FINAL REPORT
25 April 2000

ARCTIC FOX DEN DISTRIBUTION AND ACTIVITY BETWEEN THE SAGAVANIRKTOK AND STAINES RIVERS, ALASKA, INCLUDING THE POINT THOMSON UNIT AREA

Prepared by

LGL ALASKA RESEARCH ASSOCIATES, INC.
4175 Tudor Centre Drive, Suite 202
Anchorage, Alaska 99508-5917

Prepared for

BP EXPLORATION (ALASKA) INC.
P.O. Box 196612
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by

Craig J. Perham

LGL ALASKA RESEARCH ASSOCIATES, INC.
4175 Tudor Centre Drive, Suite 202
Anchorage, Alaska 99508-5917

for

BP EXPLORATION (ALASKA) INC.
P.O. Box 196612
Anchorage, Alaska 99519-6612

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ABSTRACT

Aerial and ground surveys of Arctic fox (*Alopex lagopus*) den sites were conducted between the Sagavanirktok and Staines Rivers, including the Point Thomson Unit Area (PTUA), to determine their numbers and distribution prior to oil and gas development in the area. Den sites identified previously between the Sagavanirktok River and Bullen Point were visited to document current status, and surveys were conducted to locate additional fox den sites in areas not previously surveyed between Bullen Point and the Staines River. Twenty-eight den sites were located in July and August 1999; 13 were active (i.e. occupied) and 15 were inactive. Scat and food remains collected at the den sites indicated that Arctic foxes inhabiting this area may have eaten anthropogenic food, although it is a small percentage of their diet. Only two of the 28 dens were located in the PTUA, and the remaining dens were distributed throughout the study area. Lack of denning habitat, food availability, or a combination of the two may limit the number of foxes in the PTUA compared to surrounding areas. A small number of foxes in the area suggest human/fox interactions will be infrequent.

Key words: Arctic fox, *Alopex lagopus*, den, Point Thomson, North Slope, Alaska

INTRODUCTION

The potential for future oil and gas development of the Point Thomson Unit Area (PTUA), approximately 100 km east of the Prudhoe Bay Oil Fields (PBOF) of the Arctic Coastal Plain of Alaska, prompted an assessment of Arctic fox (*Alopex lagopus*) den site distribution and occupancy (Fig. 1). This study was part of a broad inventory of wildlife populations in PTUA (Funk et al. 1999).

The ecology of Arctic foxes and their interaction with industrial activities in and around the Alaska North Slope oil fields has been described previously (Eberhardt 1977; Fine 1980; Eberhardt et al. 1982; Eberhardt et al. 1983a, 1983b; Burgess and Stickney

1992; Burgess et. al 1993; Burgess and Banyas 1993; Rodrigues et al. 1994a; Robards et al. 1996; Ballard et al. 2000a, 2000b). However, little data has been collected on the ecology of Arctic foxes in the oil fields prior to development, although numerous studies have been conducted in other non-oil field areas on the Alaskan North Slope, and the Canadian Arctic (Chesemore 1967; Macpherson 1969; Speller 1972; Quimby and Snarski 1974; Garrott 1980; Garrott et al. 1983; Smits et al. 1988; Hiruki and Sterling 1989; Smith et al. 1992; Burgess et al. 1993).

Issues

The availability of supplemental food sources, (e.g. garbage) in the vicinity of the PBOF complex is suspected to have increased Arctic fox abundance by increasing over-winter survival. Consequently, the number of fox/human interactions has increased (Fine 1980; Eberhardt et. al 1982; Rodrigues et al. 1994b). High fox densities can also increase predation on tundra-nesting shorebirds and waterfowl (Johnson et al. 1993a and 1993b) and facilitate the transmission of disease epizootics, such as rabies (Dieterich and Ritter 1982; Ritter and Follmann 1995; Robards et al. 1996).

The lack of pre-development demographic data in the PBOF has made it difficult to determine the causes of fluctuations in Arctic fox populations. Although foxes have used garbage as a food source (Urquhart 1973; Fine 1980; Eberhardt et al. 1982; Rodrigues et al. 1994b), the impact of this additional food on survival and reproduction is speculative. Arctic fox den studies before development in the PTUA will provide baseline data on location, distribution, and productivity of fox dens, as well as potential denning habitat. This information can be used to assess potential impacts of development on foxes and to devise appropriate management plans.

Objectives

The objectives of this study were:

- To determine the location and density of Arctic fox dens between the Sagavanirktok River and Staines River, including the PTUA.

- To determine the status (i.e. active, inactive) of den sites identified during aerial surveys and describe individual den characteristics.
- To augment the long-term geographic database of fox den sites on the Alaska North Slope.
- To collect fox scats and prey remains around den sites to determine food sources.

STUDY AREA

The study area is located on the Alaskan North Slope from the Sagavanirktok River east to the Staines River (148°05'00" to 146°00'00" West Longitude) and from the Beaufort Sea coast south to 70° 00'00" north latitude. The study area was approximately 1700 km^2 (Fig. 1). For the purpose of this report, our study area was divided into two study sub-areas: the Point Thomson study area (640 km^2) located between Bullen Point and the Staines River, and the Badami study area (1060 km^2) located between the Sagavanirktok River and Bullen Point.

The PTUA is located on the Canning River alluvial fan. This alluvial fan is the underlying substrate that controls most plant growth and ultimately habitat types (Noel and Funk 1999). Soils in PTUA are generally much coarser than elsewhere in the Arctic Coastal Plain, as sand and gravel are typically near the surface (Noel and Funk 1999). Areas with coarse sediments are not modified by thermokarst (irregular terrain caused by the melting of massive ground ice) because of the smaller amounts of ground ice (Lawson 1983). Consequently, the presence of permafrost related landforms, such as pingos, thaw lakes, and ice-wedge polygons are relatively uncommon (Walker and Everett 1991).

No major rivers or streams flow through the PTUA, although the Staines River forms PTUA's eastern boundary. Much of the coastal area in the Point Thomson study area is characterized by small, beaded drainage streams. These streams have a limited number of high banks, which provide suitable habitat for denning.

In contrast to the PTUA, the Badami study area has large expanses of moist sedge and dwarf shrub tundra and soil characterized by a thick organic surface layer (BPXA 1995, Schick and Noel 1995). The shallow permafrost layer creates poor drainage, numerous shallow, thaw lakes, and other permafrost related land features, such as pingos and ice wedge polygons. The Badami study area contains four major braided rivers, the Sagavanirktok, Kadleroshilik, Shaviovik, and No Name Rivers. The Badami study area also contains numerous small, beaded drainage streams.

METHODS

Aerial Surveys

Two aerial surveys were conducted in the fox den study area on 28 May and 4 June, 1999. One systematic aerial survey was conducted on 28 May within the Badami study area to document occupancy at previously identified fox dens (Burgess and Stickney 1992; Burgess and Banyas 1993; Rodrigues et al. 1994a). A second aerial survey of strip-transects was conducted on 4 June between Bullen Point and the Staines River in the Point Thomson study area to locate new fox dens. North-south transects were flown using a fixed-wing aircraft (Piper PA-18 or Cessna 206) flying 90 m above ground level and at approximately 115 km/hr. Transects were spaced 1.6 km apart and were centered on township and section lines mapped at 1:63,360–scale U.S. Geological Survey (USGS) topographic maps. Transects were flown from the coast to a latitude of N 70° 00' 00" and back to the coast. A Garmin® GPS 12XL Global Positioning System (GPS) was used to record location data with Program GEOLINK® during the surveys. The pilot and observer searched an 800 m–wide swath on either side of the transect centerline. Aircraft wing struts were marked to enable visual control of transect strip–width (Pennycuick and Western 1972).

Dens were classified as either active or inactive. Chesemore (1969) and Burgess and Banyas (1993) noted that active fox dens were usually conspicuous during the spring due to the contrast of recent surface excavations and tracks surrounding the sites against the snow. During aerial surveys, inactive dens were recorded and ultimately verified with ground surveys.

Ground Surveys

Ground surveys of Arctic fox dens in the study area were conducted 8, 9 July and 12 August 1999 to confirm the status of previously identified den sites, to record den characteristics, and to document recently discovered den sites. A helicopter (Bell 206 Long Ranger) was used to access den locations. Any additional fox den sites discovered in transit to ground sites were also investigated and recorded. Coordinates for all den site locations were determined using a GPS receiver to within $\leq$ 100 m accuracy.

A den site was considered active when it was occupied by foxes during the current season (Spring/Summer 1999). This was determined when adult fox or kits were sighted at the den, or when direct evidence of Arctic foxes was detected (e.g. fresh scat, fresh diggings, recent fox tracks, prey remains, molted winter hair or odor in den entrances, or a combination of these characteristics) (Chesemore 1967). Dens lacking any physical evidence were considered inactive.

General den characteristics were also recorded, including the orientation (i.e. aspect) of den sites and main burrow entrances to the cardinal directions, habitat land features at the den site, and approximate age. Den ages were categorized as youthful, mature, old, or senile depending on the number of entrances, amount of vegetation on the den site, extent of burrowing system, and the number of collapsed burrows (after Macpherson 1969).

Previously identified den sites were compared across studies (Quimby and Snarski 1974; WCC and ABR 1983; and Burgess and Banyas 1993). Dens described by Burgess and Banyas (1993), including those dens that overlapped with Quimby and Snarski (1974), retained their Burgess and Banyas (1993) identification numbers. New numbers were given to, 1) den sites described in Quimby and Snarski (1974) which did not overlap with den sites described by Burgess and Banyas (1993); 2) den sites described by WCC and ABR (1983) which were not numbered; and 3) newly discovered den sites. New numbers began with 201 for this study.

Scat and Prey Remains

Fresh scats and prey remains were collected from active and inactive fox den sites to determine if any human food products were present. Fresh scats were identified by visible bile pigments on the surface or inside, an odor, fresh hair, and no observable green mold (Macpherson 1969). Fresh scats were assumed to represent late spring and summer food sources. A cursory search of each den site was conducted and all fresh scats were collected and then analyzed as a group.

Scats were prepared for food composition analysis according to the protocol described by Kelly (1991). After collection, scats were frozen, and then autoclaved to kill eggs of *Echinococcus* spp. Scats where then placed in nylon bags (20-cm x 20-cm), secured with rubberbands, and labeled. The bags were soaked in water for 72 hours. The water was changed once, and the bags were kneaded during the soaking process to help breakdown the fecal "matrix" (Springer and Smith 1981). Following soaking, bagged scats were washed in a clothes washer until the rinse water was fairly clear (Kelly 1991). Finally, the bagged scats were air-dried, and then dried in a clothes drier.

We were interested in anthropogenic materials found in the scats or near the den sites. Evidence of human-generated foods and products, such as food wrappers, Styrofoam, tinfoil, etc., were identified as garbage (Fine 1980) and were classified as anthropogenic. Natural food sources were identified when possible based on teeth and bones from small mammals, and feathers, bones, and shell fragments from birds. The frequency of prey remains in fox scat, such as microtines and avian prey species was not estimated.

