, American Golden-Plovers were recorded in greater abundance than in the transportation-corridor, Bristol Bay drainages study area. American Golden-Plover was the third most abundant shorebird recorded in LCNP, but in KNP and the transportation-corridor, Bristol Bay drainages study area, the species was among the least abundant of the shorebirds recorded. The absolute numbers of Solitary Sandpipers recorded in both LCNP and the transportation-corridor, Bristol Bay drainages study area were quite low.

16.11.7.6 Shorebird Habitat Associations

Average-occurrence figures (numbers of birds observed per point-count), derived from focal observations only, were used to evaluate habitat use of shorebirds in the transportation-corridor, Bristol Bay drainages study area. Using an average measure of abundance for each species in each habitat eliminates the bias that occurs in comparing total numbers of birds observed among habitats when unequal numbers of point-counts are conducted in different habitats (see Section 16.5.6.1).

Shorebirds were found in only four of the 12 habitats sampled in the transportation-corridor, Bristol Bay drainages study area. Although the total number of observations of habitat use for shorebirds in the study area is low, all shorebirds that were recorded as focal observations during point-counts were found in relatively open habitats: Lowland Wet Graminoid–Shrub Meadow, Lowland Ericaceous Scrub Bog, Upland Moist Dwarf Scrub, and Upland and Lowland Spruce Forest (when in an open forest form; Table 16.11-10). The two most frequently observed shorebirds in the survey area often were recorded as calling birds in the distance and/or were observed in aerial display, both cases in which use of habitats was unclear.

An assessment of the value of all the available habitats in the transportation-corridor, Bristol Bay drainages study area for a subset of shorebird species of conservation concern is presented in Section 16.6.

16.11.7.7 Shorebird Species of Conservation Concern

No shorebirds that breed in Alaska are listed as federally endangered or threatened, or as proposed or candidate species (USFWS, 2006). Shorebirds are, however, of increasing conservation concern worldwide because many species have relatively low reproductive rates, small effective population sizes, and declining population numbers (IWSG, 2003). Shorebirds also are vulnerable to habitat alteration, especially at migratory staging sites where large numbers of birds congregate (Brown et al., 2001; ASG, 2004). A number of shorebird species in Alaska are listed as species of conservation concern by government agencies and non-governmental organizations that consider bird-conservation issues in the state and some of these species occur in the transportation-corridor, Bristol Bay drainages study area (Table 16.11-1). Using the criteria defined for this study to assess which species are of conservation concern (see Section 16.5.6.2), researchers determined that 29 percent (two) of the seven shorebird species recorded in the transportation-corridor, Bristol Bay drainages study area are of conservation concern for Alaska (Table 16.11-1, Figure 16.11-3). Neither species (American Golden-Plover or Solitary Sandpiper) was confirmed as nesting in the study area. The conservation concerns for these two species are outlined below.

American Golden-Plover

American Golden-Plovers are widely dispersed across arctic regions in Alaska where they defend large territories and breed at low densities. The American Golden-Plover is considered a species of concern for conservation because substantial population declines since the 1970s have been noted on the breeding grounds in the Northwest Territories (Gratto-Trevor et al., 1998). However, analysis of population levels at another Nearctic breeding site did not show population declines, and significant population declines have not been noted at migration staging areas on the North American east coast (Morrison et al., 1994). Population threats from habitat loss on the wintering grounds for this species in South America and from alteration of migratory staging habitats and pesticide exposure in the mid-western U.S. during migration are of concern (Johnson, 2003). Because this species breeds in remote and relatively undisturbed arctic regions, population declines generally are suspected to occur from increased mortality during the nonbreeding seasons. Concerns about breeding population declines in this species are still warranted because little information is known about population trends of this species during breeding. The American Golden-Plover is listed as a species of conservation concern for Alaska on three of the eight agency or working group lists that consider shorebird conservation issues in the state (Table 16.11-1).

American Golden-Plovers were considered uncommon in the transportation-corridor, Bristol Bay drainages study area and were observed only once during point-count sampling (Table 16.11-8) in an undetermined habitat type. Habitat use by this species in the study area is assessed in Section 16.6.

Solitary Sandpiper

Solitary Sandpipers are of concern for conservation primarily because analyses of BBS data have indicated downward population trends in datasets from eastern Canada (Sauer et al., 2005). However, analyses of data from western Canada do not indicate declining population trends. In Alaska, an analysis of BBS data indicated a population decline of 3.3 percent per year from 1980 to 2004 (Sauer et al., 2005). Although the species has a broad breeding range across boreal forests in North America (from Alaska to the Atlantic coast), the global population estimate is only approximately 25,000 birds (ASG, 2004). Furthermore, the western race, *Tringa solitaria cinnamomea*, has a breeding population of possibly no more than 4,000 birds. It is estimated that over 75 percent of the birds in the western race breed in Alaska (ASG, 2004). Given the downward population trend in the state and the small breeding population size, the Solitary Sandpiper is considered of conservation concern in Alaska. The Solitary Sandpiper is listed as a species of conservation concern for Alaska on five of the eight agency or working group lists that consider shorebird conservation issues in the state (Table 16.11-1).

Solitary Sandpipers were considered uncommon in the transportation-corridor, Bristol Bay drainages study area and were observed only once, as an incidental sighting, in Lowland Wet Graminoid–Shrub Meadow. Habitat use by this species in the study area is assessed in Section 16.6.

16.11.7.8 Synopsis of Species of Conservation Concern

Based on the species-selection criteria outlined in Section 16.5.6.2, seven (13 percent) of the 53 landbird and shorebird species recorded in the transportation-corridor, Bristol Bay drainages study area are considered species of conservation concern for Alaska. All five of the landbird species of conservation concern, and particularly Blackpoll Warbler, Gray-cheeked Thrush, Varied Thrush, and Olive-sided Flycatcher, occurred more frequently in the transportation-corridor, Bristol Bay drainages study area than in LCNP (Ruthrauff et al., 2007). As noted above, however, this likely is an artifact of the larger number of points sampled and the greater geographical extent and elevational range surveyed in LCNP. None of the five landbird species were observed in KNP. The only landbird species of conservation concern in the transportation-corridor, Bristol Bay drainages study area that also was found in other studies on the upper Alaska Peninsula (Dewhurst et al., 1996a; Moore and Leeman, 1996; Egan and Adler, 2001) was Gray-cheeked Thrush. This species was more abundant at Mother Goose Lake and Becharof Lake than in the transportation-corridor, Bristol Bay drainages study area.

Olive-sided Flycatchers appeared to be more common in the transportation-corridor, Bristol Bay drainages study area than found historically in the Iliamna Lake area (the species was not recorded by Williamson and Peyton [1962]). The Blackpoll Warbler was considered an abundant breeding species in the transportation-corridor, Bristol Bay drainages study area in 2005, and similarly, Williamson and Peyton (1962) indicated Blackpoll Warblers were very abundant in the Iliamna Lake area in the 1950s. Osgood (1904) considered it the most abundant warbler in the area at the turn of the century. Blackpoll Warblers are known to be patchy in occurrence in Alaska, however, and Hurley (1931, 1932) did not observe the species during surveys on the Kvichak River.

The two shorebird species of conservation concern recorded in the transportation-corridor, Bristol Bay drainages study area (American Golden-Plover and Solitary Sandpiper) were found to be less common there than in LCNP. American Golden-Plovers also were more common in KNP than in the transportation-corridor, Bristol Bay drainages study area. In earlier work in the Iliamna Lake area, Williamson and Peyton (1962) documented an abundance of American Golden-Plovers similar to that found in this study and suspected that the species was nesting in suitable habitats in the area. Williamson and Peyton, however, had no records of Solitary Sandpipers from the Iliamna Lake area. Solitary Sandpipers were not recorded in any of the studies on the Alaska Peninsula south of the transportation-corridor, Bristol Bay drainages study area.

16.11.8 Summary

Researchers conducted 154 point-counts and recorded 1,831 individual birds in the transportation-corridor, Bristol Bay drainages study area in 2005. Including incidental and in-transit observations, researchers identified 46 landbird species and seven shorebird species in the study area. Using point-count survey data, researchers calculated a mean of 11.6 landbirds and 0.3 shorebirds per point-count. Ten landbird species (Wilson's Warbler, Orange-crowned Warbler, Swainson's Thrush, Yellow-rumped Warbler, Golden-crowned Sparrow, Dark-eyed Junco, Ruby-crowned Kinglet, American Robin, Varied Thrush, and Hermit Thrush) were considered abundant in the study area. Three of these species (Wilson's Warbler, Orange-crowned Warbler, and Swainson's Thrush) were especially abundant and comprised 33 percent of all point-count observations. Shorebird species were much less common; no shorebird species was considered to be abundant in the transportation-corridor study area. The two most frequently observed shorebird species were Greater Yellowlegs and Wilson's Snipe, and they were considered common breeders in the area. These two species accounted for 92 percent of all point-count observations of shorebirds. Of the landbird and shorebird species-groups observed, warblers were by far the most abundant breeders (more than 650 individuals). Thrushes were the second most abundant group, and sparrows and allies (including juncos) also were common. Kinglets and finches were less common, and the rest of the landbird species-groups and shorebirds were much less common in the study area.

Landbirds were recorded in all 12 of the wildlife-habitat types sampled in the study area and shorebirds were recorded in four of the 12. Species richness of landbirds and shorebirds observed in each of the sampled habitats ranged from two to 30 and bird abundance within each habitat sampled ranged from 0.7 to 7.8 birds per point-count. The three sampled forest habitats in the study area (Upland and Lowland Moist Mixed Forest, Upland and Lowland Spruce Forest, and Riverine Moist Mixed Forest) had the highest numbers of breeding landbird and shorebird species (both groups considered together). Dwarf-, low-, and tall-scrub habitats and bogs were intermediate in landbird and shorebird species richness, and open meadow areas supported the fewest number of landbird and shorebird species. Six forest and scrub habitats (Riverine Moist Mixed Forest, Riverine Low Willow Scrub, Upland and Lowland Moist Mixed Forest, Upland and Lowland Spruce Forest, Upland Moist Tall Alder Scrub, and Upland Moist Low Willow Scrub) were the most productive in terms of bird abundance and supported five or more birds per point-count. Individual landbird species often used a range of different forest, scrub, bog, and meadow habitats with the more common species using a larger set of habitats than the uncommon species. Shorebirds, however, were found primarily in four relatively open habitat types: Lowland Wet Graminoid–Shrub Meadow, Lowland Ericaceous Scrub Bog, Upland Moist Dwarf Scrub, and Upland and Lowland Spruce Forest (when in an open forest form).

Seven (13 percent) of the 53 landbird and shorebird species observed during surveys in the transportation-corridor, Bristol Bay drainages study area are considered conservation priority species for Alaska. Five of the species of conservation concern are landbirds (Olive-sided Flycatcher, Gray-cheeked Thrush, Varied Thrush, Blackpoll Warbler, and Rusty Blackbird) and two are shorebirds (American Golden-Plover and Solitary Sandpiper).

16.11.9 References

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16.11.10 Glossary

Avifauna—the set of bird species occurring in a particular geographic region

Corvid—any bird species in the family Corvidae, which includes the jays, crows, and ravens

Graminoid—grass and grass-like plants (including sedges and rushes)

Mesic—an area or habitat characterized by a moderate amount of moisture, not dry and not wet

Nearctic—the arctic, boreal, and temperate climate regions in the New World in which the wildlife species present share many biogeographic and taxonomic affinities

Passerine—collectively, the group of songbirds or perching birds in the taxonomic order Passeriformes

Photosignature—a combination of color and texture on an aerial photo indicative of a particular vegetation or land-cover type

Physiography—in the limited sense used here, a categorization of landforms/topographic regions into classes, which are based largely on the geomorphological forces shaping the landforms in those areas (e.g., alpine, subalpine, upland, lowland, riverine [see below], and coastal)

Riverine—associated with rivers and streams, and landscape features developed from the actions of rivers and streams

TABLES

TABLE 16.11-1
Landbird and Shorebird Species of Conservation Concern[a] for Alaska Observed in the Transportation-corridor, Bristol Bay Drainages Study Area, 2005, and Listing Status

Species	USFWS[b]	BLM[c]	USFS[d]	ADF&G[e]	Audubon[f]	AKNHP[g]	BPIF[h]	ASG[i]
Olive-sided Flycatcher	Species of conservation concern	Sensitive species	—[j]	Species of special concern and featured species for conservation	Species at risk	—	Priority species for conservation	—
Gray-cheeked Thrush	—	Sensitive species	—	Species of special concern	—	Vulnerable	Priority species for conservation	—
Varied Thrush	—	—	—	Featured species for conservation	—	—	Priority species for conservation	—
Blackpoll Warbler	Species of conservation concern	Sensitive species	—	Species of special concern and featured species for conservation	Species at risk	—	Priority species for conservation	—
Rusty Blackbird	Species of conservation concern	—	—	Featured species for conservation	Species at risk	—	Priority species for conservation	—
American Golden-Plover	Species of conservation concern	—	—	—	Species at risk	—	—	Species of high conservation concern
Solitary Sandpiper	Species of conservation concern	—	—	Featured species for conservation	Species at risk	Imperiled	—	Species of high conservation concern

Notes:

a. See Section 16.5.6.2 for definition of species of conservation concern.

b. U.S. Fish and Wildlife Service (USFWS), Birds of Conservation Concern (USFWS, 2002); species shown are listed in either, or both, of two Bird Conservation Regions (BCRs) (western Alaska and northwestern interior forest) because the transportation-corridor, Bristol Bay drainages study area is near the border between the two BCRs.

c. Bureau of Land Management (BLM), Alaska Threatened, Endangered, and Sensitive Species List (BLM, 2005).

d. U.S. Forest Service (USFS), Alaska Region Sensitive Species List (USFS, 2002).

e. Alaska Department of Fish and Game (ADF&G), Species of Special Concern (ADG&G, 1998) and Comprehensive Wildlife Conservation Strategy (ADF&G, 2006).

f. Audubon Alaska WatchList 2005 (Stenhouse and Senner, 2005).

g. Alaska Natural Heritage Program (AKNHP), Birds Tracking List (AKNHP, 2007); state listings only; the highest conservation ranking for either the breeding or nonbreeding season is shown; secure and apparently secure rankings (roughly equivalent to low and moderate conservation-concern classes) are not shown.

h. Boreal Partners in Flight Working Group (BPIFWG), Landbird Conservation Plan for Alaska Biogeographic Region (BPIFWG, 1999).

i. Alaska Shorebird Group (ASG), A Conservation Plan for Alaska Shorebirds (ASG, 2004); species of high concern only are listed.

j. A dash indicates the species was not listed by that group or its ranking fell below the conservation-status threshold for inclusion (see notes above).