Vegetation Classification

To relate the occurrence of dens and various habitats we quantified vegetation using information from the Badami Development Area (BDA) (Schick and Noel 1995) and the Point Thomson Unit Area (Noel and Funk 1999). Schick and Noel (1995) and

Noel and Funk (1999) used Walker's (1983) tundra vegetation categories to determine habitat type within these two areas. When combined together, the BDA and the PTUA represented approximately 11% (194 km^2 of 1700 km^2) of the entire 1999 fox denning study area. The BDA comprised 3% of the 1999 Badami study area, while the PTUA comprised 8% of the 1999 Point Thomson study area. Both BDA and PTUA studies were concentrated in the coastal habitats. Comparing data from these two areas as a sample of the denning study area may add insight into the vegetation comprising these areas and serve as an index of denning habitat.

Habitat classification for den locations were described in Walker's (1983) hierarchical categories. Level B categories included Habitat V (Moist or Dry Tundra) and Habitat IX (Partially Vegetated). Level C classification, Moist or Dry Tundra, included habitat types Va (Moist Sedge, Dwarf Shrub Tundra), Vc (Dry Dwarf Shrub, Crustose Lichen Tundra, i.e. *Dryas* tundra and pingos) and Vd (Dry Dwarf Shrub, Fructicose Lichen Tundra, i.e. dry acidic tundra). Partially vegetated habitats included IXb (Dry Barren/ Dwarf shrub, Forb Grass Complex, i.e. forb-rich river bars) and IXe (Dry Barren/ Grass complex, i.e. coastal sand dune grassland).

RESULTS

Badami Study Area

Aerial Survey

A single, site-specific aerial den survey in the Badami study area was conducted on 28 May. Visibility for the survey was 4-10 miles with overcast skies. Flat light conditions also were present. On 28 May, ground snow cover was approximately 90%, with only pingos and other elevated areas exposed and free of snow. Total flight time for the survey was approximately 2.5 hours. Burgess and Banyas (1993) documented 17 den sites within the Badami study area. We relocated all 17 den sites, and all were determined to be inactive based on the lack of fox excavations and tracks at the den (Table 2).

Ground Survey

We investigated 26 Arctic fox dens on the ground within the Badami study area on 8 and 9 July and 12 August (Table 1, Fig. 2). Seventeen of these dens were previously identified by Burgess and Banyas (1993) and relocated in our aerial survey. Nine new den sites were located. Eight dens (202, 205-211) were found using the helicopter, and one fox den (201) was located during LGL aerial caribou surveys during the early summer of 1999 (Noel and King 2000).

Den 201 was on the peat bank of a drained lake in the Badami study area. The den appeared to be recently excavated with only one entrance. Den 202 was discovered in a sand dune on the Beaufort Sea coast approximately 2 km from the Badami Development during transit between sites. Den 205, located on a pingo, appeared to have been abandoned and inactive for some years, as it was overgrown with vegetation and the main entrance had collapsed. Dens 206 and 207 were located on the same pingo. One of them was most likely den 10 of Quimby and Snarski (1974). Due to limited information, it was unclear which of the dens was den 10. The remaining four dens (208-211) were originally documented by Quimby and Snarski (1974), but were not included in data published by Burgess and Banyas (1993). Four of the nine dens (206-208, 210) appeared to be old, inactive dens, while dens 209 and 211 were active and appeared to be mature. See the Section, "Den Attributes – Badami and Point Thomson Study Areas," in this report for a detailed description for den sites from the Badami and Point Thomson study areas.

Four dens (7, 8, 71, 72) described by Quimby and Snarski (1974) within the Badami study area were not located despite an extensive search. Dens 71 and 72, on the banks of the Shaviovik River below the mouth of the Kavik River, were probably destroyed by streambank erosion. Dens 7 and 8, on the same pingo, were also not found, probably because of limited site descriptions and inaccurate coordinates.

Point Thomson Study Area

Aerial Survey

A systematic strip-transect survey for the Point Thomson study area was initiated on 28 May immediately after the Badami survey of the same day and completed on 4 June (the next day that weather was suitable). Visibility on 28 May was identical to the Badami aerial survey. On 4 June, visibility was 10-20 miles with sunny to overcast skies. Flight time for the survey was approximately 3.5 hours (0.5 hours and 3.0 hours for 28 May and 4 June, respectively). No den sites were found during the aerial surveys of the Point Thomson study area, including the dens first observed by WCC and ABR (1983).

As stated earlier, on 28 May, ground snow cover was approximately 90%. By 4 June, snow cover had decreased to approximately 60% west of the Badami Pad and approximately 80% to 85% east of the Badami Pad. As snow cover decreased, our ability to observe dens decreased due to the difficulty of locating tracks.

Ground Survey

Two Arctic fox dens were located in the Point Thomson study area during ground surveys on 8 July 1999. Den sites (203 and 204), initially observed in 1983 (WCC and ABR 1983), were not relocated during the systematic aerial survey but were found during the ground survey in July 1999 (Fig. 3). These were the only den sites found in the Point Thomson study area and they were also in the PTUA. Den 203 was approximately 1.7 km south of Point Thomson Pad #3 on a stream bank while den 204 was located on a streambank approximately 7 km southwest of Point Thomson Pad #3 (Table 1). See the following Section for a detailed description of all den sites from the Badami and Point Thomson study areas.

Den Attributes – Badami and Point Thomson Study Areas

Den Activity

All active fox dens documented in 1999 appeared to have been used by Arctic foxes. There was no evidence of red foxes (*Vulpes vulpes*) occupying active dens. This was based on sightings of Arctic foxes at various dens, the sizes of tracks and scats, and molted winter hair found around burrow entrances.

Although our Badami aerial survey in the Spring 1999 suggested none of the seventeen previously identified den sites were inactive, ground surveys verified that 41% (7 of 17) of these dens were active. Forty-six percent (13 of 28 dens) of all dens located during the ground surveys, including the new dens, were active (Table 2). Arctic foxes were found at 11 of the dens during the ground survey. Adult fox were observed at four den sites (dens 88, 90, 93, and 203) and a litter of five kits was observed at den 90. At den 87, a fox was heard barking inside the den.

Two dens (dens 89 and 91) appeared to have been active earlier in the season based on physical evidence, but were inactive and vacant at the time of the ground survey. Distinct fox odor and molted winter hair was documented in burrows at the den sites. These sites may have been "natal dens" where fox pups were whelped, then abandoned (Burgess and Banyas 1993).

Fifty-four percent (15 of 28 dens) of the dens were inactive during the 1999 denning season. All of these inactive dens were located in the Badami study area. Although fresh scat was evident at some of these dens, the dens showed no signs of constant use, such as fresh excavations and tracks. Foxes moving through the area and not residing at these sites could have deposited the fresh scats.

Den Characteristics

All 28 fox den sites observed in the fox den study area were located in natural habitats. Sixty-four percent (18 of 28 dens) were on pingos, while 25% (7 of 28 dens) were in banks along waterways (Table 1). Dens were also located in each of the following habitats: coastal bank, peat bank along lake margin, and sand dune. Pingos were a predominant den site habitat in the Badami study area, whereas pingos were not as prevalent in the Point Thomson study area. Dens 203 and 204, the only 2 dens located in the PTUA were located on streambanks.

Sixty-four percent (18 of 28 dens) of the den sites had an eastern orientation, while 15% (4 of 28 dens) had a western orientation (Table 1). Twenty-one percent (6 of 28 dens) were located on the tops of ridges or pingos and did not exhibit a specific orientation. These dens were categorized as having an open exposure.

Sixty-four percent (18 of 28 dens) appeared to be old or mature (Table 1). It was difficult to distinguish between mature and old sites because the dens had characteristics of both categories. No dens appeared to have extensive, collapsed burrows, a characteristic of old den sites, but many had burrows surrounded by rich vegetation. Only 7% (2 of 28 dens) were classified as youthful, while 18% (5 of 28 dens) were classified as senile. We could not determine the classification on the remaining two den sites (11%).

Fox Den Density

The density of Arctic fox dens throughout the 1999 Fox den study area was estimated to be 1 den/60.7 km^2 (Table 3). The density of fox dens in the Badami study area was 1 den/40.8 km^2, while the density for the Point Thomson study area was 1 den/320 km^2. The fox den density in the PTUA was estimated as 1 den/90 km^2.

Scat and Prey Remains

Approximately 300 Arctic fox scats were analyzed from 17 den sites (Table 4). Garbage was found in the scats from two den sites (83 and 84, Fig. 2). White rigid foam, such as that found in Styrofoam dishes, was in scats from den 83 at the Badami Development, and wood chips from processed lumber were in scats from den 84. Garbage was also found near several dens. These remains were rigid foam, such as, Styrofoam. Styrofoam pieces (< 5 cm) were found around the den site and in the entrances of den 202 (3 pieces of foam) and den 83 (2 pieces of foam). Bite marks were clearly visible on one of the styrofoam pieces recorded at den 202.

Scat analysis and prey remains collected around the den sites indicated foxes used a variety of natural food sources. Microtines, including lemmings, were present in the scats from all den sites. Arctic ground squirrels (*Spermophilis parryii*) were present in scats from 88% of the den sites (15 of 17 dens), whereas avian prey species were present in scats from all 17 den sites. Avian prey species included remains from Scolopidae, Anatidae, and possibly Phasianidae families. Insect remains were present in scats from 23% of the den sites (4 of 28 dens) and consisted primarily of beetle carapaces (Order Coleoptera). Caribou (*Rangifer tarandus*) remains were present in scats from 18% of the dens (3 of 28 dens). All scat samples contained vegetation. Prey species that were positively identified included brown lemming (*Lemmus trimucronatus*), greater white-fronted geese (*Anser albifrons*), red phalarope (*Phalaropus fulicarius*), Arctic ground squirrel, and caribou.

Vegetation Classification

Seven fox dens in the 1999 den study were located within the habitat maps of the Badami Development Area (Schick and Noel 1995) and the Point Thomson Unit Area (Noel and Funk 1999). Five dens were located in the BDA (dens 82-84, 201, 202) and 2 were located in the PTUA (dens 203 and 204). Habitat classification for the den locations indicated that Arctic fox used Habitat V (Moist or Dry Tundra) and Habitat IX (Partially Vegetated). At level C classification, dens were located in Va (den 82), Vc (dens 203, 204), i.e. *Dryas* tundra and pingos; Vd (den 201), i.e. dry acidic tundra; IXb (den 84), i.e. forb-rich river bars and IXe (dens 83, 202) i.e. coastal sand dune grassland. In the PTUA, only 13.8% of the habitat was classified as Va, Vc and Vd (Noel and Funk 1999). However, Schick and Noel (1995) found that these same vegetation categories comprised 33.8% of the total area surveyed in the BDA. Habitat types, IXb and IXe, comprised 0.5% of the habitat classified in the PTUA (Noel and Funk 1999), while these habitats comprised 1.3% of the BDA (Schick and Noel 1995).