TABLE 16.11-2
Number of Point-counts, Number of Focal Observations, Focal Observations per Count, and Species Richness Recorded in Mapped Habitat Types[a] during Point-count Surveys for Landbirds and Shorebirds, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Aggregated Habitat Type	No. of Point-counts	No. of Focal Observations[b]	Focal Observations per Count	Species Richness[c]
Alpine Dry Barrens	0	0	0.0	0
Alpine Moist Dwarf Scrub	0	0	0.0	0
Alpine Wet Dwarf Shrub–Sedge Scrub	0	0	0.0	0
Upland Dry Barrens	0	0	0.0	0
Upland Dry Dwarf Shrub–Lichen Scrub	0	0	0.0	0
Upland Moist Dwarf Scrub	8	15	1.9	8
Upland Moist Low Willow Scrub	5	26	5.2	8
Upland Moist Tall Alder Scrub	6	43	7.2	9
Upland Moist Tall Willow Scrub	0	0	0.0	0
Upland and Lowland Spruce Forest	24	151	6.3	24
Upland and Lowland Moist Mixed Forest	58	390	6.7	30
Rivers and Streams	0	0	0.0	0
Rivers and Streams (Anadromous)	0	0	0.0	0
Riverine Barrens	0	0	0.0	0
Riverine Wet Graminoid–Shrub Meadow	2	7	3.5	2
Riverine Low Willow Scrub	3	20	6.7	9
Riverine Tall Alder or Willow Scrub	4	5	1.3	3
Riverine Moist White Spruce Forest	0	0	0.0	0
Riverine Moist Mixed Forest	19	148	7.8	22
Lakes and Ponds	0	0	0.0	0
Lacustrine Moist Barrens	0	0	0.0	0
Lowland Sedge–Forb Marsh	0	0	0.0	0
Lowland Ericaceous Scrub Bog	12	26	2.2	15
Lowland Wet Graminoid–Shrub Meadow	7	5	0.7	2
Lowland Low and Tall Willow Scrub	6	23	3.8	9

Notes:

a. See Section 16.6 for information on wildlife habitat mapping in the transportation-corridor, Bristol Bay drainages study area.

b. Focal observations were recorded in the habitat being sampled; observations recorded in adjacent habitats are not shown.

c. Species richness calculated only for focal observations in each habitat.

TABLE 16.11-3
Landbird Species Observed during Point-count Surveys and Incidentally at Point-count Locations[a], Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Avian Group	Common Name	Scientific Name
Grouse & Ptarmigan	Spruce Grouse	*Falcipennis canadensis*
	Willow Ptarmigan	*Lagopus lagopus*
	Rock Ptarmigan	*Lagopus muta*
Cranes	Sandhill Crane[b]	*Grus canadensis*
Kingfishers	Belted Kingfisher[b]	*Ceryle alcyon*
Woodpeckers	Downy Woodpecker	*Picoides pubescens*
	Hairy Woodpecker	*Picoides villosus*
	American Three-toed Woodpecker	*Picoides dorsalis*
	Black-backed Woodpecker[b]	*Picoides arcticus*
Corvids & Shrikes	Northern Shrike	*Lanius excubitor*
	Gray Jay	*Perisoreus canadensis*
	Black-billed Magpie	*Pica pica*
	Common Raven	*Corvus corax*
Passerines	Olive-sided Flycatcher *	*Contopus cooperi*
	Alder Flycatcher	*Empidonax alnorum*
	Tree Swallow	*Tachycineta bicolor*
	Violet-green Swallow	*Tachycineta thalassina*
	Black-capped Chickadee	*Poecile atricapillus*
	Boreal Chickadee	*Poecile hudsonicus*
	Red-breasted Nuthatch	*Sitta canadensis*
	Golden-crowned Kinglet	*Regulus satrapa*
	Ruby-crowned Kinglet	*Regulus calendula*
	Arctic Warbler	*Phylloscopus borealis*
	Gray-cheeked Thrush *	*Catharus minimus*
	Swainson's Thrush	*Catharus ustulatus*
	Hermit Thrush	*Catharus guttatus*
	American Robin	*Turdus migratorius*
	Varied Thrush	*Ixoreus naevius*
	Bohemian Waxwing	*Bombycilla garrulus*
	Orange-crowned Warbler	*Vermivora celata*
	Yellow Warbler	*Dendroica petechia*
	Yellow-rumped Warbler	*Dendroica coronata*
	Blackpoll Warbler *	*Dendroica striata*
	Northern Waterthrush	*Seiurus noveboracensis*
	Wilson's Warbler	*Wilsonia pusilla*
	American Tree Sparrow	*Spizella arborea*
	Savannah Sparrow	*Passerculus sandwichensis*
	Fox Sparrow	*Passerella iliaca*

Avian Group	Common Name	Scientific Name
	Lincoln's Sparrow	*Melospiza lincolnii*
	White-crowned Sparrow	*Zonotrichia leucophrys*
	Golden-crowned Sparrow	*Zonotrichia atricapilla*
	Dark-eyed Junco	*Junco hyemalis*
	Rusty Blackbird *	*Euphagus carolinus*
	Pine Grosbeak[b]	*Pinicola enucleator*
	White-winged Crossbill	*Loxia leucoptera*
	Common Redpoll	*Carduelis flammea*

Notes:

a. No additional landbird species were observed in transit between point-count locations.

b. Incidental observations only.

* Denotes a species of conservation concern for Alaska (see Table 16.5-1).

TABLE 16.11-4
Number, Percent of Total Observations, and Average Occurrence of Landbird Species Observed during Point-count Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Avian Species	**No.**	**%**	**Avg. Occurrence[a] (*n* = 154)**
Wilson's Warbler	208	11.7	1.351
Orange-crowned Warbler	200	11.2	1.299
Swainson's Thrush	181	10.2	1.175
Yellow-rumped Warbler	132	7.4	0.857
Golden-crowned Sparrow	125	7.0	0.812
Dark-eyed Junco	114	6.4	0.740
Ruby-crowned Kinglet	100	5.6	0.649
American Robin	99	5.6	0.643
Varied Thrush	91	5.1	0.591
Hermit Thrush	72	4.0	0.468
Blackpoll Warbler	52	2.9	0.338
White-crowned Sparrow	43	2.4	0.279
Common Redpoll	42	2.4	0.273
Yellow Warbler	40	2.2	0.260
Fox Sparrow	31	1.7	0.201
Gray-cheeked Thrush	26	1.5	0.169
Savannah Sparrow	26	1.5	0.169
Olive-sided Flycatcher	25	1.4	0.162
White-winged Crossbill	23	1.3	0.149
Northern Waterthrush	21	1.2	0.136
Tree Swallow	16	0.9	0.104
Gray Jay	14	0.8	0.091
Boreal Chickadee	12	0.7	0.078
American Tree Sparrow	12	0.7	0.078
Alder Flycatcher	11	0.6	0.071
Lincoln's Sparrow	10	0.6	0.065
American Three-toed Woodpecker	6	0.3	0.039
Red-breasted Nuthatch	6	0.3	0.039
Unidentified Woodpecker	5	0.3	0.032
Black-capped Chickadee	5	0.3	0.032
Northern Shrike	4	0.2	0.026
Golden-crowned Kinglet	4	0.2	0.026
Violet-green Swallow	3	0.2	0.019
Bohemian Waxwing	3	0.2	0.019
Rusty Blackbird	3	0.2	0.019
Willow Ptarmigan	2	0.1	0.013
Downy Woodpecker	2	0.1	0.013

Avian Species	No.	%	Avg. Occurrence[a] (n = 154)
Hairy Woodpecker	2	0.1	0.013
Black-billed Magpie	2	0.1	0.013
Common Raven	2	0.1	0.013
Unidentified Thrush	2	0.1	0.013
Unidentified Crossbill	2	0.1	0.013
Spruce Grouse	1	<0.1	0.006
Rock Ptarmigan	1	<0.1	0.006
Unidentified Chickadee	1	<0.1	0.006
Arctic Warbler	1	<0.1	0.006

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

TABLE 16.11-5
Average Occurrence[a] of Landbird Species Observed in the Transportation-corridor, Bristol Bay Drainages Study Area, 2005, and in other Studies in Southwestern Alaska in which Off-road Point-count Surveys Were Conducted

Landbird Species	**Mother Goose Lake (*n*=141)[b]**	**Becharof Lake (*n*=99)[c]**	**Katmai NP (n=468)[d]**	**Lake Clark NP (*n*=417)[d]**	**This study (*n*=154)**
Wilson's Warbler	3.057	1.808	0.485	0.261	1.351
Orange-crowned Warbler	0.993	1.091	0.295	0.077	1.299
Swainson's Thrush				0.012	1.175
Yellow-rumped Warbler			0.143	0.362	0.857
Golden-crowned Sparrow	0.915	1.879	0.868	0.628	0.812
Dark-eyed Junco			0.115	0.369	0.740
Ruby-crowned Kinglet			0.015	0.170	0.649
American Robin	0.745	0.152	0.291	0.300	0.643
Varied Thrush			0.041	0.192	0.591
Hermit Thrush	1.589	1.455	0.415	0.297	0.468
Blackpoll Warbler				0.002	0.338
White-crowned Sparrow	0.163		0.226	0.288	0.279
Common Redpoll	1.723	1.182	0.222	0.568	0.273
Yellow Warbler	0.993	0.727	0.051	0.098	0.260
Fox Sparrow	0.603	0.394	0.575	0.374	0.201
Gray-cheeked Thrush	0.482	0.414		0.034	0.169
Savannah Sparrow	0.255	1.707	0.239	0.175	0.169
Olive-sided Flycatcher				0.012	0.162
White-winged Crossbill				0.005	0.149
Northern Waterthrush			0.004	0.019	0.136
Tree Swallow	0.759	0.071	0.038	0.026	0.104
Gray Jay			0.009	0.034	0.091
Boreal Chickadee			0.006	0.017	0.078
American Tree Sparrow		0.182	0.327	0.360	0.078
Alder Flycatcher	0.376	0.030			0.071
Lincoln's Sparrow			0.002	0.007	0.065
American Three-toed Woodpecker			0.009	0.007	0.039
Red-breasted Nuthatch					0.039
Black-capped Chickadee	0.064	0.081	0.009	0.007	0.032
Northern Shrike	0.057	0.020	0.002	0.002	0.026
Golden-crowned Kinglet				0.002	0.026
Violet-green Swallow				0.005	0.019
Bohemian Waxwing				0.012	0.019
Rusty Blackbird				0.007	0.019
Willow Ptarmigan		0.192	0.135	0.168	0.013
Downy Woodpecker	0.014				0.013

Landbird Species	Mother Goose Lake (*n*=141)[b]	Becharof Lake (*n*=99)[c]	Katmai NP (n=468)[d]	Lake Clark NP (*n*=417)[d]	This study (*n*=154)
Hairy Woodpecker					0.013
Black-billed Magpie	0.007		0.011	0.038	0.013
Common Raven	0.028		0.058	0.072	0.013
Spruce Grouse					0.006
Rock Ptarmigan			0.135	0.084	0.006
Arctic Warbler					0.006
White-tailed Ptarmigan			0.004	0.012	
Sandhill Crane			0.019	0.002	
Say's Phoebe				0.005	
Horned Lark			0.085	0.103	
Bank Swallow	0.021				
Northern Wheatear			0.004	0.019	
American Pipit		0.141	0.415	0.353	
Lapland Longspur		0.182	0.041	0.043	
Snow Bunting		0.020	0.122	0.082	
Gray-crowned Rosy-Finch			0.009	0.005	
Pine Grosbeak	0.170		0.006	0.002	
Pine Siskin				0.002	

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

b. Off-road point-count data collected in 1996 and 2000 at Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge; data were combined from Dewhurst et al. (1996b) and Egan and Adler (2001).

c. Off-road point-count data collected in 1996 at Becharof Lake in the Becharof National Wildlife Refuge (Moore and Leeman, 1996).

d. Off-road point-count data collected in 2004–2006 in Katmai and Lake Clark national parks (Ruthrauff et al., 2007).