DISCUSSION

Arctic fox den sites located in the undeveloped region between the Sagavanirktok and Staines Rivers were not uniformly distributed. The Point Thomson study area had fewer dens and lower den density than the Badami study area. This variation in fox den density between regions may be influenced by limited denning habitat, comparatively lower summer prey availability, or a combination of both.

The lower density of fox dens in the Point Thomson study area relative to the Badami study area is most likely due to differences in geomorphology. Topographical features of an area can directly influence the amount of habitat available for denning. In addition, topographical features may influence prey availability by limiting habitat available for avian and mammalian prey species. Foxes generally select dry, elevated habitats for den sites, taking advantage of such features as pingos, sand dunes, cutbanks or terraces of rivers or streams (Macpherson 1969; Garrott 1980; Eberhardt et al. 1983a; Smits et al. 1988). Ice-free soils above the permafrost layer and water levels, which facilitate excavation, are possible factors governing den placement (Garrott 1980).

The Canning River alluvial fan lies under the Point Thomson study area. The resulting sand and gravel soils do not provide good conditions for denning. This is in contrast to the Badami study area soils, which are more suitable for digging. In addition, the Badami study area contained 4 braided rivers, while the Point Thomson study area contained no large rivers. The action of large, braided rivers can create denning habitat for Arctic foxes along the river terraces and banks (Macpherson 1969; Garrott et al. 1984). Our observations on the ground in the Point Thomson study area also indicated a general lack of pingos and other elevated ground, such as streambanks and bluffs. In addition, the proportion of those habitats used by fox for denning was greater in the BDA than in the PTUA (14.3% and 35.1% for the PTUA and the BDA, respectively), also suggesting that the Badami study area may contain more denning habitat than the Point Thomson study area. According to Quimby and Snarski (1974), dens are not uniformly distributed throughout the North Slope but are associated with favorable soil conditions. The Point Thomson study area appeared to have less optimal denning habitat relative to other areas on the Arctic Coastal Plain.

It was difficult to determine whether den habitat was limited in the Point Thomson study area due to small sample size. Only 2 dens were found, and both were active. If, however, den habitat were limited in the Point Thomson study area, then established den sites would be important areas for the Arctic fox population. Conversely, our results suggest the Badami study area may not have been limited by habitat. Indeed, 42% (11 of 26 dens) of the fox dens located were active in the Badami study area. This appeared to be in the documented range of annual occupancy rates reported by other biologists (Macpherson 1969; Speller 1972; Quimby and Snarski 1974; Eberhardt et al. 1982; Garrott et al. 1984; Burgess et al. 1993; Rodrigues et al. 1994a). For example, the occupancy rate for the 17 previously known dens occurring in the Badami study area was 53% in 1992 (Burgess et al. 1993).

The differences in geomorphology between the Point Thomson and the Badami study areas may affect availability and abundance of summer food resources for foxes, as well. Arctic ground squirrels, like Arctic fox, use similar elevated terrain and landforms to excavate their burrows (Quimby and Snarski 1974; Garrott 1980). Ground squirrel burrows are sometimes hard to distinguish from fox dens during aerial surveys, and ground squirrels will also use abandoned fox dens (Eberhardt 1977; Garrott 1980). Macpherson (1969) found few fox dens in a region of his study area in the Northwest Territories, Canada, although there appeared to be suitable denning habitat. Prey scarcity or problems associated with capturing prey may have caused foxes to den elsewhere.

Lemmings, and other microtines, could be similarly limited by the availability of permafrost-related land features. According to Thompson (1955), the brown lemming's optimal habitat for foraging and burrowing were the polygonal troughs associated with high and low center polygons. The centers of the polygons were secondary foraging habitat. A lack of these formations may constrain microtine populations, thereby limiting availability as prey for foxes in areas without these formations.

Arctic fox den density (1 den/60.7 km^2) in the study area during 1999 was low compared to other studies conducted on the Alaskan North Slope. Garrott (1980) and Eberhardt et al. (1983a) documented densities of fox dens in the Colville River at 1 den/42.5 km^2 and 1 den/34km^2, respectively. Burgess et al. (1993) and Rodrigues et al. (1994a) recorded fox den density for active and inactive dens in the undeveloped portions of PBOF at 1 den/72.2 km^2 and 1 den/28.1 km^2, respectively. In contrast, densities of fox dens in the developed region of the PBOF have been much higher, with Arctic fox den densities at 1 den/12 km^2 and 1 den/15.2 km^2, respectively (Eberhardt et al. 1983a; Rodrigues et al. 1994a).

Density of all fox dens for the Point Thomson study area was even lower if density is estimated over the entire Point Thomson study area rather than the PTUA. Den site density for the Point Thomson study area would be one den/320 km^2, rather than one den/90 km^2, calculated for the PTUA. Density of fox dens in the Point Thomson study area may not accurately depict true availability and use of denning habitat. The search for den sites in the PTUA most likely needs further investigation to accurately depict den site abundance and density.

Differences in fox den density between Badami and Point Thomson study areas may also have been influenced by survey methodology. In the Badami study area, we flew directly to known den locations and never conducted a strip-transect survey, as conducted for the Point Thomson study area. Summer aerial surveys for locating fox dens are an accepted methodology (Chesemore 1967; Garrott et al. 1983; Burgess and Stickney 1992; Burgess et al. 1993; Rodrigues et al. 1994a). However, spring aerial surveys can be more problematic due to persistent foul weather that prohibits surveys, and the loss of ground snow cover necessary to locate tracks and occupancy of den sites. The patchiness of the snow decreased our ability to find dens and ascertain den activity during our aerial surveys for both study areas. This problem may have also accounted for discrepancies we found in the occupancy rate of dens between the ground and aerial surveys. Indeed, 41% of the dens recorded as inactive during the aerial survey were later found to be active during the ground survey.

Den site characteristics appeared similar to those reported by other researchers. Arctic fox denning in pingos, river terraces, low ridges, and dunes on the Coastal Plain has also been documented by Quimby and Snarski (1974) and Eberhardt (1977). Den sites throughout our study area appeared to be clustered, rather than uniformly distributed similar to findings reported by Quimby and Snarski (1974). Garrott (1980) found that the predominant den habitat in the Colville River Delta was the river terraces and banks, because pingos were not present. A non-uniform distribution of denning habitat where pingos were not as prevalent may occur in the Point Thomson study area, as well.

The majority of dens were classified as old or mature, which suggests that most dens are used for long durations and were rarely replaced. Macpherson (1969) also reported a similar age structure in den sites in the Northwest Territories. Based on a possible limitation of denning habitat, Macpherson (1969) suggested that Arctic foxes reuse existing den sites and that some den sites can be hundreds of years old.

Of the 3 den sites where garbage was found, dens 83 and 202 were active while den 84 was inactive (Table 4). Because dens 83 and 202 were located along the coast, it is also possible that the garbage washed ashore. However, it is interesting to note that all three dens, 83, 202, and 84, were located in close proximity to oil development operations, the Badami Pad and facilities (50 m , 2.2 km, and 5.7 km, respectively).

The quantity of anthropogenic food sources in this study was not as high as documented in previous studies in the developed portions of the North Slope oil fields (Eberhardt 1977; Fine 1980). Our analysis suggests garbage occurred in < 1% in our scat samples. Eberhardt (1977) reported that garbage comprised less than 10% of total occurrences in his North Slope study. Fine (1980) described that garbage occurred in 26% of all scats collected in Prudhoe Bay. Garrott et al. (1983) indicated that garbage occurred in 6% of scats in the PBOF. Chesemore (1968) reported that near Teshekpuk Lake, garbage comprise 3% of the Arctic fox summer diet. However, all researchers felt that garbage was used more extensively by foxes than their figures indicated, primarily because many garbage items may be digested and therefore not identified.

There is no way to confirm the origin of the garbage found in the fox scats or at the den site. The Styrofoam and wood bits could have originated from numerous locations. Foxes may have procured them from production facilities, such as Badami, or encountered the garbage on the tundra while foraging. Although other studies have noted use of artificial foods by Arctic fox, our study indicated that garbage was not an important food source for Arctic fox during the Summer 1999 season. This corresponds to the conclusions of Fine (1980) and Chesemore (1968) who indicated that garbage is used by foxes more in the winter than in the summer. The use of garbage in our study may be more of an indicator of the proximity to human development (i.e. the Badami facilities) than a reliable food source.

CONCLUSIONS AND MANAGEMENT CONSIDERATIONS

The undeveloped Point Thomson Unit Area appears to have a lower density of Arctic fox den sites than the surrounding undeveloped area of the Badami study area. This difference is most likely due to the variation of geomorphology between the two regions. Point Thomson is located on the Canning River alluvial fan, which affects the physical environment of the region. This area is flat and poorly drained, with few pingos and waterbodies, no large river systems and only short drainage creeks. The Badami study area is also poorly drained; however, drier soils and waterbodies persist due to the formation of permafrost related features, which create relief in the landscape. The lack of denning habitat, food availability, or a combination of the two may limit the number of foxes in the PTUA as compared to surrounding areas.

With Arctic fox den information from Quimby and Snarski (1974), Burgess et al. (1993), Rodrigues et al. (1994a) and this study, numerous fox dens in the Badami study area were located and verified. The two den sites recorded for the Point Thomson study area were previously found by WCC and ABR (1983). There is a possibility that more fox dens exist but have not yet been identified.

Important denning areas could be easily identified and mapped in the PTUA. Most landscape features, such as streambanks, coastlines, and possible elevated mounds within PTUA, which may have the potential for denning habitat, could be avoided during the construction of roadways and facilities. Avoiding these areas would limit potential fox/human interactions. Avoidance of established dens could also be accomplished once they are identified and accurately mapped. This would limit the susceptibility of disturbance of dens during the summer months, or the danger of being crushed and destroyed by heavy equipment during the winter months. Dens are generally located in areas of shallow snow cover (Quimby and Snarski 1974).

Although Arctic fox using den sites in undeveloped regions of the Alaska North Slope have encountered anthropogenic food sources, it appeared to be minimal (< 1% of scats). Styrofoam and wood chips were present at three den sites, either in scat or near the den site. This does not imply that they actively search for these food sources. Rather, garbage could be blown in or washed in to the regions from other areas. Arctic foxes are highly mobile and seasonally migratory (Macpherson 1969) and may encounter garbage during foraging.

Practices to minimize fox access to food, combined with the low number of dens in the PTUA, should reduce human/fox interactions. It is possible that human activity in the PTUA, which may have limited natural foods and available den sites, may attract foxes to the region. Likewise, foxes may use artificial denning habitat created with the construction and placement of permanent production facilities (Burgess et al. 1993; Rodrigues et al. 1994b) at PTUA. The influence of satellite developments, such as Badami, on local Arctic fox populations may shed insight into the potential problems and mitigation factors that could be used with future satellite developments, such as the PTUA.

Finally, for spring aerial surveys to be effective in locating fox dens, the timing of the survey is important. Once the elevated areas start melting out, sightability of dens sites was greatly reduced. In regards to snow ground cover, mid-May would be a more appropriate time for den surveys, because there is generally uniform snow cover at this time. The spring survey method should be performed with a corresponding ground survey to verify occupancy and activity at the den sites. In addition, spring surveys are only useful for finding currently active den sites. Ground surveys or summer aerial surveys are the only means of locating inactive den sites if den occupancy is an important study variable.

AKNOWLEDGEMENTS

This study was conducted for BP Exploration (Alaska) Inc. We thank Ray Jacubczak and Conce Rock of BP Exploration (Alaska) Inc., Dave Trudgen of OASIS, Inc., and the Point Thomson Unit Partners for their support. Rick Raymond and Isaac

Helmericks conducted aerial surveys. Jim Helmericks of Golden Plover Air piloted the aircraft during aerial surveys. Dick Lawrence and Todd Hayes of Air Logistics of Alaska, Inc. provided helicopter support during ground surveys of den sites.

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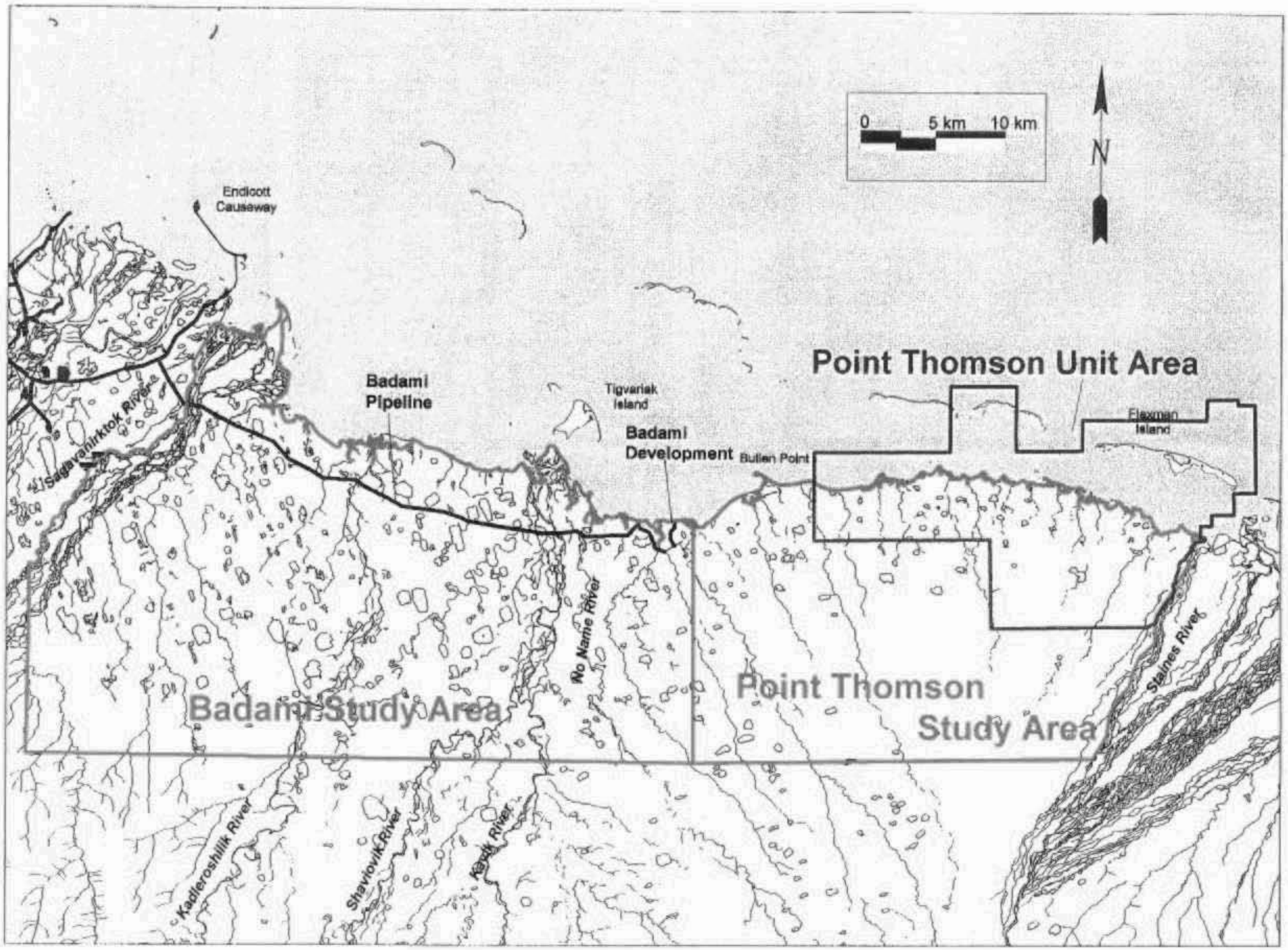

Figure 1. The Arctic fox den study area including the Badami and Point Thomson Study Areas and the Point Thomson Unit Area, Alaska, 1999.

AF_studyarea.wor

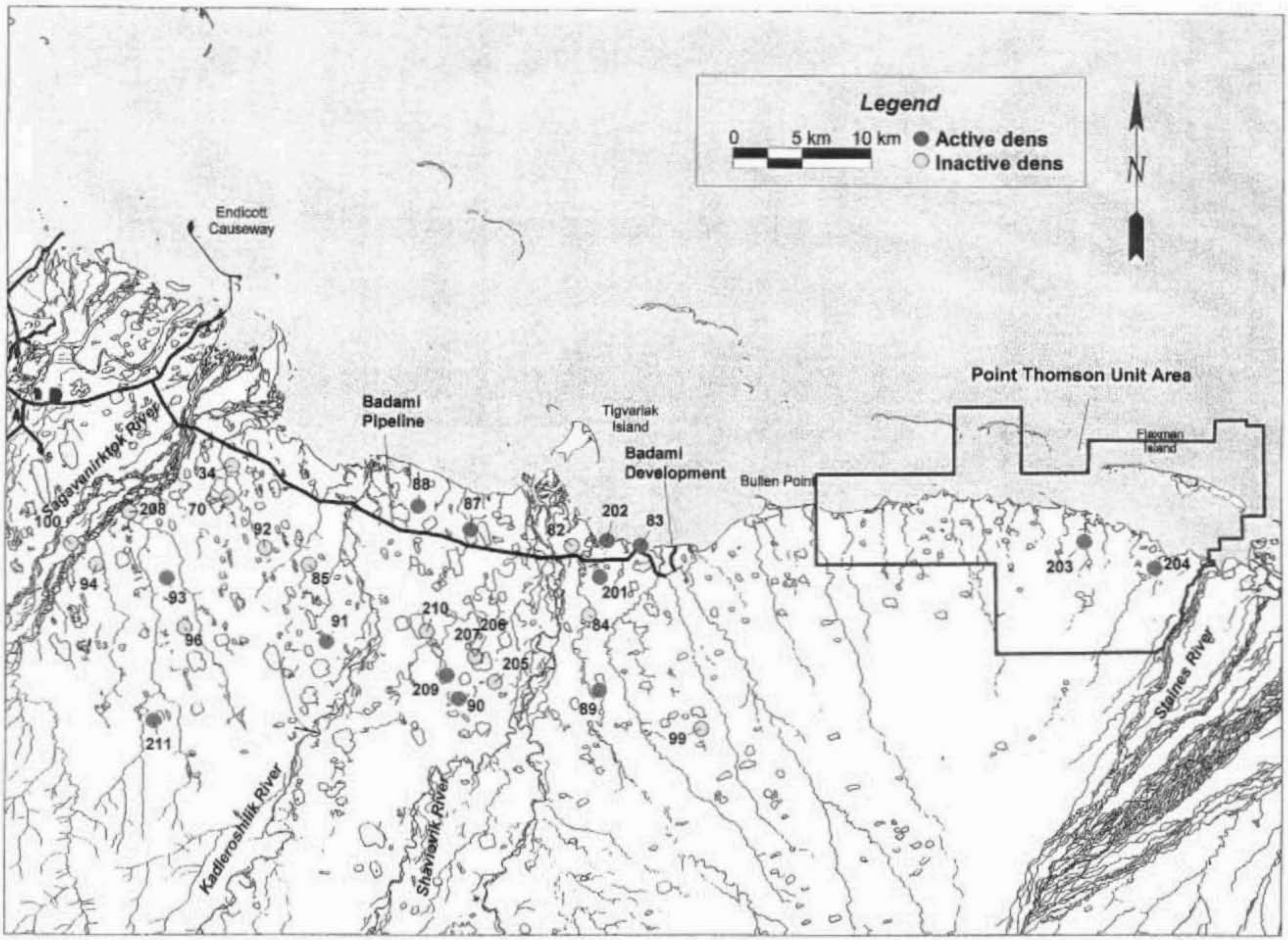

Figure 2. Arctic fox den sites (active and inactive) recorded within the Badami and Point Thomson Study Sites, Alaska, 1999 (n=28).