TABLE 16.11-6
Average Occurrence Figures[a] for Landbirds in Mapped Wildlife Habitat Types, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist White Spruce Forest	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
	n=0	*n*=0	*n*=0	*n*=0	*n*=0	*n*=8	*n*=5	*n*=6	*n*=0	*n*=24	*n*=58	*n*=0	*n*=0	*n*=0	*n*=2	*n*=3	*n*=4	*n*=0	*n*=19	*n*=0	*n*=0	*n*=0	*n*=12	*n*=7	*n*=6
Spruce Grouse											0.017														
Rock Ptarmigan											0.017														
Downy Woodpecker											0.034														
Hairy Woodpecker																			0.105						
American Three-toed Woodpecker											0.034					1.000							0.083		
Olive-sided Flycatcher										0.125	0.172														
Alder Flycatcher																			0.368						
Northern Shrike																			0.211						
Gray Jay							0.200			0.167	0.034														
Black-billed Magpie						0.125																			
Common Raven											0.017														
Tree Swallow										0.167					3.000								0.250		
Violet-green Swallow						0.375																			
Black-capped Chickadee											0.069								0.053						
Boreal Chickadee										0.083	0.103												0.083		0.167
Red-breasted Nuthatch											0.017								0.053						
Golden-crowned Kinglet											0.017								0.053						
Ruby-crowned Kinglet										0.333	0.466								0.579						
Gray-cheeked Thrush								0.500		0.042									0.105						
Swainson's Thrush								0.500		0.333	1.034				0.500				0.684				0.083		
Hermit Thrush								0.333		0.167	0.241								0.263						
American Robin						0.625				0.458	0.241					0.333			0.211				0.167		0.167
Varied Thrush								0.333		0.208	0.259								0.474						
Bohemian Waxwing										0.083	0.017														
Orange-crowned Warbler						0.125	0.800	1.167		0.917	0.966					1.000			0.526				0.083		0.667
Yellow Warbler							0.400	0.833			0.052					0.333			0.316						

Yellow-rumped Warbler	0.125				0.375	0.897								1.105				0.083		
Blackpoll Warbler					0.167	0.190						0.500		0.737				0.083		0.167
Northern Waterthrush					0.083	0.034						0.250		0.211						
Wilson's Warbler	0.125	1.200	1.500		0.500	0.879					1.667	0.500		0.842				0.333		1.000
American Tree Sparrow					0.042	0.034					0.333									
Savannah Sparrow	0.250	0.800									0.667							0.083	0.429	0.667
Fox Sparrow		0.600	0.333		0.125						0.667			0.105						0.333
Lincoln's Sparrow					0.083	0.017												0.083		
White-crowned Sparrow					0.333	0.103								0.053						0.333
Golden-crowned Sparrow		1.000	1.500		0.292	0.138					0.667			0.474				0.083		0.333
Dark-eyed Junco		0.200			1.000	0.500								0.263				0.083		
White-winged Crossbill						0.052														
Common Redpoll					0.083	0.034														

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted); only focal observations in each habitat are included (see Section 16.5.6.1, Field Surveys and Habitat-use Analyses)

TABLE 16.11-7
Shorebird Species Observed during Point-count Surveys, Incidentally at Point-count Locations, and In Transit
between Point-count Locations, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Common Name	Scientific Name
American Golden-Plover *	*Pluvialis dominica*
Pacific Golden-Plover	*Pluvialis fulva*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Solitary Sandpiper[a] *	*Tringa solitaria*
Spotted Sandpiper[b]	*Actitis macularius*
Wilson's Snipe	*Gallinago delicata*

Notes:

a. One incidental observation only.

b. One nest recorded in transit between point-count locations.

* Denotes a species of conservation concern for Alaska (see Table 16.5-1).

TABLE 16.11-8
Number, Percent of Total Observations, and Average Occurrence of Shorebird Species Observed during Point-count Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Shorebird Species	No.	%	Avg. Occurrence[a] (*n*=154)
Greater Yellowlegs	28	58.3	0.182
Wilson's Snipe	16	33.3	0.104
Lesser Yellowlegs	2	4.2	0.013
American Golden-Plover	1	2.1	0.006
Pacific Golden-Plover	1	2.1	0.006

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

TABLE 16.11-9
Average Occurrence[a] of Shorebird Species Observed in the Transportation-corridor, Bristol Bay Drainages Study Area, 2005, and in other Studies in Southwestern Alaska in which Off-road Point-count Surveys Were Conducted

Landbird Species	**Mother Goose Lake (*n*=141)[b]**	**Becharof Lake (*n*=99)[c]**	**Katmai NP (n=468)[d]**	**Lake Clark NP (*n*=379)[d]**	**This study (*n*=154)**
Greater Yellowlegs	0.014	0.374	0.147	0.031	0.182
Wilson's Snipe	0.085	0.212	0.077	0.091	0.104
Lesser Yellowlegs				0.096	0.013
American Golden-Plover			0.011	0.055	0.006
Pacific Golden-Plover			0.015		0.006
Black-bellied Plover		0.061	0.011		
Semipalmated Plover	0.007	0.212	0.058	0.022	
Solitary Sandpiper				0.005	
Wandering Tattler				0.026	
Spotted Sandpiper			0.002	0.007	
Whimbrel			0.073	0.005	
Surfbird			0.034	0.017	
Western Sandpiper	0.007				
Least Sandpiper		0.081	0.056	0.024	
Baird's Sandpiper				0.010	
Rock Sandpiper		0.020			
Short-billed Dowitcher		0.081		0.002	
Red-necked Phalarope				0.034	

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted).

b. Off-road point-count data collected in 1996 and 2000 at Mother Goose Lake in the Alaska Peninsula National Wildlife Refuge; data were combined from Dewhurst et al. (1996b) and Egan and Adler (2001).

c. Off-road point-count data collected in 1996 at Becharof Lake in the Becharof National Wildlife Refuge (Moore and Leeman, 1996).

d. Off-road point-count data collected in 2004–2006 in Katmai and Lake Clark national parks (Ruthrauff et al., 2007).

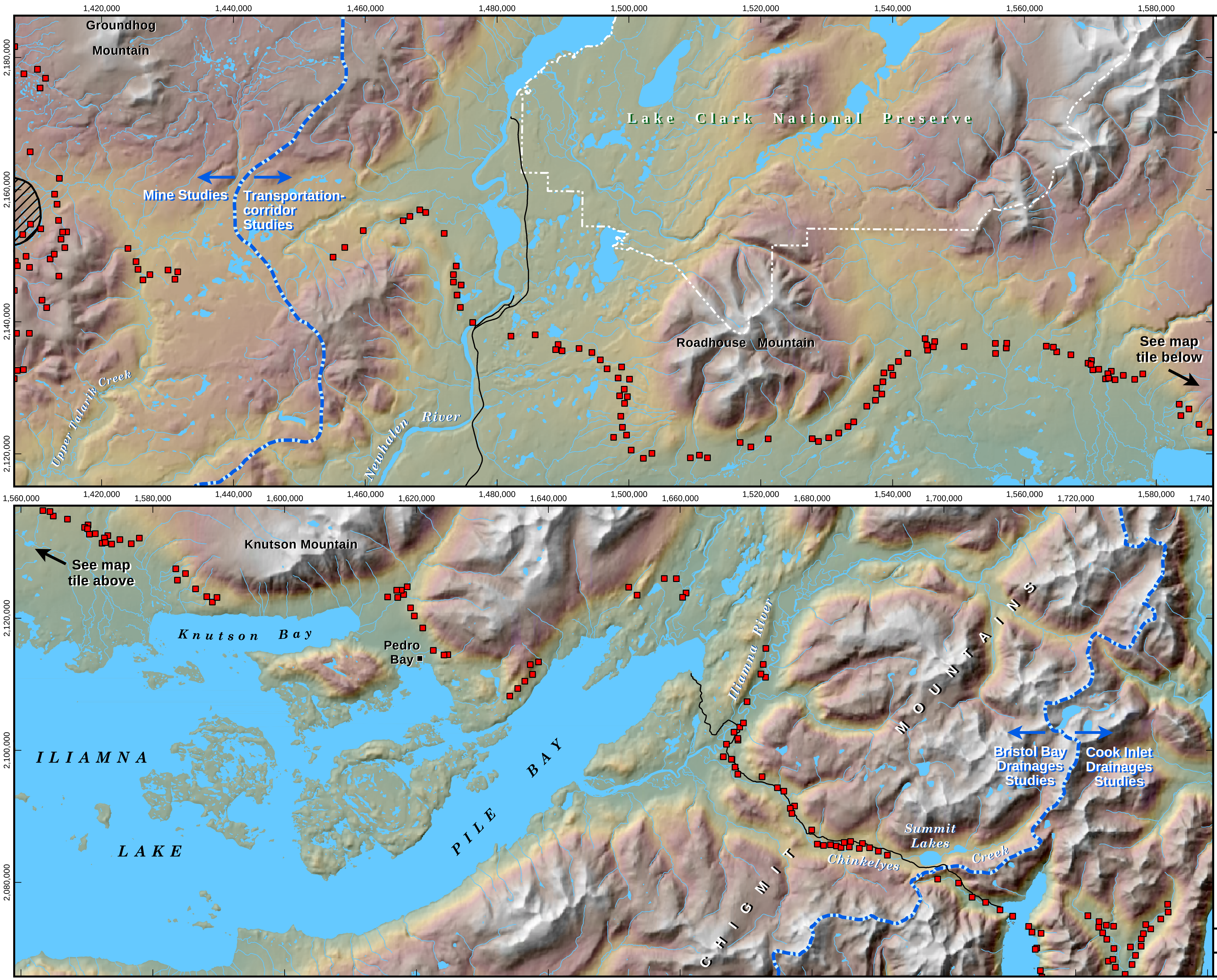
TABLE 16.11-10
Average Occurrence Figures[a] for Shorebirds in Mapped Wildlife Habitat Types, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Species	Alpine Dry Barrens	Alpine Moist Dwarf Scrub	Alpine Wet Dwarf Shrub–Sedge Scrub	Upland Dry Barrens	Upland Dry Dwarf Shrub–Lichen Scrub	Upland Moist Dwarf Scrub	Upland Moist Low Willow Scrub	Upland Moist Tall Alder Scrub	Upland Moist Tall Willow Scrub	Upland and Lowland Spruce Forest	Upland and Lowland Moist Mixed Forest	Rivers and Streams	Rivers and Streams (Anadromous)	Riverine Barrens	Riverine Wet Graminoid–Shrub Meadow	Riverine Low Willow Scrub	Riverine Tall Alder or Willow Scrub	Riverine Moist White Spruce Forest	Riverine Moist Mixed Forest	Lakes and Ponds	Lacustrine Moist Barrens	Lowland Sedge–Forb Marsh	Lowland Ericaceous Scrub Bog	Lowland Wet Graminoid–Shrub Meadow	Lowland Low and Tall Willow Scrub
	n=0	*n*=0	*n*=0	*n*=0	*n*=0	*n*=8	*n*=5	*n*=6	*n*=0	*n*=24	*n*=58	*n*=0	*n*=0	*n*=0	*n*=2	*n*=3	*n*=4	*n*=0	*n*=19	*n*=0	*n*=0	*n*=0	*n*=12	*n*=7	*n*=6
Pacific Golden-Plover						0.125																			
Greater Yellowlegs										0.083													0.167		
Lesser Yellowlegs																								0.286	
Wilson's Snipe																							0.250		

Notes:

a. Average occurrence = number of bird detections divided by *n* (number of point-counts conducted); only focal observations in each habitat are included (see Section 16.5.6.1, Field Surveys and Habitat-use Analyses)

FIGURES



THE pebble PARTNERSHIP

Figure 16.11-1
Landbird/Shorebird Point-count Locations, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Legend