AF_alldens99.wor

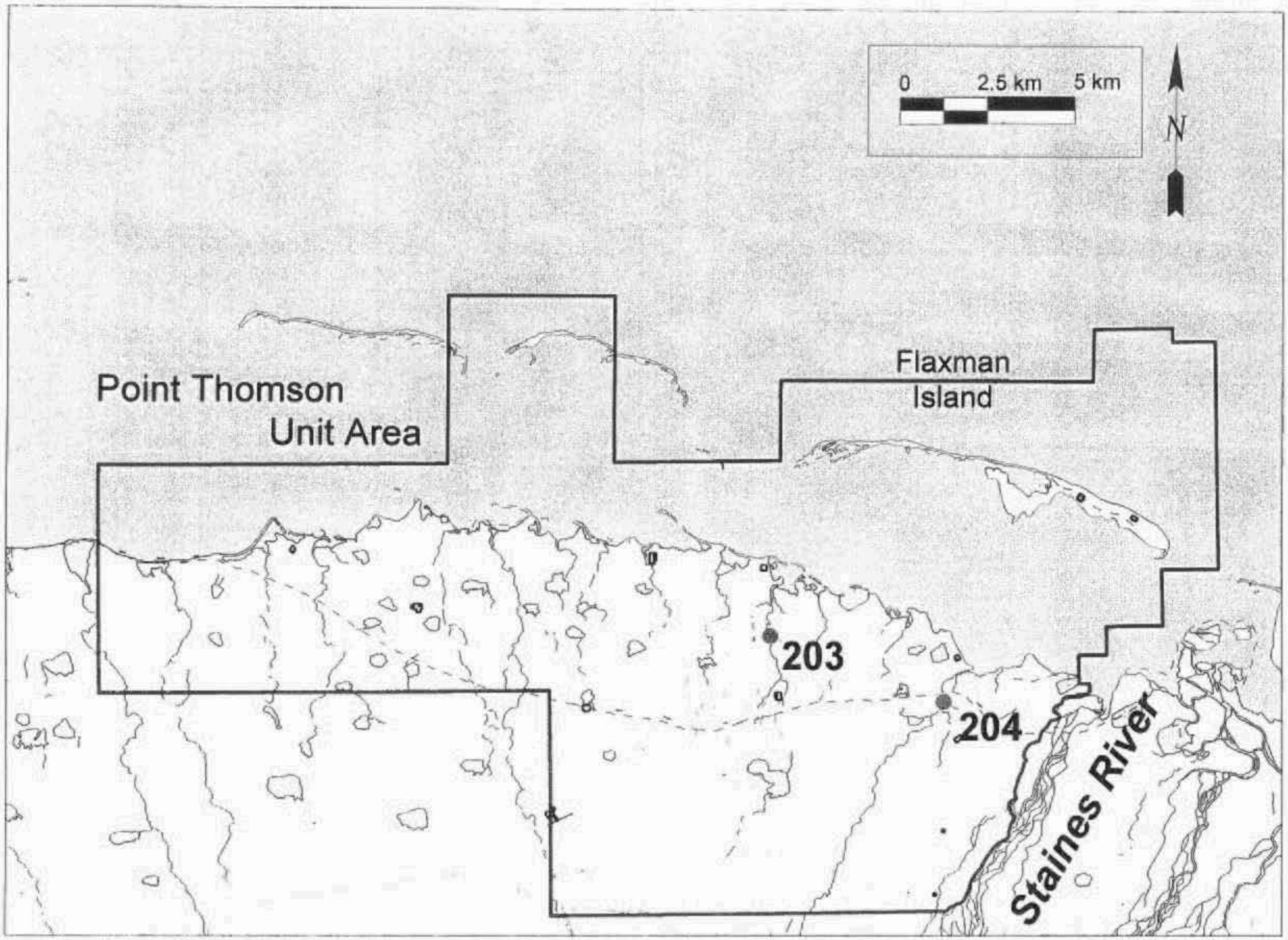

Figure 3. Location of Arctic fox dens previously identified (WCC and ABR 1983) in the Point Thomson Unit Area, Alaska, Summer 1999.

PTAC_dens99.wor

Table 1. Location and characteristics of Arctic fox den sites within the Badami and Point Thomson Study Sites, Alaska, 1999 (Coordinates in WGS 1984).

	Date	Den number[1]	Study Site	Longitude (°W)	Latitude (°N)	Activity	Den site habitat type	Age of den	Den site exposure	Comments[2]
1	8-Jul	34	Badami	147.8728160	70.2016740	I	pingo	Mature	open	
2	8-Jul	70	Badami	147.8789240	70.1816730	I	pingo	Mature	open	
3	8-Jul	82	Badami	147.2261210	70.1530720	I	river bank	?	E	
4	8-Jul	83	Badami	147.0930620	70.1537400	A	coastal bank	Mature	open	20m off Pt. Thomson #3 pad
5	8-Jul	84	Badami	147.1191947	70.1091820	I	streambank	Mature	SE	S facing bank of stream
6	9-Jul	85	Badami	147.7250240	70.1394520	I	pingo	?	open	
7	8-Jul	87	Badami	147.4194620	70.1630690	A	pingo	Mature	SE	golden eagle on den upon arrival
8	8-Jul	88	Badami	147.5191900	70.1777900	A	pingo	Mature	SE	
9	8-Jul	89	Badami	147.1727730	70.0608470	A/I	streambank	Mature	SE	S facing bank of stream
10	8-Jul	90	Badami	147.4394470	70.0550090	A	pingo	Old	E	Q/S Den 9
11	8-Jul	91	Badami	147.6900160	70.0905620	A/I	pingo	Old	SE	
12	9-Jul	92	Badami	147.8069720	70.1494510	I	pingo	Mature/Old	E	Q/S Den 74
13	8-Jul	93	Badami	147.9925310	70.1297250	A	pingo	Mature	NE	
14	8-Jul	94	Badami	148.1230910	70.1372230	I	pingo	Old	open	
15	8-Jul	96	Badami	147.9572470	70.0983350	I	low pingo	Mature	SW	
16	8-Jul	99	Badami	146.9780410	70.0364050	I	pingo	Old	SE	
17	8-Jul	100	Badami	148.1711500	70.1500000	I	river bank	?	E	W edge of Sag R. channel
18	8-Jul	201	Badami	147.1714333	70.1331667	A	peat bank	Youthful	SE	Found by caribou crew in drained lake bed
19	8-Jul	202	Badami	147.1583500	70.1565666	A	sand dune	Youthful	SE	Coastal sand dune
20	8-Jul	203	Pt. Thomson	146.2506000	70.1547500	A	streambank	Mature	open	W/C den, S bank
21	8-Jul	204	Pt. Thomson	146.1198166	70.1373666	A/I	streambank	Old	NE	W/C den, E bank
22	12-Aug	205	Badami	147.3719000	70.0657000	I	pingo	Senile	NE	old, collapsed den, Q/S Den 11
23	12-Aug	206	Badami	147.4080000	70.0825000	I	pingo	Senile	E	Q/S Den 10?; on ridge with den 207
24	12-Aug	207	Badami	147.4079000	70.0815833	I	pingo	Senile	E	Q/S Den 10?; on ridge with den 206
25	12-Aug	208	Badami	148.0655330	70.1713166	I	old riverbank	Senile	W	Q/S Den 12, E side of Sag R.
26	12-Aug	209	Badami	147.4659333	70.0702333	A	pingo	Old	NE	Q/S Den 11
27	12-Aug	210	Badami	147.5009666	70.0979166	I	pingo	Senile	SW	Q/S Den 73
28	12-Aug	211	Badami	148.0118000	70.0381166	A	pingo	Old	W	Q/S Den 5

[1] Location of den numbers 34-100, are originally from Burgess and Banyas (1993); den numbers 203, 204, are from WCC and ABR (1983); and den numbers 206-211 are from Quimby and Snarski (1974).

[2] Q/S refers to fox dens first documented by Quimby and Snarski (1974), while W/C refers to dens first documented by WCC and ABR (1983).

Table 2. Evidence of Arctic fox presence at active den sites within the Badami and Point Thomson Study Sites, Alaska, 1999.

Den number	Date	Activity[1]	Presence								
			Visual		Recent Scats		Tracks				
			Adult	Pup	Adult	Pup	Adult	Pup	Hair	Odor	Other
83	8-Jul	A	-	-	-	yes	yes	-	-	-	-
87	8-Jul	A	-	-	-	yes	-	-	-	-	Ad in den
88	8-Jul	A	1	-	-	yes	-	yes	-	yes	-
89	8-Jul	A/I	-	-	yes	-	-	-	yes	yes	-
90	8-Jul	A	1	5	-	-	-	-	-	-	-
91	8-Jul	A/I	-	-	yes	-	-	-	-	yes	-
93	8-Jul	A	F	-	-	yes	-	-	-	-	-
201	8-Jul	A	-	-	-	-	yes	-	-	-	-
202	8-Jul	A	-	-	-	yes	yes	-	-	-	-
203	8-Jul	A	1	-	-	yes	-	-	-	-	-
204	8-Jul	A/I	-	-	yes	yes	-	-	-	-	-
209	12-Aug	A	-	-	yes	yes		-	yes	yes	-
211	12-Aug	A	-	-	yes	yes	yes	-	-	yes	-

[1] A = active den site at time of ground survey; A/I = active den site earlier in the year, but vacant at time of ground survey. Den activity based on physical evidence at time of ground survey (see methods).

Table 3. Number and density of Arctic fox dens within the Badami and Point Thomson Study Sites, Alaska, 1999.

Area	Area (km^2)	Number of active fox dens	Total number of fox dens	Density
Overall Study Area	1700	13	28	1 den/ 60.7 km^2
Badami Study Area	1060	11	26	1 den/ 40.8 km^2
Point Thomson Study Area[1]	640	2	2	1 den/ 320 km^2
Point Thomson Area[1,2]	180	2	2	1 den/ 90 km^2

[1] Active fox dens included only den numbers 203 and 204.

[2] The Point Thomson Area is located within the Point Thomson Study Area. Active dens in the Point Thomson Study Area and the Point Thomson Area were the same two dens.

Table 4. Arctic fox scat analysis describing presence of natural prey species and anthropogenic material during 1999 denning season in the Badami and Point Thomson Study Sites, Alaska, 1999.

Den #	Microtine	Ground Squirrel	Eggshell Fragments	Feathers	Insects	Vegetation	Artificial Food	Other	Prey Remains Found Near Den Site
34	bones	bones	Y*	--	--	Y	--	leg bone (goose)	Big bird pelvis (not recent; goose?), bird long bone (goose?)
70	bones	bones	Y	Y	--	Y	--		Sandpiper head and feathers
83	bones	bones	--	--	--	Y	sytrofoam	bird leg bones	
84	bones	hair	--	Y	--	Y	wood bits (processed)	large white feather (Goose, snowy owl, or ptarmigan?)	
87	bones	bones	Y	Y	--	Y	--	seeds	Medium-sized dark feathers
88	bones	bones	bluish; goose	Y	--	Y	--	Guard hair (caribou?), atlas/axis piece of medium-size mammal	Medium-sized dark feathers (goose?)
89	bones	--	--	Y	--	Y	--	Some feathers are goose	Goose egg, ground squirrel skull, small mammal ulna (ungulate? caribou calf?), waterfowl (?) radia/ulna
90	bones	hair	Y	Y	beetle parts	Y	--	goose and shorebird feathers, guard hair, some downy feathers, rock	Fresh goose wing bone (meat still on it), scoot/scales from a waterfowl leg. Medium-sized dark feathers, big feather stem, ground squirrel-turned inside-out
91	bones	bones	Y	--	--	Y	--	Egg frags (goose and blotched shorebird)	
93	bones	bones	Y	Y	--	Y	--	Bird breastbone and femur	Medium-sized dark feathers (goose?)
96	bones	-	Y	Y	--	Y	--		Feathers - white, brown with light tan blotches, 1 with lower white upper dark brown (ptarmigan ?)
99	bones	bones	Y	Y	--	Y	--	goose feathers	
202	bones	bones/hair	Y	Y	--	Y	--	bird bones	Bird breastbone, seaweed, styrofoam with bite marks
203	bones	bones	Y	Y	--	Y	--	unknown black mass	3/4 goose egg, ground squirrel skul, bird skull cap (waterfowl?), small mammal rib bone (caribou calf?), caribou hair, bird femur bone
204	bones	bones/hair	--	Y	parts/wing	Y	--	bird skull, pebbles	
209	bones	paw	Y	Y	parts/wing	Y	--	ground squirrel paw, egg frags (goose?), also light-bluish egg shell	Waterfowl skull, bird breastbone, medium-sized dark feathers (goose?), goose egg
211	bones	bones	Y	Y	beetle parts	Y	--	egg frags (goose?), some downy feathers	Small/medium bird pelvis (ptarmigan or shorebird?), small bird wing intact with feathers (juvenile passerine?), goose egg, 3 eggs - white with dark blotches (Scolopacidae)

* "Y" indicates presence of material.

APPENDIX A.

Locations of Arctic Fox Dens

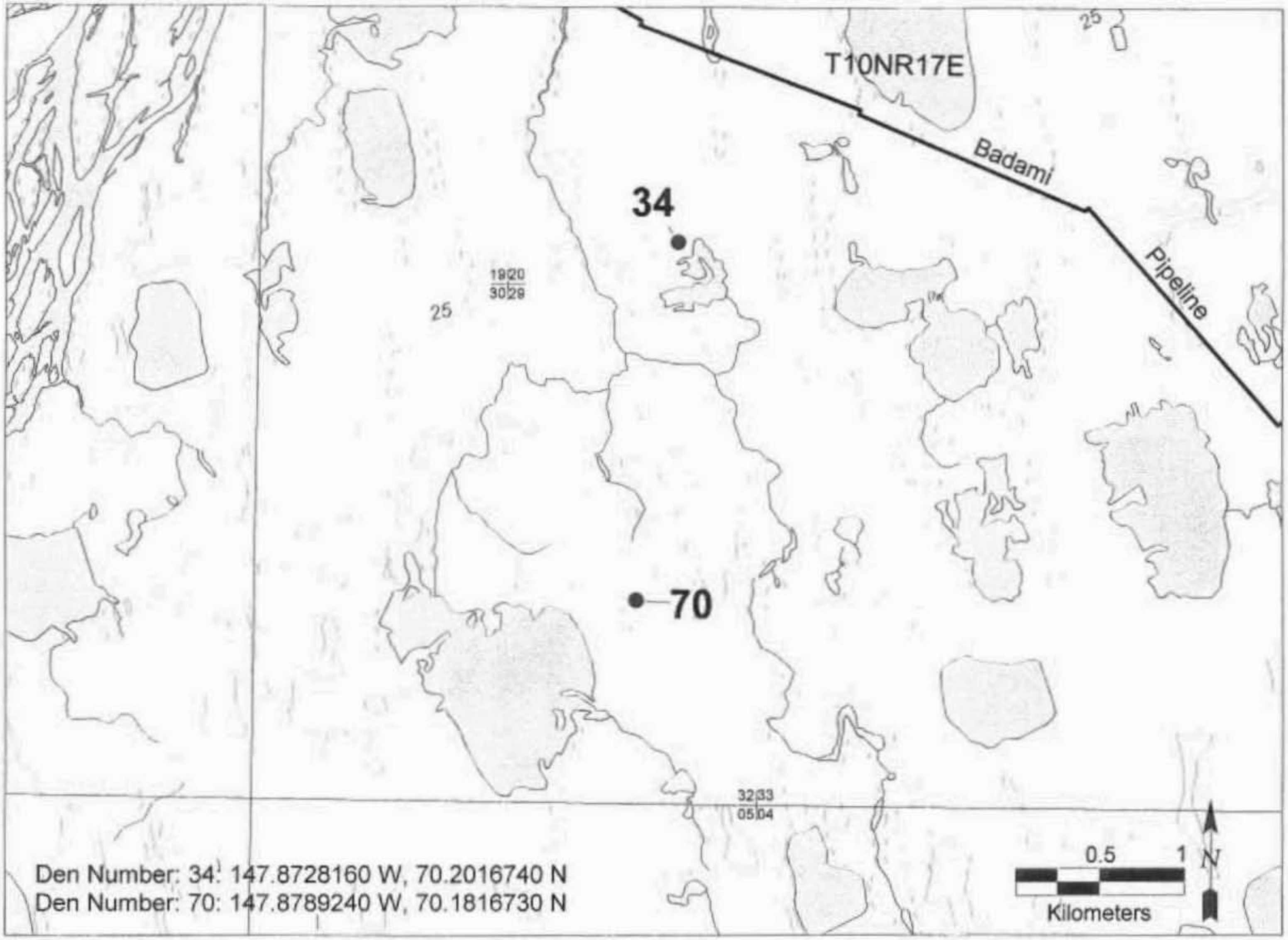

Figure A1. Locations of Arctic fox den 34 (Beechey Point Quadrangle, Township 10N, Range 17E, Section 20), and fox den 70 (Beechey Point Quadrangle, Township 10N, Range 17E, Section 32), Alaska.

AF_den34_70.wor

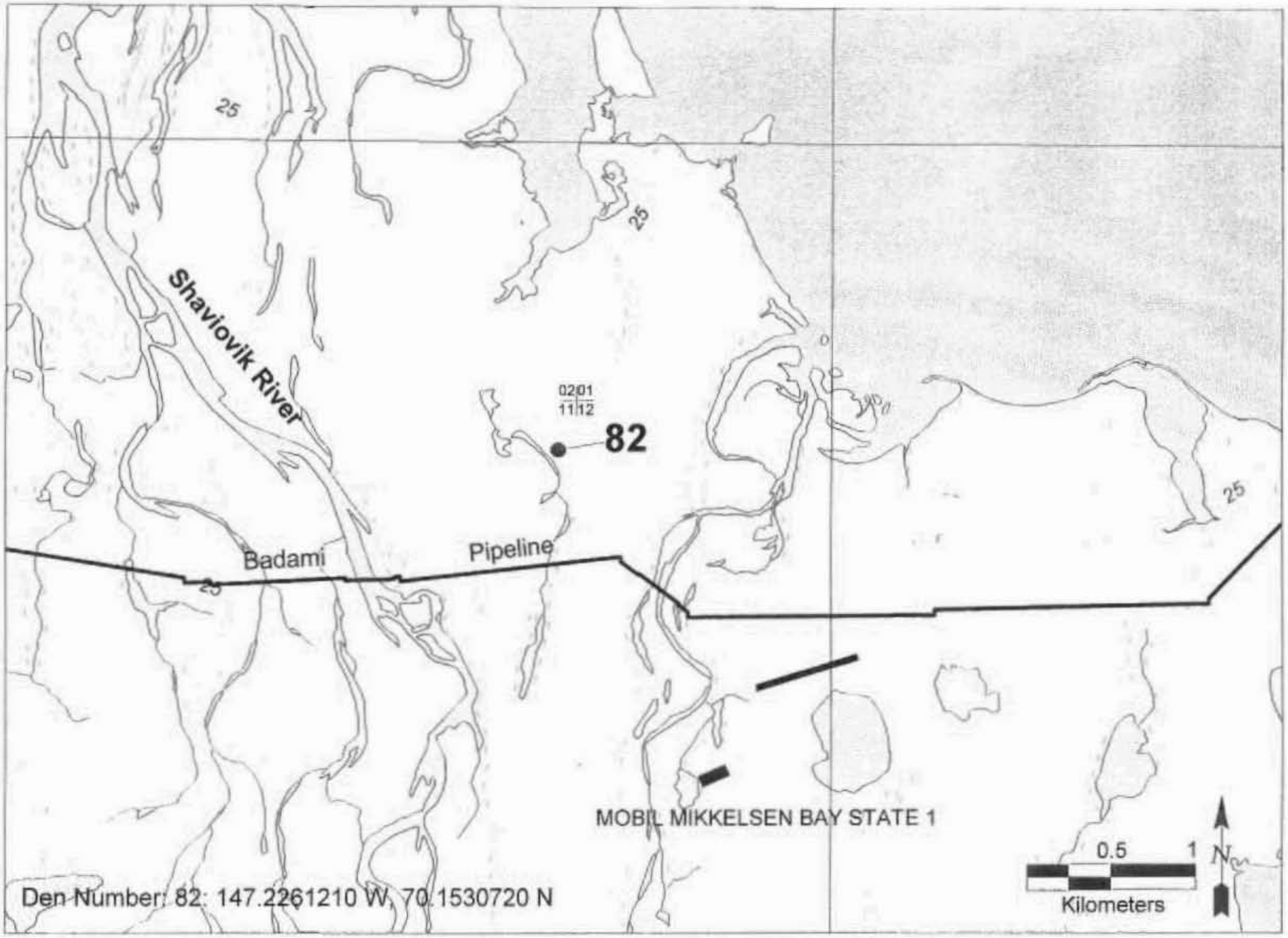

Figure A2. Locations of Arctic fox den 82, Beechey Point Quadrangle, Township 9N, Range 19E, Section 11, Alaska.

AF_dens82.wor

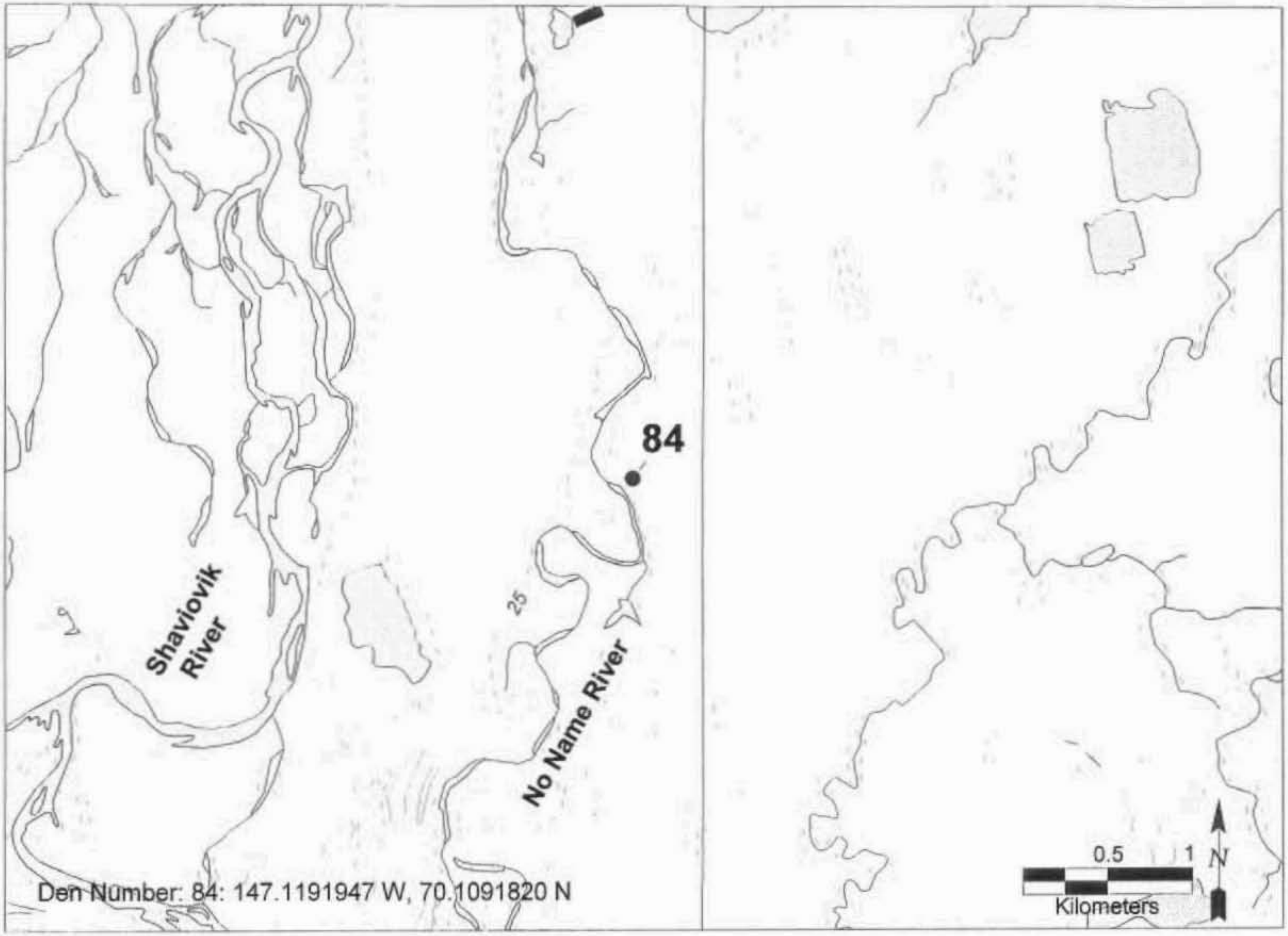

Figure A3. Locations of Arctic fox den 84, Beechey Point Quadrangle, Township 9N, Range 19E, Section 25, Alaska.