- Point-count Location
- General Deposit Location
- Existing Road

Miles: 0 1 2 3 4 5 6

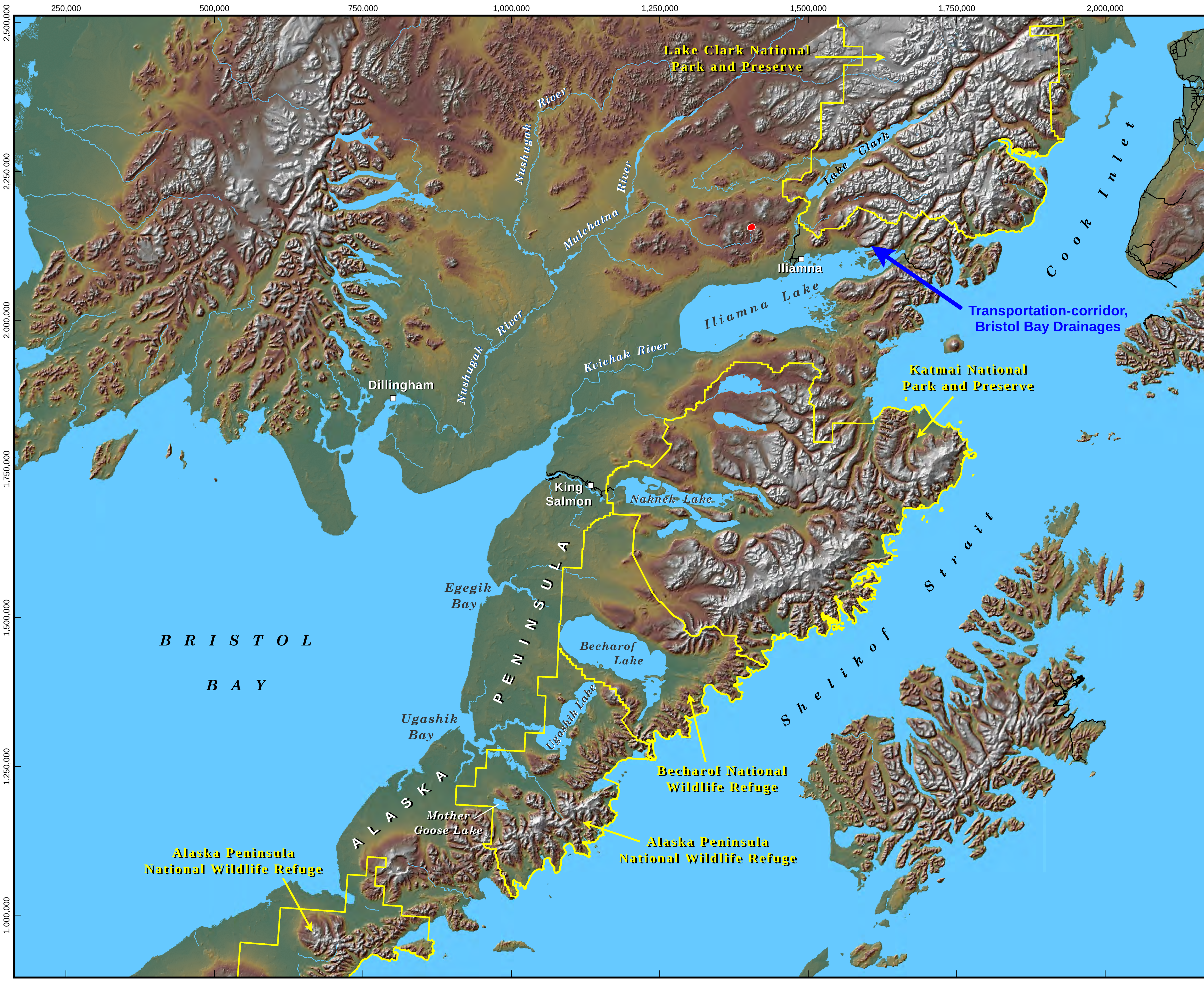
Kilometers: 0 1 2 3 4 5 6 7 8 9

Scale 1:180,000

N

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

File: 16-11-1_BrBird_Road_PLP_EBD_v01.mxd	Date: June 16, 2010
Version: 1	Author: ABR-AZC



THE pebble PARTNERSHIP

Figure 16.11-2
Region Surrounding the Transportation-corridor, Bristol Bay Drainages Study Area in which Previous Studies of Landbirds and Shorebirds were Conducted

Legend

- General Deposit Location
- Existing Road
- Town or Village

Miles: 0 10 20 30 40 50 60

Kilometers: 0 20 40 60 80 100

Scale 1:2,000,000

N

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

File: 16-11-2_BrBird_Previous_PLP_EBD_v01.mxd	Date: June 17, 2010
Version: 1	Author: ABR-AZC

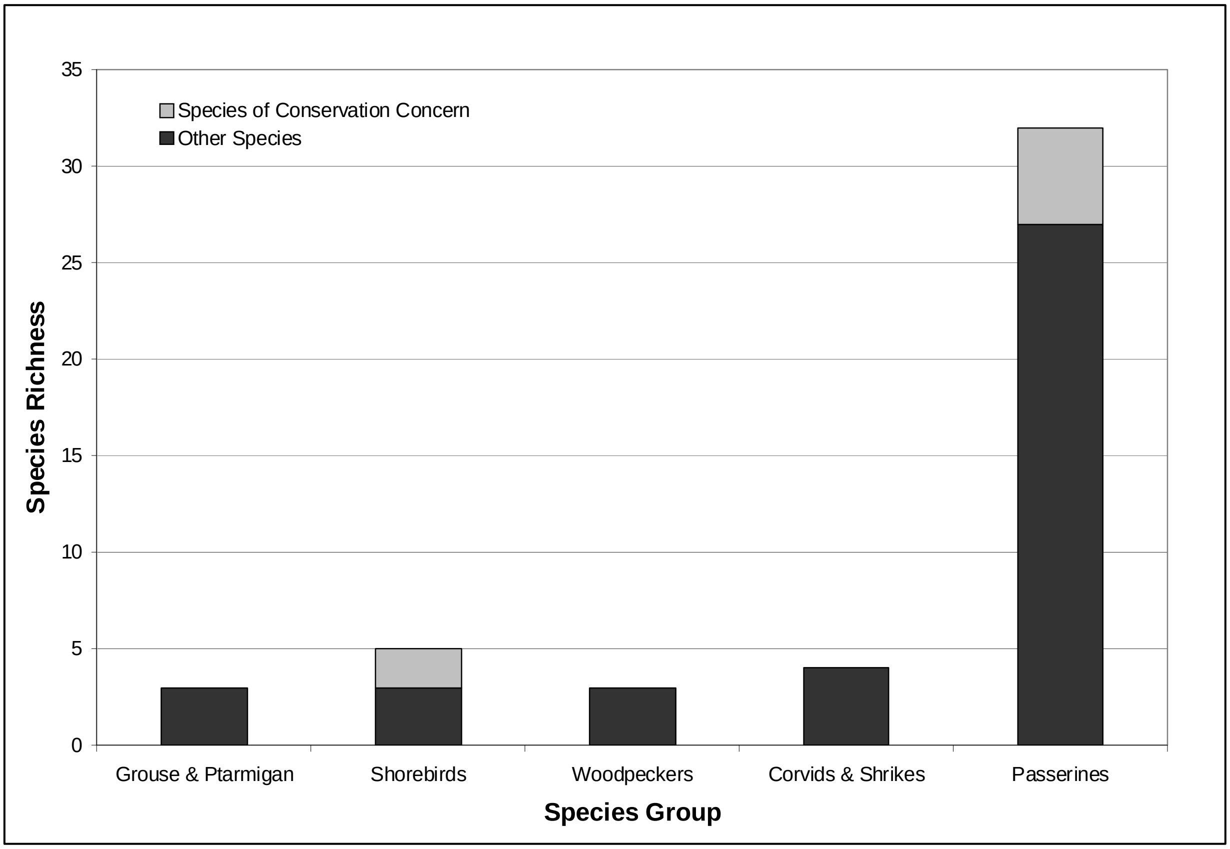


FIGURE 16.11-3
Numbers of Landbird and Shorebird Species (Species Richness) by Species-group Recorded during Point-count Surveys in the Transportation-corridor, Bristol Bay Drainages Study Area, 2005

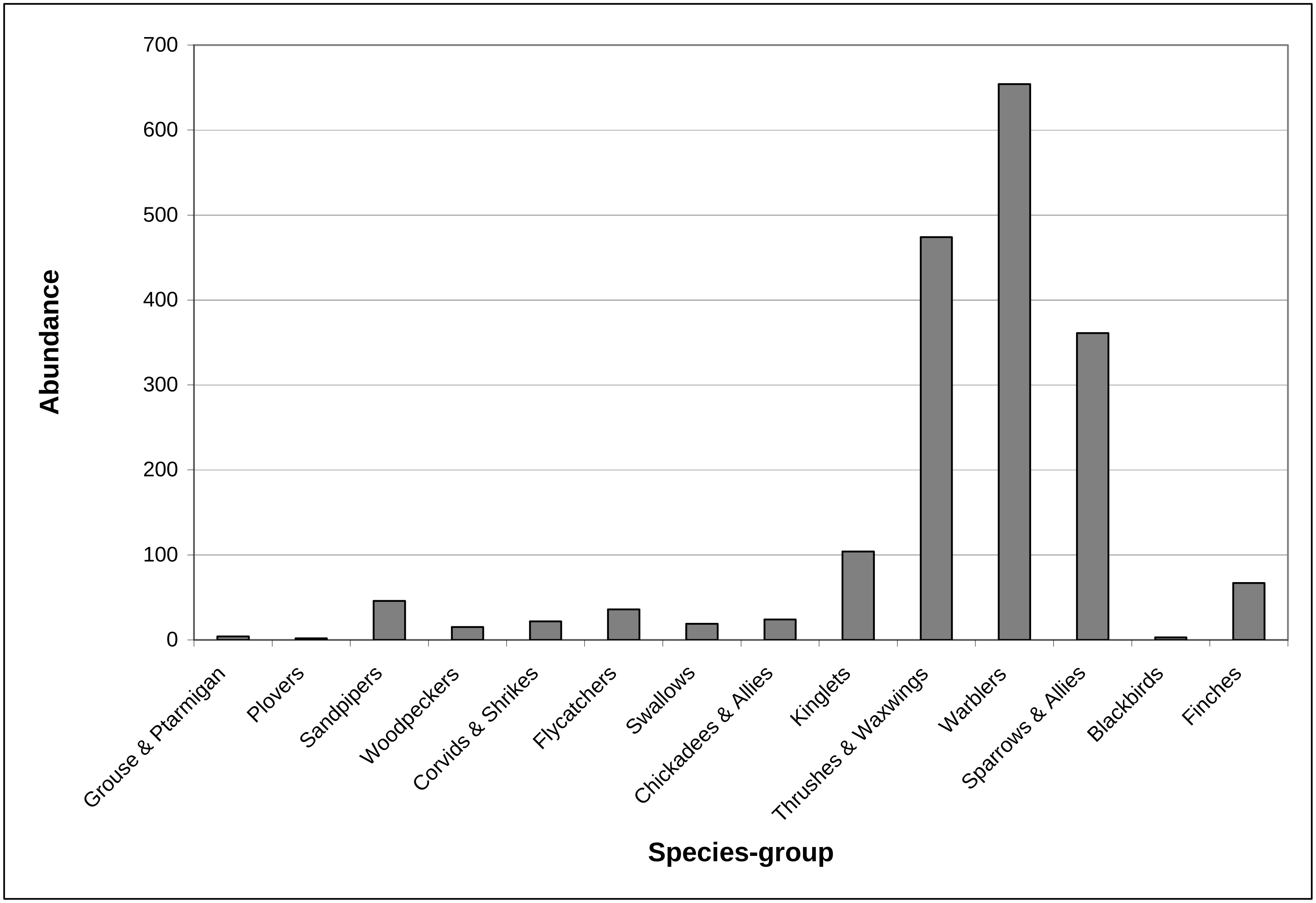


FIGURE 16.11-4
Abundance of Landbirds and Shorebirds by Species-group Recorded during Point-count Surveys, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

APPENDICES

APPENDIX 16.11A

NUMBERS OF LANDBIRDS AND SHOREBIRDS OBSERVED INCIDENTALLY DURING POINT-COUNT SURVEYS AND IN TRANSIT BETWEEN POINT-COUNT LOCATIONS TRANSPORTATION-CORRIDOR, BRISTOL BAY DRAINAGES STUDY AREA, 2005

APPENDIX 16.11A
Numbers of Landbirds and Shorebirds Observed Incidentally during Point-count Surveys and In Ttransit between Point-count Locations, Transportation-corridor, Bristol Bay Drainages Study Area, 2005

Avian Species	No. Incidental[a]	No. In Transit[b]
LANDBIRDS		
Blackpoll Warbler	10	0
Boreal Chickadee	9	0
Varied Thrush	9	4
American Robin	7	0
Yellow-rumped Warbler	6	0
Gray Jay	5	0
Red-breasted Nuthatch	5	0
Savannah Sparrow	5	4
Dark-eyed Junco	5	7
Golden-crowned Kinglet	4	0
Orange-crowned Warbler	4	0
Lincoln's Sparrow	4	1
White-crowned Sparrow	4	3
White-winged Crossbill	4	0
American Three-toed Woodpecker	3	10
Hermit Thrush	3	0
Fox Sparrow	3	0
Common Redpoll	3	0
Willow Ptarmigan	2	0
Olive-sided Flycatcher	2	0
Common Raven	2	0
Ruby-crowned Kinglet	2	0
Swainson's Thrush	2	0
Pine Grosbeak	2	0
Spruce Grouse	1	3
Sandhill Crane	1	0
Belted Kingfisher	1	1
Black-backed Woodpecker	1	1
Alder Flycatcher	1	0
Black-billed Magpie	1	0
Black-capped Chickadee	1	0
Arctic Warbler	1	0
Gray-cheeked Thrush	1	0
Bohemian Waxwing	1	0
Yellow Warbler	1	0
Northern Waterthrush	1	0

Avian Species	No. Incidental[a]	No. In Transit[b]
Wilson's Warbler	1	0
American Tree Sparrow	1	0
Northern Shrike	0	7
SHOREBIRDS		
Lesser Yellowlegs	2	0
Wilson's Snipe	2	0
Greater Yellowlegs	1	0
Solitary Sandpiper	1	0
Spotted Sandpiper	0	1

Notes:

a. Incidental observations were recorded at point-count locations but not during the count period.

b. In-transit observations recorded while moving on foot between point-count locations are primarily observations of less commonly recorded species and/or observations of nests, defensive behavior indicative of the presence of a nest, or fledglings being tended by adults.

16.12 Wood Frogs—Mine Study Area

16.12.1 Introduction

The results of occupancy surveys for wood frogs (*Rana sylvatica*) conducted in 2007 in the mine study area are presented in this section. Researchers conducted studies to assess population and habitat characteristics of wood frogs in the vicinity of the deposit area.

Amphibians are of increasing conservation concern worldwide because of widespread population declines and extirpation of local populations (McCallum, 2007). Amphibians are viewed as gages of environmental health because they are sensitive to changes in the environment and often exhibit effects caused by small changes in environmental conditions that are not yet evident in other vertebrate species (Blaustein and Wake, 1990; Wyman, 1990; Blaustein et al., 1994; Licht, 2003; Blaustein et al., 2005; Dohm et al., 2005; Bancroft et al., 2007). Wood frogs are the most common amphibian in Alaska (MacDonald, 2003), and the only amphibian species that occurs in southwestern Alaska (Hodge, 1976); however, little is known about their actual distribution, population status, or habitat-use characteristics outside of populated areas near eastern Cook Inlet (Gotthardt, 2004 and 2005).

16.12.2 Study Objectives

The goal of wood frog surveys in 2007 was to determine the presence and distribution of breeding wood frogs, estimate the occupancy rate of waterbodies by breeding wood frogs, and evaluate habitat characteristics of waterbodies used by breeding wood frogs in the mine study area. Specific study objectives were as follows:

- Determine the sampled distribution of wood frogs in the mine study area.
- Accurately estimate the rate of occupancy by wood frogs of waterbodies within the mine study area.
- Identify important habitat characteristics associated with breeding wood frog occupancy of waterbodies in the mine study area.

16.12.3 Study Area

The study area for breeding wood frogs included all waterbodies mapped in a geographical information system (GIS) in an area from 59° 77’ to 60° 00’ north latitude and from 155° 22’ to 155° 52’ west longitude. This area encompasses the Pebble deposit area (Figure 16.12-1). The mine study area occurs in an ecological transition zone between the Bristol Bay/Nushagak lowlands, and interior forested lowlands and uplands (Gallant et al., 1995), in which interior mixed spruce/hardwood forests on the east grade into alpine tundra habitats to the west.

Waterbodies in the mine study area ranged from very small ponds (less than 0.01 hectare) to large lakes (approximately 60 hectares), but the majority of waterbodies (93 percent) were less than 1.0 hectare in size. Waterbodies in the area varied in their depth, complexity of the shoreline (i.e., simple or convoluted), connectivity to stream drainages, annual water retention, presence of emergent and aquatic vegetation, and type and composition of shoreline vegetation.

16.12.4 Previous Studies

Although wood frogs are the most common amphibian in Alaska (MacDonald, 2003), distribution and population numbers of wood frogs in the state are largely unknown. A study of amphibians in the Yukon region indicated that wood frogs were abundant in interior Alaska in the mid-1970s (Hodge, 1976), and two more recent studies suggested that wood frogs may be more abundant in other parts of Alaska than in the southeastern portion of the state (Carstensen et al., 2003; Gotthardt, 2005). Though numerous anecdotal reports from the Kenai Peninsula, Anchorage bowl, and Talkeetna area indicated that wood frogs were no longer present at many historical breeding sites (Gotthardt, pers. comm., 2008), recent studies of wood frogs in southcentral Alaska suggested that the species was “widespread and abundant” in developed areas along eastern Cook Inlet (Gotthardt, 2004 and 2005). In southeastern Alaska, Carstensen et al. (2003) surveyed 352 ponds and found wood frogs in only one location. Few dedicated surveys for wood frogs have been conducted farther west in Alaska, though anecdotal information indicates the species is less common in that area. An Alaska amphibian inventory conducted by the National Park Service in 2001 through 2003 confirmed the presence of wood frogs in Lake Clark and Katmai national parks and preserves (Anderson, 2004), but no information is available about population abundances in these areas.

16.12.5 Scope of Work

Researchers conducted ground-based field surveys from May 16 through 23, 2007. Jennifer H. Boisvert of ABR, Inc., conducted the wood frog study with field support from Dawn E. Bragg and John C. Seigle, and supervisory support from Charles T. Schick.. Alex K. Prichard of ABR, Inc., and Darryl I. MacKenzie of Proteus Wildlife Research Consultants provided statistical advice.

The wood frog study in the mine study area included the following tasks:

- Collection and review of relevant literature on wood frogs inhabiting Alaska and the region encompassing the mine study area.
- Sampling of a random set of waterbodies in the study area (mapped in a GIS) for the presence of breeding wood frogs.
- Evaluation of the distribution of breeding wood frogs.
- Estimation of the occupancy rate of waterbodies used for breeding by wood frogs.
- Identification of important habitat characteristics associated with wood frog presence.

16.12.6 Methods

16.12.6.1 Occupancy Surveys

Researchers stratified waterbody types in the mine study area for random sampling using a GIS hydrology layer for the mine study area (produced by Kodiak Mapping, Inc., and Eagle Mapping, Ltd., and reprocessed by RDI, Inc., Anchorage, AK) in coordination with field data collected from waterbird brood-rearing surveys (conducted by ABR, Inc., in 2004 and 2005). Habitat characteristics of waterbodies were applied to applicable mapped waterbody polygons in the GIS layer in ArcGIS 9.2 (ESRI, 2006), and an assessment was made of known waterbody characteristics that were thought to be important to breeding wood frogs. Waterbody size and the presence of emergent vegetation were selected as the most useful known characteristics of waterbodies in the study area that could be associated with the occurrence of breeding wood frogs. Fish presence also is a likely contributing factor to occupancy by frogs, but sufficient data on fish occurrence within the study area waterbodies was not currently available. Researchers stratified all mapped polygons of waterbodies from the hydrology layer by size (small ponds—less than 0.1 hectare, large ponds—0.1 to 0.9 hectare, small lakes—1.0 to 3.0 hectares, and large lakes—3.0 hectares or more) and by the presence or absence of emergent vegetation. Approximately 15 waterbodies from each combination of variables were randomly selected using a random-point generator tool in ArcGIS 9.2. Figure 16.12-1 shows the 120 waterbodies selected for survey in the mine study area from the waterbodies that were available for random selection.

Surveys for wood frogs in the mine study area were conducted during the peak period for breeding of wood frogs in southcentral Alaska following data presented in Gotthardt (2004). Researchers followed standard amphibian calling-survey protocols (USGS, 2005), with modifications only in the diurnal timing of the survey period to correct for Alaska's long daylight hours in May and to work within safety constraints of the project (e.g., not working at night in an area known to have bears). Presence/absence survey methods, accounting for detectability, (MacKenzie et al., 2006) were used to obtain a more accurate estimate of wood frog occurrence in the study area. The sampling design was a repeated survey with pseudo double-blind-observer. All randomly selected waterbodies in the mine study area were surveyed twice (approximately two to four days apart) during the peak breeding period for wood frogs. Two different observers were used, and each waterbody was surveyed by one observer during the first survey and by the other observer during the second survey. The observers had no previous knowledge of frog occupancy in any of the waterbodies.

Researchers conducted wood-frog calling surveys May 16 through 23, 2007. Surveys were conducted daily from approximately 1200 hours to 2200 hours when frogs were most actively calling and only under favorable weather conditions (i.e., light or no rain, air temperature more than 4° Celsius, and wind speeds less than or equal to 25 kilometers per hour). Selected waterbodies were located in the field by navigating to the centroid coordinates of the mapped waterbody polygon using a hand-held global positioning system (GPS) unit. Waterbodies were accessed by helicopter or on foot. When using a helicopter, the pilot landed the helicopter 100 meters or more from the waterbody edge and shut down the helicopter or moved from the area during surveys to minimize disturbance to calling frogs.

Observers chose a survey location on each waterbody margin that allowed good visibility and audible detectability over the entire waterbody. When the waterbody was 3.0 hectares or larger (i.e., a large lake), two to four sites were surveyed approximately 500 meters apart along the waterbody shoreline to enable complete coverage of the waterbody and accurate detection of any wood frogs present. At initiation of each survey, the observer first recorded habitat, weather, and survey conditions to allow male wood frogs additional time to resume calling if they had been disturbed by helicopter activity or by the observer approaching the waterbody. Habitat characteristics that were expected to remain constant during the eight-day survey period (site-specific variables) were recorded only during the initial survey of each waterbody (i.e., the first of the two surveys conducted during the survey period or the first survey site on large lakes where surveys were conducted at multiple sites). The site-specific variables recorded included the following:

- Wildlife habitat type surrounding the waterbody.

- Percent herbaceous vegetation within a 50-meter radius of the shoreline.
- Percent dwarf shrub vegetation (less than 20 centimeters in height) within a 50-meter radius of the shoreline.
- Percent low shrub vegetation (0.2 to 1.5 meters in height) within a 50-meter radius of the shoreline.
- Percent tall shrub vegetation (more than 1.5 meter in height) within a 50-meter radius of the shoreline.
- Percent bare ground within a 50-meter radius of the shoreline.
- Maximum water depth (less than 1.5 meter, or more than 1.5 meter).
- Waterbody substrate (mud/silt, organic, sand, gravel).
- Presence of (more than 1 percent cover) emergent and/or aquatic vegetation.
- Visual presence of fish.
- Whether or not the waterbody was inhabited by beavers.

Observers recorded survey-specific conditions at each survey site prior to conducting each calling survey. At large lakes where calling surveys were conducted at multiple sites to adequately detect frogs, weather and water-quality conditions were measured only at the initial sampling site. Survey-specific variables included the survey replicate number, and all weather and water-quality conditions that differed or could potentially differ between repeated surveys at a given site. These variables included the following:

- Survey replicate number.
- Observer.
- Percent cloud cover (estimated to the nearest 10 percent).
- Precipitation.
- Wind speed.
- Air temperature.
- Water temperature.
- Electrical conductivity of the water.
- Dissolved oxygen concentration in the water.
- pH level of the water.
- Percent ice cover (estimated to the nearest 5 percent).

Cloud cover and precipitation were estimated visually by the observer. Wind speed and air temperature were measured with a Kestrel 2000 anemometer. Water temperature, electrical conductivity, and dissolved oxygen were measured with a Yellow Springs Instrument (YSI) 556 multimeter, and pH level was measured with a pH meter. The survey date and waterbody identification number were recorded for each survey.

After site and survey conditions were recorded, the observer initiated the frog calling survey. Because this study was a presence/absence survey, if the observer audibly or visually detected frogs at the site at any time prior to initiating the calling survey, wood frogs were recorded as being present in the waterbody and the survey was concluded. If wood frogs had not yet been detected at the site, the observer moved 10 to 20 meters from the shoreline and sat quietly for 1 minute to allow any frogs present to resume their calling activity. The observer then listened quietly for 5 minutes for any calling wood frogs. At any time within the 5 minutes, if a frog was heard calling, the observer concluded the calling survey and recorded wood frogs as present at that waterbody. If the observer was surveying a large lake with multiple sampling sites along the shoreline, the survey was concluded with no further sampling whenever a frog was detected at any of the sites for that waterbody. If no frogs were heard during the allotted survey time, wood frogs were recorded as undetected at the waterbody. Calling conditions were recorded for each survey after conclusion of the survey. These conditions included noise level during the survey (e.g., caused by wind, insects, drill rigs, etc.) and the Wisconsin Calling Index rank of wood frog calling activity (0 = no calling amphibians; 1 = individuals can be counted and there is space between calls; 2 = calls of individuals can be distinguished but there is some overlap in calls; or 3 = full chorus and calls are constant, continuous, and overlapping). When present, individual calling male frogs were counted, if possible, and recorded.

16.12.6.2 Data Analysis

Researchers conducted a statistical analysis of the data from the wood frog survey to provide a more accurate estimation of the occupancy rate of waterbodies by frogs in the mine study area and to determine habitat characteristics that may predict wood frog use of waterbodies. The study design and analysis followed occupancy estimation and modeling techniques suggested by MacKenzie et al. (2006) to provide a corrected occupancy estimate by accounting for imperfect detectability of frogs during surveys. Although attempts are made to promote detection of individual animals during surveys, nondetection still occurs for various reasons (e.g., observer differences, weather conditions, temporal variation in diurnal breeding effort, temporal variation in seasonal breeding effort) and is a reality in ecological field studies (MacKenzie et al., 2002). Researchers addressed bias from nondetection in this study by implementing methods to allow for statistical assessment of the detection rate by modeling data to account for the detection probability (MacKenzie et al., 2002). Researchers conducted all statistical analyses and covariate modeling with the software program PRESENCE 2.2 (Hines, 2006) using the single-season analysis format and custom model-building feature.

Researchers reviewed literature on amphibians and used professional knowledge to limit the number of site- and survey-specific variables used as parameters in modeling of wood frog detectability and occupancy. They chose model covariates thought to be most biologically relevant in predicting wood frog occurrence and for which there were sufficient data for all waterbodies. Researchers reduced the number of covariates and avoided autocorrelation problems by combining the vegetation-structure variables recorded within 50 meters of each waterbody shoreline (e.g., percent herbaceous vegetation, dwarf shrub vegetation, low shrub, tall shrub, and bare ground) into a single habitat type that incorporated the vegetation types likely used by wood frogs for nonbreeding and/or hibernation. Researchers derived a hibernation habitat covariate by summing only the percentages of herbaceous, low shrub, and tall shrub vegetation within 50 meters of the shoreline of the waterbody because these types are those that likely contain the nonbreeding and hibernation characteristics used by frogs (i.e., terrestrial insect food sources, protection from predators, and leaf litter and soils used for hibernation). Although presence of fish is biologically important for influencing amphibian occupancy in waterbodies (Knapp and Matthews, 2000; Knapp et al., 2003; Knapp et al., 2007), researchers were unable to sufficiently assess or obtain accurate data on fish presence for study area waterbodies; therefore, they did not use this variable in the analyses. The final set of site-specific variables used in analyses was percent hibernation habitat within 50 meters of the shoreline, waterbody size, water depth, presence of emergent and/or aquatic vegetation, and whether or not the waterbody was a beaver pond (Table 16.12.1). The survey-specific variables used were survey replicate number, observer, water temperature, dissolved oxygen concentration, and electrical conductivity. Researchers used Pearson's correlation analyses (Zar, 1999) to evaluate that all covariates used in the modeling had low to moderately-low correlations ($r < 0.39$) between them.