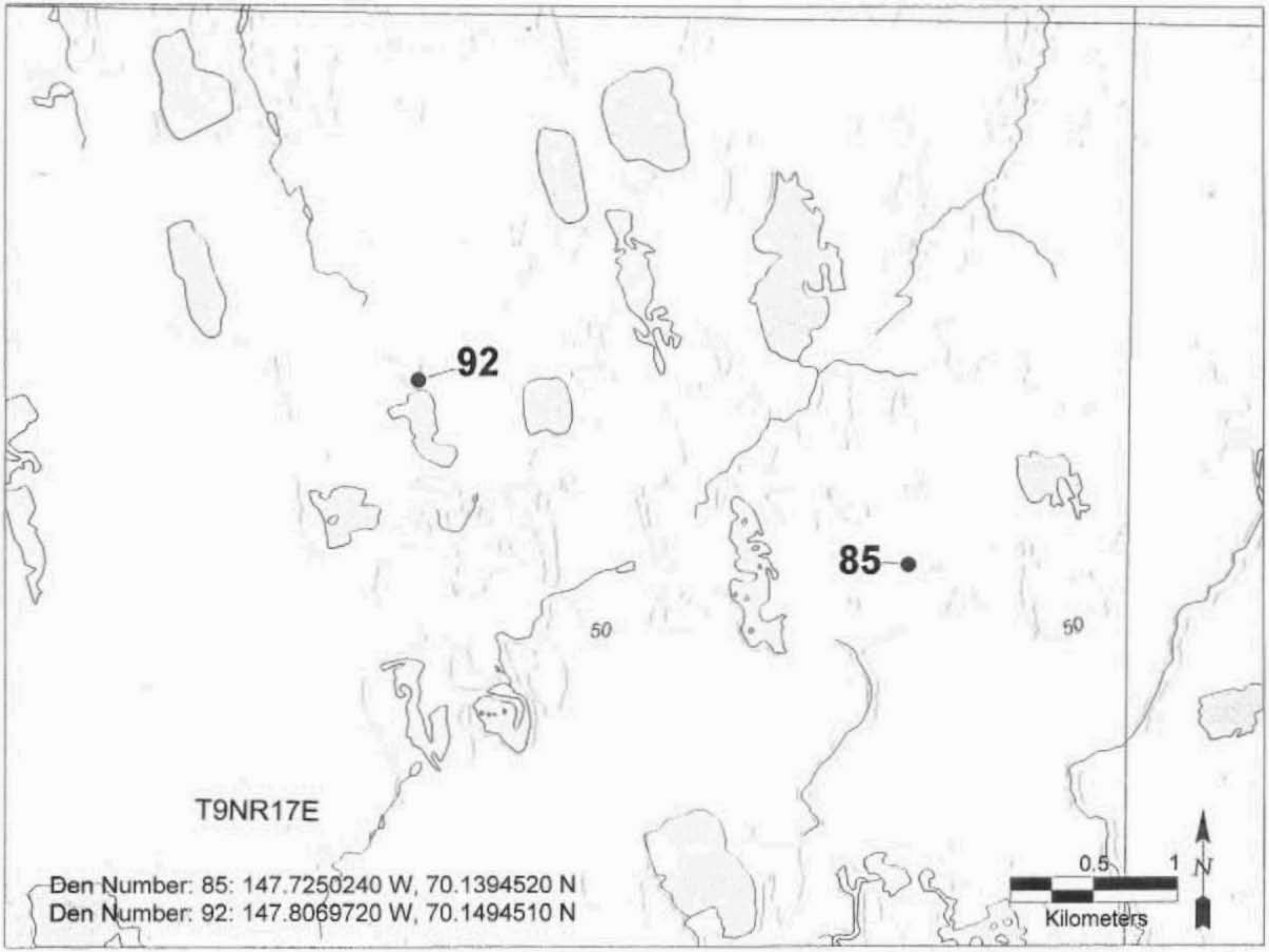

Figure A4. Locations of Arctic fox den 85 (Beechey Point Quadrangle, Township 9N, Range 17E, Section 13), and fox den 92 (Beechey Point Quadrangle, Township 9N, Range 17E, Section 10), Alaska.

AF_den85_92.wor

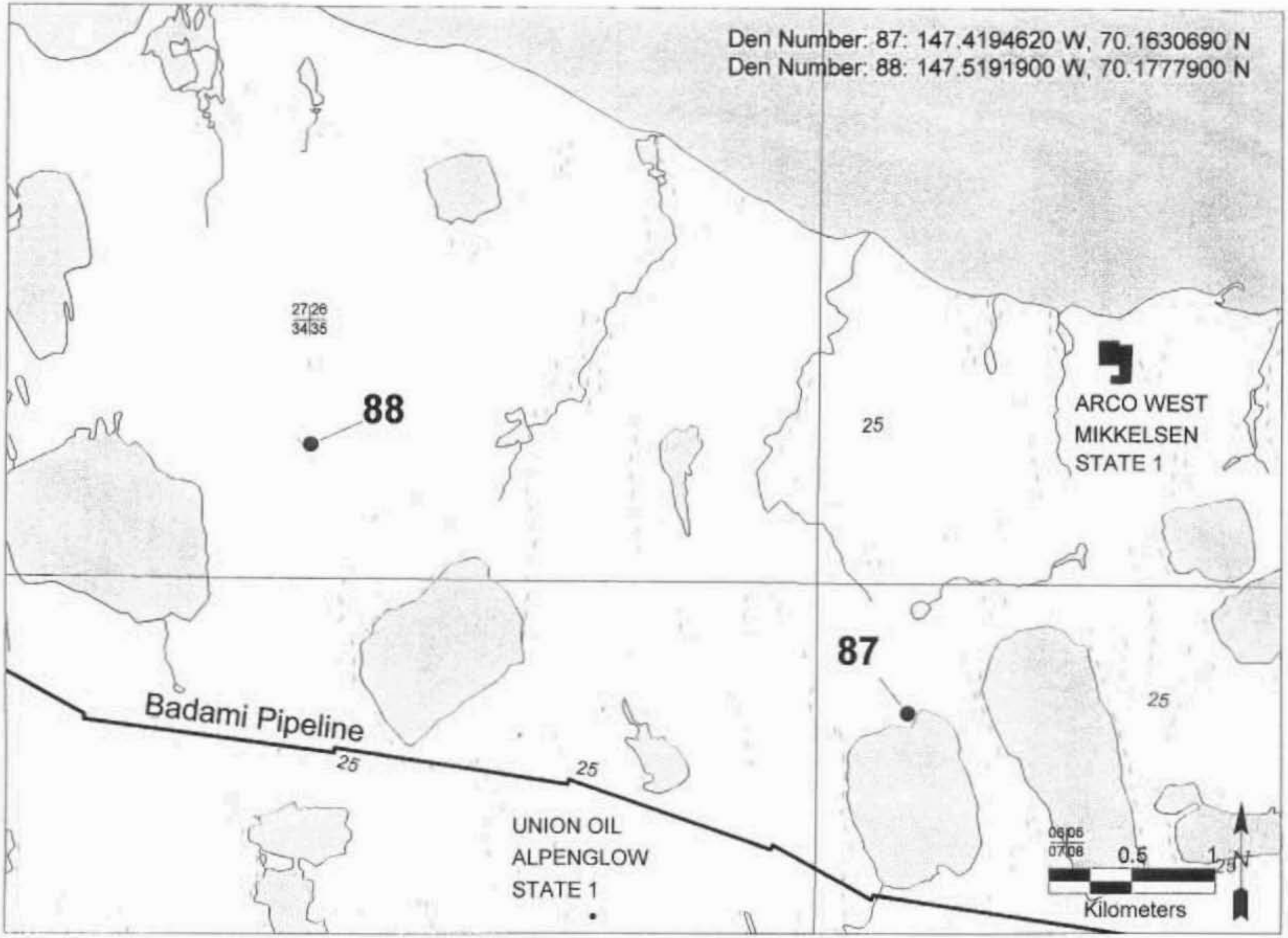

Figure A5. Locations of Arctic fox den 87 (Beechey Point Quadrangle, Township 9N, Range 19E, Section 6), and fox den 88 (Beechey Point Quadrangle, Township 10N, Range 18E, Section 35), Alaska.