Before analyses, researchers coded all categorical variables (survey number, observer, water depth, emergent/aquatic vegetation, and beaver pond) as binomials, and standardized all continuous variables (water temperature, dissolved oxygen concentration, electrical conductivity, percent hibernation habitat, and waterbody size) to a normal distribution. They transformed waterbody size using a natural logarithm because data were dominated by smaller waterbodies and were skewed toward the few outlying large waterbodies that occur in the study area. They transformed all other continuous variables using a z-transformation.

Researchers reduced the number of models to be fit to parameters estimating wood frog occupancy by modeling for detectability first and then for overall occupancy. This is an accepted approach to fitting models in which 10 or more parameters are being modeled (MacKenzie, pers. comm., 2008). Akaike's Information Criterion (AIC) scores were used to determine the best models in the candidate-model set (Burnham and Anderson, 2002). Researchers fit models by first adjusting only the survey-specific (i.e., detectability) covariates and keeping site-specific (i.e., occupancy) covariates constant. Then they used the top model of detectability and adjusted only the occupancy covariates to determine the best overall model for estimating wood frog occupancy in the study area.

16.12.7 Results and Discussion

Of the 120 randomly selected waterbodies in the mine study area, 119 were surveyed for wood frogs. A second survey was conducted two to four days after the initial survey at 86 of the 119 waterbodies initially surveyed. Repeat surveys were not completed at the remaining 33 waterbodies because on the last day of the field sampling period high winds (25 kilometers per hour or greater) prevented sufficient survey for the audible detection of frogs.

Wood frogs were detected at 10 of the sampled waterbodies during the first survey and at 15 waterbodies during the second survey. Frogs were detected during both visits at only three of the same waterbodies. Of the waterbodies where frogs were detected, only four were categorized with a Wisconsin Calling Index of 2 (calls of individuals could be distinguished but there was overlap in calls; typically three or more frogs present) while all other waterbodies had an index of 1 (frog calls did not overlap and individuals could be counted; typically one to three frogs present).

Researchers detected wood frogs at surveyed waterbodies and incidentally at waterbodies that were not selected for surveys throughout the mine study area. Distribution of breeding wood frogs did not indicate any obvious spatial pattern of occupancy within the study area (Figure 16.12-2).

16.12.7.1 Detectability and Occupancy Estimation

The unadjusted occupancy estimate of wood frogs in the study area (based solely on detections at the 119 waterbodies surveyed), and not accounting for frogs that were present but undetected, was 18.5 percent. This estimate, however, does not account for nondetection error. A low detection rate of breeding wood frogs by observers is evident in the raw data, as frogs were observed in only three of the same 86 waterbodies that were surveyed twice. Modeling of the covariate data for detection probability indicated that the detection rate of calling wood frogs occupying waterbodies was indeed low (only 26.6 percent), and should be accounted for.

Researchers fit 31 detectability models (Table16.12-2), and the top model was chosen as the most parsimonious model to further fit models for occupancy probability (Table 16.12-3). Because no model of occupancy probability was clearly superior in explaining wood frog occupancy, the researchers accounted for the model uncertainty by averaging all acceptable models in the model set. This is an acceptable practice in this case (Burnham and Anderson, 2002; MacKenzie et al., 2006), and researchers used the final ‘model-averaged’ model to properly estimate wood frog occupancy and assess the influences of individual model parameters on occupancy in the study area (MacKenzie, pers. comm., 2008; MacKenzie et al., 2006).

The corrected estimate of occupancy from the final derived occupancy model (Table 16.12-4) indicated that wood frog occupancy of waterbodies in the mine study area in 2007 was 49.5 percent. This is considerably higher than the uncorrected estimate of 18.5 percent, and is reasonable considering the low detectability of wood frogs (26.6 percent) during the surveys. This suggests that although many waterbodies were occupied by wood frogs at some time during the survey period, the detectability was not always consistent, and was likely an effect of diurnal timing of the survey, variable weather conditions, changes in waterbody conditions (e.g., water temperature, ice cover), observer differences, and/or timing of surveys in relation to the peak of frog breeding in the area. Frogs likely were in different stages of calling intensity or exhibited diurnal differences in calling behavior over the survey period. Wood frogs generally have a short breeding period, about two to three weeks, which peaks rapidly as seasonal changes provide suitable frog breeding conditions. During the survey period, waterbody conditions such as ice cover and water temperatures also changed rapidly and varied substantially among different types of waterbodies (e.g., shallow versus deep), and weather conditions varied within and between survey days. Although covariates representing these factors were not present in the top detectability model, all of them were in models that had some evidence of support (i.e., less than 7.0 difference from the top model, Table 16.12-2), indicating that some of these factors did affect wood frog detectability during the surveys.

Few studies in Alaska have established occupancy rates of wood frogs. A recent study in Denali National Park estimated wood frog occupancy as 45 percent (Hokit and Brown, 2006), which is similar to that estimated in this study. Wood frogs are thought to be abundant in southcentral Alaska, though possibly less so in southwestern Alaska (Gotthardt, 2004 and 2005). Therefore, an occupancy rate of 49.5 percent for the mine study area appears reasonable.

16.12.7.2 Habitat Characteristics of Occupied Waterbodies

Examination of the frequency, placement, and weight of different occupancy covariates within the model set provides an indication of their importance as factors influencing wood frog occupancy. Water depth and percent hibernation habitat occur in most of the top (lower AIC-scoring) models (Table 16.12-3), suggesting they are the most important waterbody characteristics affecting wood frog occupancy. Waterbody size and presence of emergent/aquatic vegetation appear throughout the model set, while the beaver pond covariate was not found as often in the top models (Table 16-12-3). The summed model (AIC) weights of the five occupancy covariates (from all the suitable occupancy models) give an indication of their potential strength of influence on occupancy by wood frogs. The summed model weights were 87 percent for waterbody depth, 58 percent for percent hibernation habitat, 37 percent for waterbody size, 40 percent for emergent/aquatic vegetation, and 28 percent for beaver pond. All values are large enough to suggest some affect on occupancy of waterbodies by wood frogs, but the considerably higher values of waterbody depth and percent hibernation habitat indicate that they may be much more important in influencing occupancy by wood frogs than the other covariates.

Researchers used the parameter estimates from the model-averaged occupancy model, conditional standard errors of the estimates, back-transformed odds ratios, and odds ratio confidence intervals (Table 16.12-5) to further examine the effects of individual parameters on wood frog occupancy and the level of support for their effects. All the estimates are positive, indicating that occupancy of the waterbodies is predicted to increase as the covariate values increase, but the magnitude of the influence varies for each covariate (Table 16.12-5). However, conclusions ascertained about the extent of influence are not always statistically-supported (Table 16.12-5).

General assessments regarding the influence of habitat characteristics that affect occupancy of waterbodies in the mine study area by breeding wood frogs suggest that:

- Depth of the waterbody has a stronger magnitude of effect than the presence of emergent/aquatic vegetation and whether or not the waterbody is a beaver pond (Table 16.12-5).

- Deep waterbodies (more than 1.5 meters deep) are 10.12 times more likely to be occupied by wood frogs than shallow waterbodies (less than 1.5 meters deep). (Table 16.12-5).

- As the percent of hibernation habitat surrounding waterbodies increases, wood frog occupancy also increases in a near linear manner, and most so near shallow waterbodies (Figure 16.12-3).

- Waterbodies with more than 1 percent cover of emergent or aquatic vegetation are 2.88 times more likely to be used by wood frogs than waterbodies without such vegetation (Table 16.12-5).

- The size of a waterbody is only marginally important, but suggests a moderate increase in wood frog occupancy as waterbody size increases. The magnitude of influence is fairly linear and is most pronounced in shallow waterbodies (Figure 16.12-4).

- Whether a waterbody is a beaver pond likely is not a large factor affecting wood frog occupancy.

Overall, results indicate that if a waterbody is more than 1.5 meters deep, that the more herbaceous, low shrub, and tall shrub vegetation that is present within 50 meters of it, and if it contains even a small amount (more than 1 percent) of emergent and/or aquatic vegetation, then the waterbody is more likely to be occupied by wood frogs (Figures 16.12-3 and Table 16.12-5).

Waterbody depth may be important because deeper waterbodies retain water, often maintain more consistent water-quality characteristics throughout the egg and larval growth stages, and do not generally freeze to the bottom during winter. This was implicated as important in a study on the mountain yellow-legged frog (*Rana muscosa*) that use high-elevation lakes where larvae often are unable to completely metamorphose in a single summer, and therefore overwinter in the lakes (Knapp et al., 2003). Wood frogs are adapted to northern climates and short summers, however, and typically metamorphose in a single season in Alaska. Additionally, surveys of wood frogs in Denali National Park (Hokit and Brown, 2006) indicated that wood frogs exhibited less breeding activity in deeper waterbodies. Waterbody depth appeared to be the most important factor with the greatest magnitude of effect on wood frog occupancy in the mine study area, but the certainty and significance of this postulation is unclear.

It is reasonable to expect that increased availability of vegetation that provides suitable hibernation or foraging habitats for terrestrial adult wood frogs in the vicinity of the waterbodies would be important in influencing occupancy of waterbodies. Proximity to other life-stage habitats reduces frog exposure to predators and excessive energy use in travel. Habitat proximity also allows a rapid return to the breeding pond in spring, which could result in increased reproductive success.

The importance of emergent and aquatic vegetation to breeding frogs has been noted in other studies (Egan and Paton, 2004; Hokit and Brown, 2006; Stevens et al., 2006), and emergent and aquatic vegetation has been proposed as a characteristic important to waterbody occupancy by wood frogs in this study as well. Emergent and aquatic vegetation in waterbodies provides a substrate for egg-mass attachment and escape cover from aquatic predators, as well as helping to increase dissolved oxygen in the water (France, 1997; Babbitt and Tanner, 1998). It is reasonable that the presence of emergent/aquatic vegetation is a waterbody characteristic that is favorable for wood frog occupancy.

The role that waterbody size plays on wood frog occupancy is somewhat obscured by confounding effects with other covariates that may be influential. Waterbody size has a slight positive correlation ($r = 0.28$) with waterbody depth, which has a large effect on wood frog occupancy. Yet, waterbody size also has a negative correlation ($r = -0.38$) with percent presence of emergent/aquatic vegetation, which also has some influence on wood frog occupancy. Thus, it is unclear how much waterbody size influences occupancy by breeding wood frogs individually because of its slight counteracting correlation with both these variables. However, it appears from graphical representation of the occupancy model (Figure 16.12-4) that wood frog occupancy is influenced by waterbody size, particularly when the waterbody is shallow.

Although the analyses in this study indicated that there was a slight influence of beaver ponds on breeding wood frog occupancy, this covariate also likely has confounding effects within ponds. Beaver ponds are thought, in some situations, to be beneficial to amphibians because of improved waterbody characteristics such as increased dissolved oxygen, submergent vegetation, and seasonal water retention (Gill, 1978; France, 1997; Babbitt and Tanner, 1998; Stevens et al., 2006). Beaver ponds, however, often are built on streams that contain predatory macroinvertebrates or fish that feed on amphibian eggs and larvae (Schlosser and Kallemyn, 2000). It is possible that beaver pond characteristics in the mine study area may vary, most times providing benefits, but at other times being detrimental to breeding wood frogs.

The occupancy rate estimated for wood frogs in the mine study area and conclusions regarding covariate effects on occupation of study area waterbodies by wood frogs are based on a marginal sample size. Researchers based the study design on predictions of much higher detectability, and repeat surveys of 33 of the waterbodies were not completed because of poor weather conditions. Thus, sample unit size and numbers of repeat surveys of the sample units were apparently insufficient for strongly interpreting the results waterbody characteristics have on occupancy. Because of this, model results implied that there is some effect of the covariates on wood frog occupancy, yet none of the waterbody characteristics can be supported statistically as important to wood frogs in the mine study area. Additionally, other waterbody characteristics on which data were unavailable may be more influential to wood frog occupancy of waterbodies. The most notable of these is the presence of fish that feed on wood frog eggs or tadpoles. Studies often indicate predatory fish as a factor preventing or reducing amphibian presence in a waterbody (Resetarits and Wilbur, 1989; Hopey and Petranka, 1994; Knapp and Matthews, 2000; Knapp et al., 2003; Knapp et al., 2007). Northern pike (*Esox lucius*), which are considered a predatory fish of amphibians, are known to occur in the mine study area, but adequate presence data for this species were unavailable during this study. Other variables that may influence occupancy of waterbodies by wood frogs in the mine study area include seasonal water retention and seasonal water-temperature variation.

16.12.8 Summary

Researchers conducted calling surveys for breeding wood frogs in the mine study area in May 2007. The study area contains 1,668 waterbodies, of which 119 were randomly selected and surveyed for breeding wood frogs. Repeat surveys were conducted at 86 of the sampled waterbodies two to four days later, following a study design which appropriately accounted for detectability to estimate the occupancy rate of wood frogs breeding in the mine study area. Waterbody habitat characteristics also were evaluated for their influence on wood frog occupancy of waterbodies.

The surveys were successful in mapping the general distribution of wood frog occurrence and for estimating the occupancy rate of wood frogs breeding in waterbodies in the mine study area. Wood frogs were detected at waterbodies throughout the study area, and without any obvious spatial distribution. Detectability of wood frogs during the surveys was only 27 percent. Modeling for the low detectability rate estimated that the true occupancy rate of wood frogs breeding in mine study area waterbodies was approximately 50 percent.

Although not statistically conclusive, modeling of habitat covariates indicated some influence on wood frog occupancy to varying degrees from various waterbody characteristics. Model results suggest that depth of the waterbody and percent of hibernation habitat may be important factors influencing wood frog occupancy, and that presence of emergent and/or aquatic vegetation also may increase occupation of waterbodies by wood frogs in the mine study area. Model parameter estimates indicate that deep waterbodies (more than 1.5 meters deep) are approximately 10 times more likely to be occupied by wood frogs than shallow waterbodies (less than 1.5 meters), that an increase in percent hibernation habitat surrounding a waterbody positively influences occupation by wood frogs, and that waterbodies with more than 1 percent emergent or aquatic vegetation present are approximately three times more likely to be used by wood frogs than waterbodies without vegetation. The size of a waterbody and whether it is a beaver pond have only minimal influence and little magnitude of effect on wood frog occupancy rates in the mine study area. Generally, study results suggest that if a waterbody in the mine study area is more than 1.5 meters deep, that if herbaceous, low shrub, and tall shrub vegetation are present within 50 meters of its shoreline, and if the waterbody contains even a small amount (more than 1 percent) of emergent and/or aquatic vegetation then it is more likely to be occupied by wood frogs, though none of these results are statistically conclusive.

16.12.9 References

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16.12.10 Glossary

A posteriori—with prior knowledge of the experience or, specifically, the results of the analysis.

Binomial—an expression that has only two values, for example, 1 or 0.

Centroid coordinates—the central GPS point coordinate of a polygon shape, such as a waterbody.

Covariates—factors or variables measured during a study and used in the statistical analysis to determine their effect on an observed outcome.

Extirpation—when a species ceases to exist in a local or regional area, but still exists elsewhere; a localized extinction.

Over-parameterized—when the statistical model being tested has an overabundance of covariates or variables for the available sample size.

TABLES

TABLE 16.12-1
Covariates Used for Occupancy and Detectability Estimation Modeling for Wood Frogs in the Mine Study Area, 2007

Model Covariate	Model Parameter Abbreviation	Covariate Type
Site-specific:	psi	
Hibernation habitat within 50 meters of shoreline (%)	hab	Continuous
Waterbody size (hectares)	size	Continuous
Waterbody depth (< or > 1.5 meters)	depth	Categorical
Presence of >1% emergent and/or aquatic vegetation (yes or no)	ESveg	Categorical
Beaver pond (yes or no)	beaver	Categorical
Survey-specific:	p	
Survey replicate number[a]	svy	Categorical
Observer	obs	Categorical
Water temperature (°C)	temp	Continuous
Dissolved oxygen concentration (milligrams per liter)	DO	Continuous
Electrical conductivity (microSiemens per centimeter)	EC	Continuous

Notes:

a. The survey replicate number parameter was used during model-fitting to asses for differences in detectability between survey days at the same sites.

TABLE 16.12-2
Akaike's Information Criterion Rankings of Models of Detectability Parameters for Wood Frogs in the Mine Study Area, 2007

No.	Model[a]	AIC Score	Delta AIC	AIC Weight	Evidence Ratio[b]	No. of Param.	-2*LogLike
1	psi(global),p(obs)	151.89	0.00	0.1695	1.0000	9	133.89
2	psi(global),p(obs+water)	152.36	0.47	0.1340	0.7906	10	132.36
3	psi(global),p(svy+obs)	153.32	1.43	0.0829	0.4892	10	133.32
4	psi(global),p(obs+DO)	153.81	1.92	0.0649	0.3829	10	133.81
5	psi(global),p(svy+obs+water)	153.87	1.98	0.0630	0.3716	11	131.87
6	psi(global),p(obs+EC)	153.89	2.00	0.0624	0.3679	10	133.89
7	psi(global),p(obs+water+DO)	154.34	2.45	0.0498	0.2938	11	132.34
8	psi(global),p(obs+water+EC)	154.36	2.47	0.0493	0.2908	11	132.36
9	psi(global),p(svy+obs+DO)	155.10	3.21	0.0340	0.2009	11	133.10
10	psi(global),p(svy+obs+EC)	155.31	3.42	0.0307	0.1809	11	133.31
11	psi(global),p(svy+water)	155.50	3.61	0.0279	0.1645	9	137.50
12	psi(global),p(obs+EC+DO)	155.80	3.91	0.0240	0.1416	11	133.80
13	psi(global),p(svy+obs+water+EC)	155.87	3.98	0.0232	0.1367	12	131.87
14	psi(global),p(svy+obs+water+DO)	155.87	3.98	0.0232	0.1367	12	131.87
15	psi(global),p(svy+DO)	156.03	4.14	0.0214	0.1262	9	138.03
16	psi(global),p(global)	156.33	4.44	0.0184	0.1086	12	132.33
17	psi(global),p(svy+EC)	156.36	4.47	0.0181	0.1070	9	138.36
18	psi(global),p(.)[c]	156.65	4.76	0.0157	0.0926	7	142.65
19	psi(global),p(svy+obs+EC+DO)	157.09	5.20	0.0126	0.0743	12	133.09
20	psi(global),p(svy+water+DO)	157.37	5.48	0.0109	0.0646	10	137.37
21	psi(global),p(svy+water+EC)	157.48	5.59	0.0104	0.0611	10	137.48
22	psi(global),p(water)	157.65	5.76	0.0095	0.0561	8	141.65
23	psi(global),p(svy+global)	157.87	5.98	0.0085	0.0503	13	131.87
24	psi(global),p(svy+EC+DO)	157.94	6.05	0.0082	0.0486	10	137.94
25	psi(global),p(EC)	158.47	6.58	0.0063	0.0373	8	142.47
26	psi(global),p(DO)	158.51	6.62	0.0062	0.0365	8	142.51
27	psi(global),p(svy+water+EC+DO)	159.36	7.47	0.0040	0.0239	11	137.36
28	psi(global),p(water+EC)	159.54	7.65	0.0037	0.0218	9	141.54
29	psi(global),p(water+DO)	159.65	7.76	0.0035	0.0207	9	141.65
30	psi(global),p(EC+DO)	160.32	8.43	0.0025	0.0148	9	142.32
31	psi(global),p(water+EC+DO)	161.54	9.65	0.0014	0.008	10	141.54

Notes:

a. See Table 16.12.-1 for definitions of model parameter abbreviations.

b. The evidence ratio (AIC weight of the listed model divided by the AIC weight of the best model) represents the evidence of model support.

c. p(.) is the null model of detectability, which sets the initial value of p = 1 and tests for no effect from detectability covariates.

TABLE 16.12-3
Akaike's Information Criterion Rankings of Models for Wood Frog Occupancy Parameters in the Mine Study Area, 2007

No.	Model[a]	AIC Score	Delta AIC	AIC Weight	Evidence Ratio[b]	No. of Param.	-2*LogLike
1	psi(hab+depth),p(obs)	146.98	0.00	0.1315	1.0000	6	134.98
2	psi(depth),p(obs)	147.57	0.59	0.0979	0.7445	5	137.57
3	psi(depth+ESveg),p(obs)	147.92	0.94	0.0822	0.6250	6	135.92
4	psi(hab+size),p(obs)	148.23	1.25	0.0704	0.5353	6	136.23
5	psi(hab+depth+ESveg),p(obs)	148.24	1.26	0.0701	0.5326	7	134.24
6	psi(hab+size+depth),p(obs)	148.79	1.81	0.0532	0.4045	7	134.79
7	psi(hab+depth+beaver),p(obs)	148.98	2.00	0.0484	0.3679	7	134.98
8	psi(depth+beaver),p(obs)	149.30	2.32	0.0412	0.3135	6	137.30
9	psi(size+depth),p(obs)	149.55	2.57	0.0364	0.2767	6	137.55
10	psi(depth+ESveg+beaver),p(obs)	149.86	2.88	0.0312	0.2369	7	135.86
11	psi(size+depth+ESveg),p(obs)	149.92	2.94	0.0302	0.2299	7	135.92
12	psi(hab+size+depth+ESveg),p(obs)	149.93	2.95	0.0301	0.2288	8	133.93
13	psi(hab+size+ESveg),p(obs)	150.02	3.04	0.0288	0.2187	7	136.02
14	psi(hab+depth+ESveg+beaver),p(obs)	150.21	3.23	0.0262	0.1989	8	134.21
15	psi(hab+size+beaver),p(obs)	150.23	3.25	0.0259	0.1969	7	136.23
16	psi(hab),p(obs)	150.24	3.26	0.0258	0.1959	5	140.24
17	psi(.),p(obs)[c]	150.46	3.48	0.0231	0.1755	4	142.46
18	psi(hab+size+depth+beaver),p(obs)	150.79	3.81	0.0196	0.1488	8	134.79
19	psi(size+depth+beaver),p(obs)	151.30	4.32	0.0152	0.1153	7	137.30
20	psi(size),p(obs)	151.69	4.71	0.0125	0.0949	5	141.69
21	psi(ESveg),p(obs)	151.70	4.72	0.0124	0.0944	5	141.70
22	psi(size+depth+ESveg+beaver),p(obs)	151.86	4.88	0.0115	0.0872	8	135.86
23	psi(global),p(obs)	151.89	4.91	0.0113	0.0859	9	133.89
24	psi(hab+size+ESveg+beaver),p(obs)	152.02	5.04	0.0106	0.0805	8	136.02
25	psi(hab+ESveg),p(obs)	152.06	5.08	0.0104	0.0789	6	140.06
26	psi(beaver),p(obs)	152.08	5.10	0.0103	0.0781	5	142.08
27	psi(hab+beaver),p(obs)	152.20	5.22	0.0097	0.0735	6	140.20
28	psi(size+ESveg),p(obs)	152.33	5.35	0.0091	0.0689	6	140.33
29	psi(size+beaver),p(obs)	153.12	6.14	0.0061	0.0464	6	141.12
30	psi(ESveg+beaver),p(obs)	153.49	6.51	0.0051	0.0386	6	141.49
31	psi(hab+ESveg+beaver),p(obs)	154.05	7.07	0.0038	0.0292	7	140.05

Notes:

a. See Table 16.12.-1 for definitions of model parameter abbreviations.

b. The evidence ratio (AIC weight of the listed model divided by the AIC weight of the best model) represents the evidence of model support.

c. psi(.) is the null model of occupancy, which sets the initial value of psi = 1 and tests for no effect from occupancy covariates.

TABLE 16.12-4
Final Detectability and Occupancy Probability Models of Breeding Wood Frogs in the Mine Study Area, 2007

Model Type	Probability Estimate
Detectability	logit(p) = [0.62-2.08*obs1-1.98*obs2]
Occupancy	logit(psi) = [-0.86+0.56*hab+0.10*size+2.32*depth+1.06*ESveg+0.14*beaver]

TABLE 16.12-5
Parameter Estimates, Back-transformed Odds Ratios, Conditional Parameter Standard Errors, and Odds Ratio Confidence Intervals for Site-specific Covariates Influencing Wood Frog Occupancy in the Mine Study Area, 2007

Model Covariate	Parameter Estimate (β_i)	Odds Ratio (e^{β_i}) [a]	Standard Error of β_i [b]	Confidence Interval of Odds Ratio [c]
Site-specific:				
Hibernation habitat within 50 meters of shoreline (%)	0.56	1.76	0.655	0.47–6.51
Waterbody size (hectares)	0.10	1.10	0.213	0.71–1.68
Waterbody depth (< or > 1.5 meters)	2.32	10.12	2.411	0.08–1258.76
Presence of >1% emergent and/or aquatic vegetation (yes or no)	1.06	2.88	1.471	0.15–54.65
Beaver pond (yes or no)	0.14	1.14	1.017	0.14–8.75

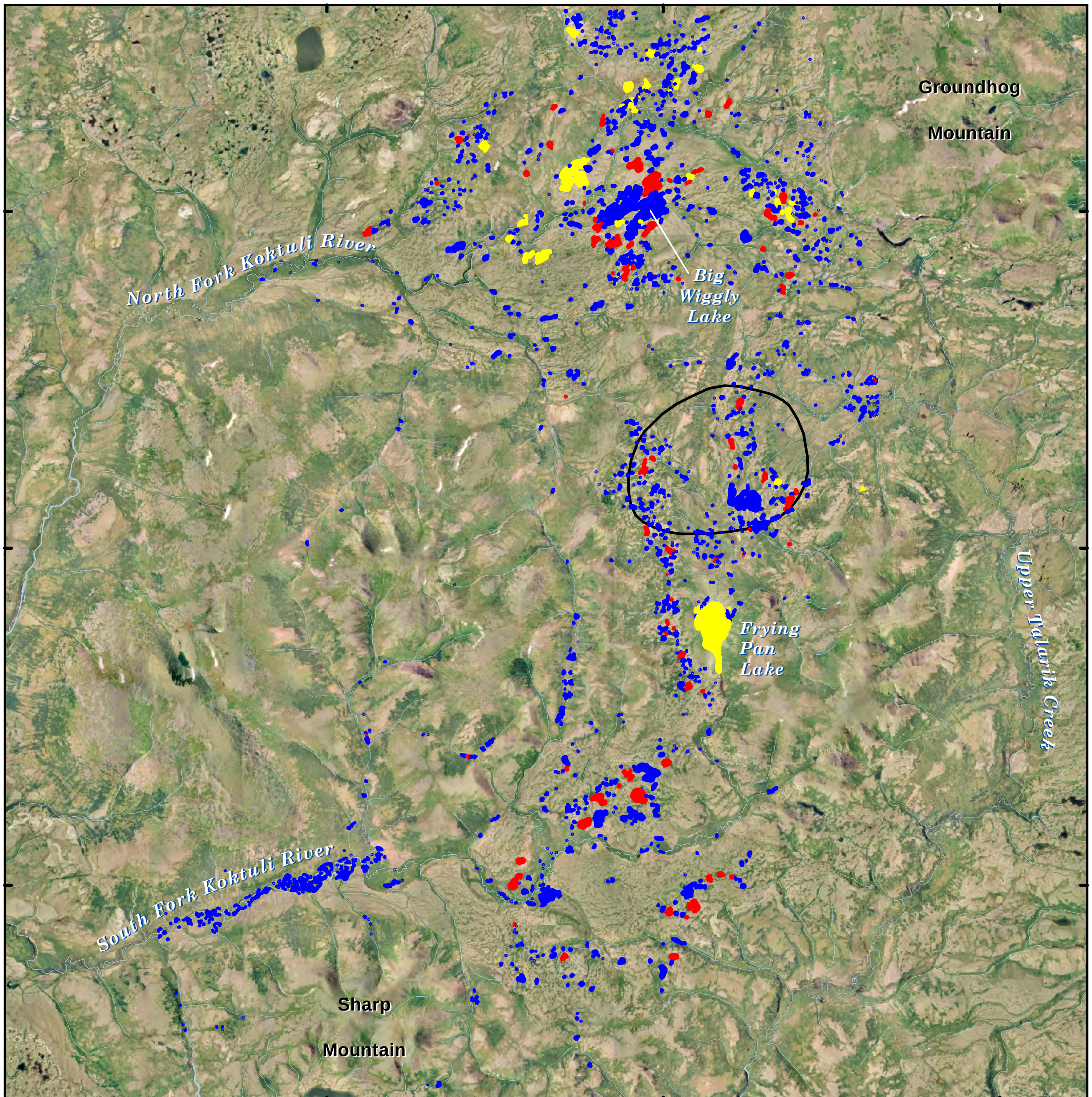
Notes:

a. The odds ratio value is a relative value that indicates the magnitude of the influence of the parameter on occupancy of a waterbody by wood frogs. A larger value is indicative of a larger influence by that covariate and cannot be compared to other covariate values.

b. A high standard error (>1.0) suggests there is little statistical support of significance regarding the parameter influence on occupancy.

c. A wide confidence interval of odds ratio (range >10), and that includes the value 1.0, indicates there is little statistical support of significance regarding the parameter influence on occupancy.

FIGURES



N

Miles
0 1 2 3

Kilometers
0 1 2 3 4 5

Scale 1:143,000

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

Background imagery: color orthophotography for the Pebble mine area based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Image credit: Kodiak Mapping Inc., Eagle Mapping Ltd., Resource Data, Inc.

Legend

Surveyed Twice

Surveyed Once

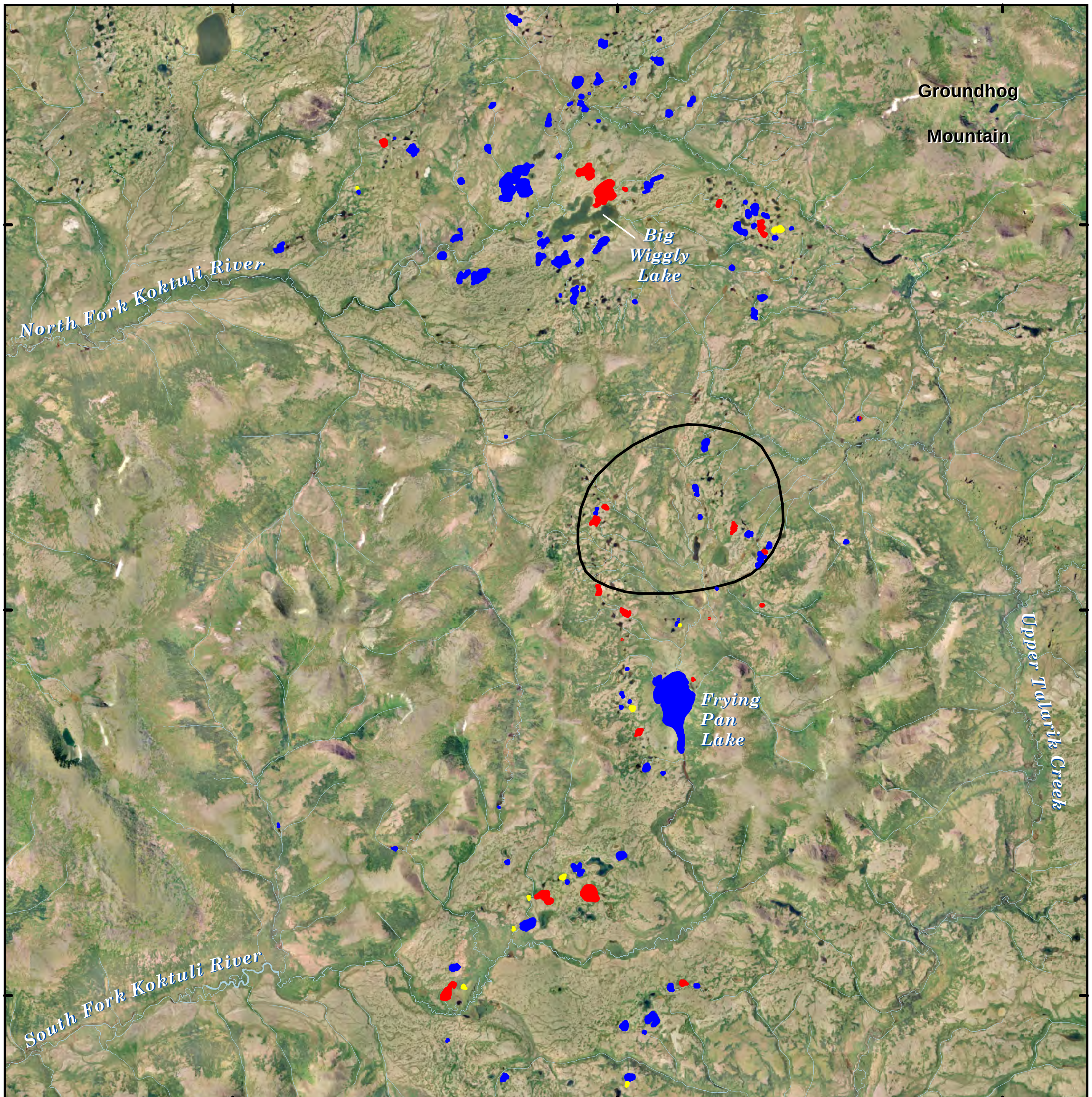
Not Surveyed

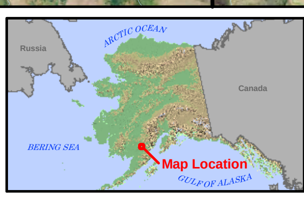
General Deposit Location

THE pebble PARTNERSHIP

Figure 16.12-1
Waterbodies Surveyed for Breeding Wood Frogs, Mine Study Area, 2007

File: 16-12-1_WoodFrogSA_Mine_PLP_EBD_v01.mxd	Date: June 17, 2010
Version: 1	Author: ABR-AZC





N

Miles
0 1 2 3

Kilometers
0 1 2 3 4 5

Scale 1:125,000

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

Background imagery: color orthophotography for the Pebble mine area based on July 2004 1:20,000 scale photography; pixel size is 1.5 feet. Image credit: Kodiak Mapping Inc., Eagle Mapping Ltd., Resource Data, Inc.

Legend

- Frog(s) Detected on Survey
- Frog(s) Detected as Incidental Observations
- No Frog(s) Detected on Survey
- General Deposit Location

THE pebble PARTNERSHIP

Figure 16.12-2
Calling Wood Frog Observations,
Mine Study Area, 2007

File: 16-12-2_WoodFrogObs_Mine_PLP_EBD_v01.mxd	Date: June 17, 2010
Version: 1	Author: ABR-AZC

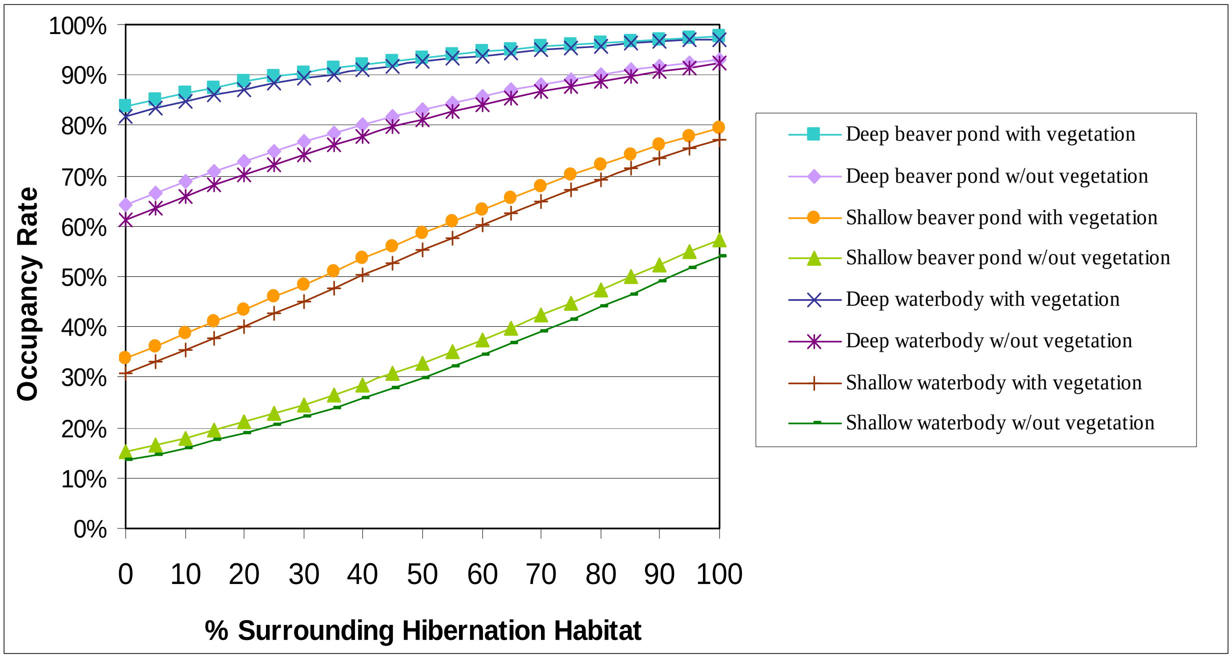


FIGURE 16.12-3
Predicted Occupancy Rate of Breeding Wood Frogs in Relation to Changes in Percent Hibernation Habitat (Herbaceous, Low Shrub, and Tall Shrub Vegetation) Present within 50 Meters of Waterbody Shorelines in the Mine Study Area (waterbody size is set to its mean value)

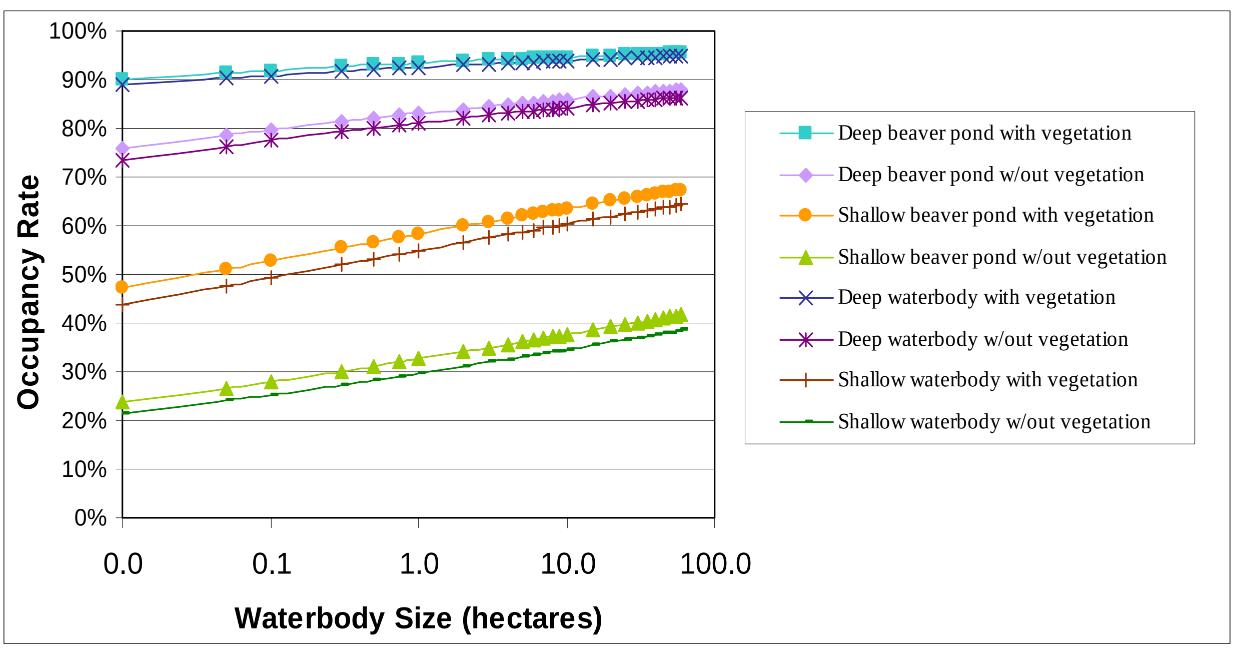


FIGURE 16.12-4
Predicted Occupancy Rate of Breeding Wood Frogs in Relation to Changes in Waterbody Size in the Mine Study Area (percent hibernation habitat is set to its mean value)