AF_dens88_87.wor

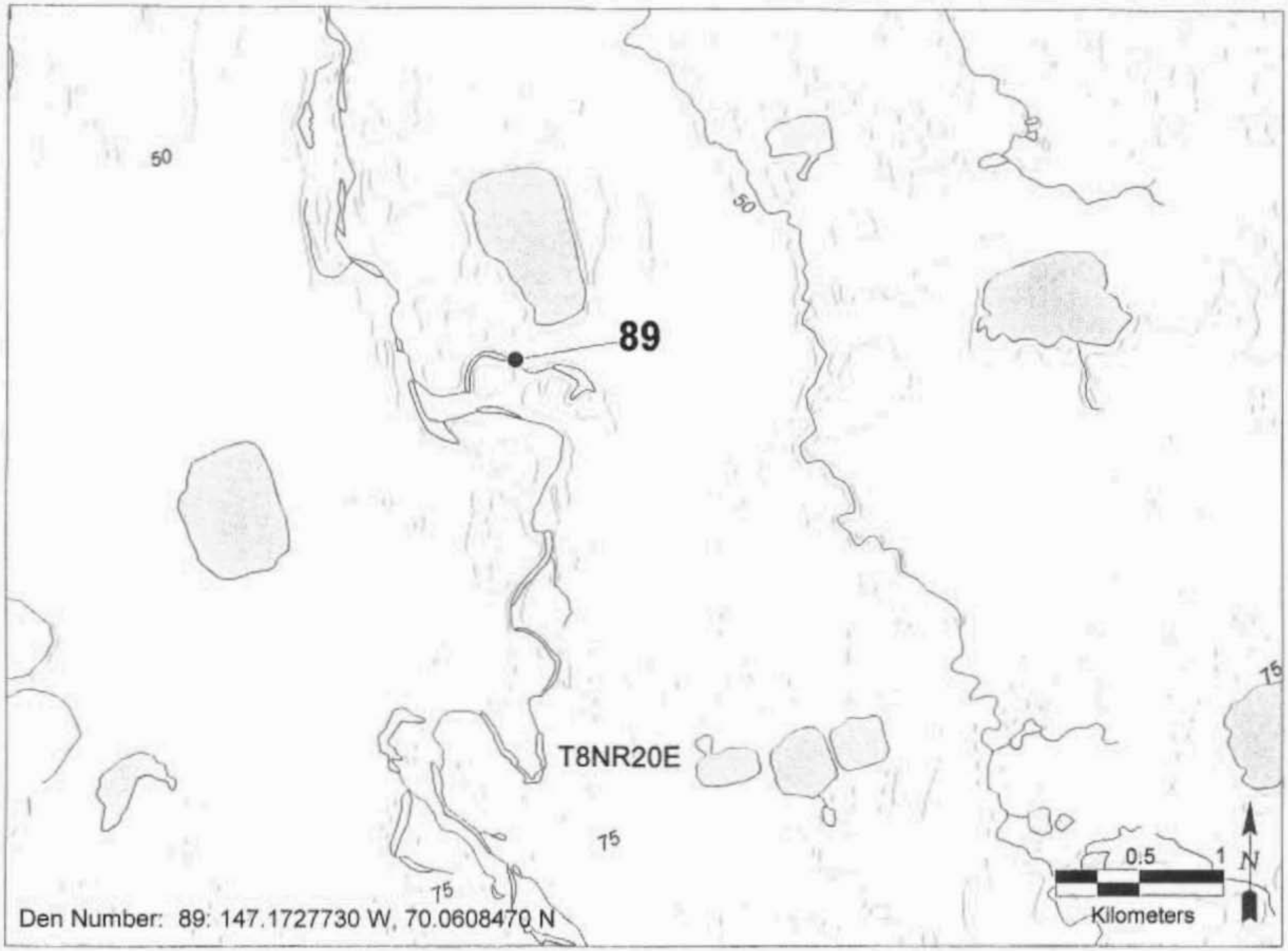

Figure A6. Locations of Arctic fox den 89, Beechey Point Quadrangle, Township 8N, Range 20E, Section 9, Alaska.

AF_dens89.wor

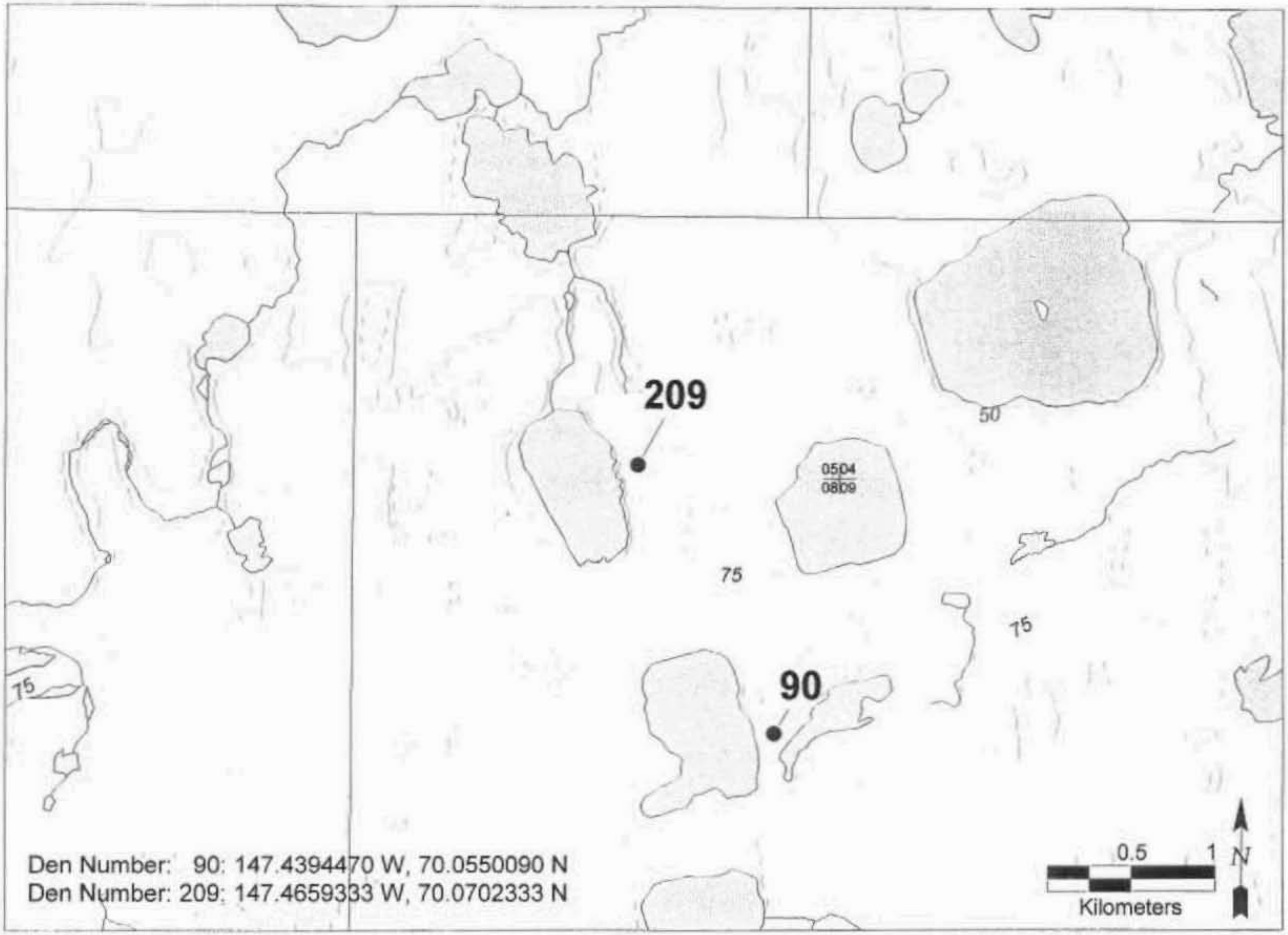

Figure A7. Locations of Arctic fox den 90 (Beechey Point Quadrangle, Township 8N, Range 19E, Section 8), and fox den 209 (Beechey Point Quadrangle, Township 8N, Range 19E, Section 5), Alaska.

AF_den209_90.wor

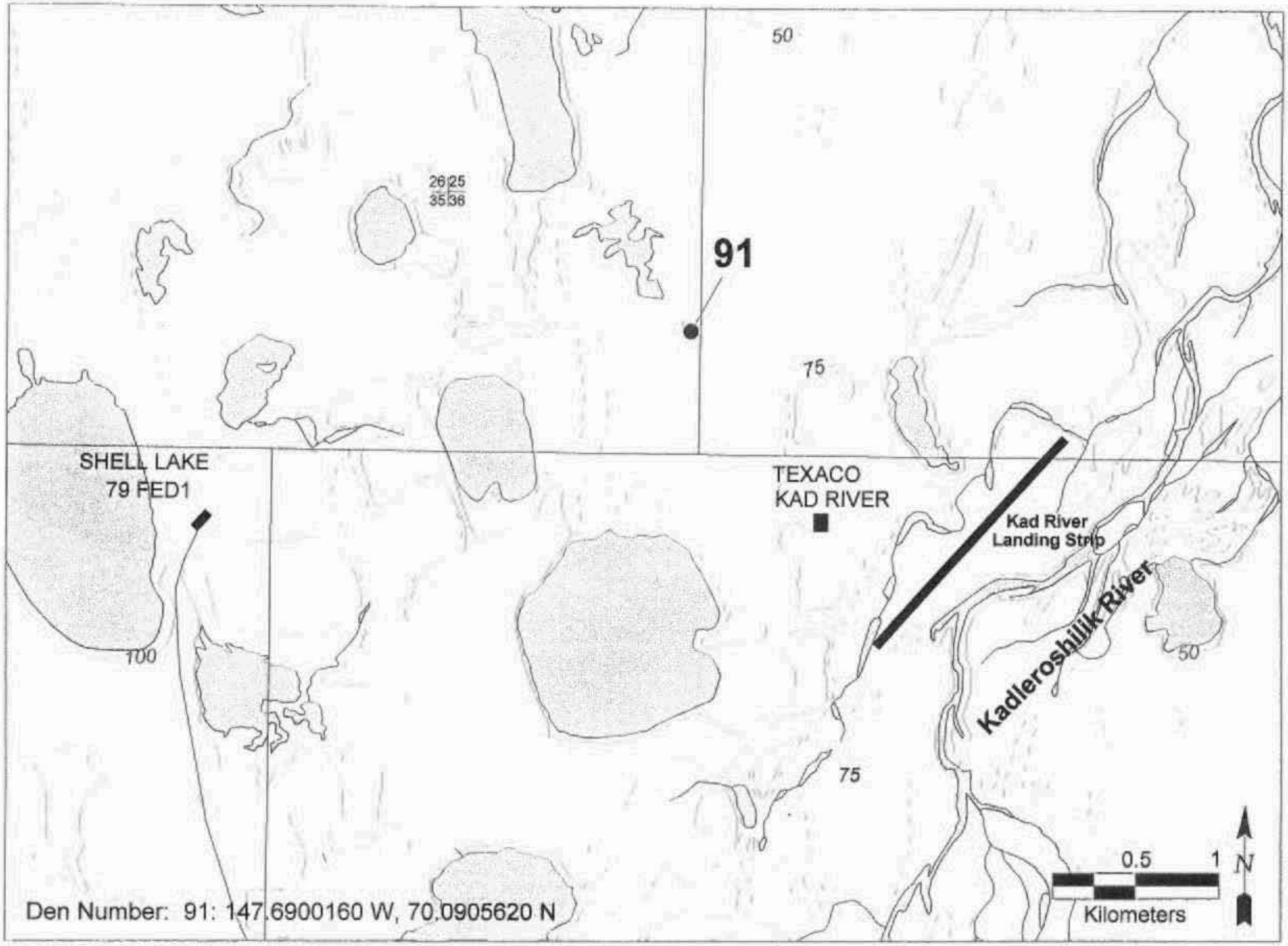

Figure A8. Locations of Arctic fox den 91, Beechey Point Quadrangle, Township 9N, Range 17E, Section 36, Alaska.

AF_den91.wor

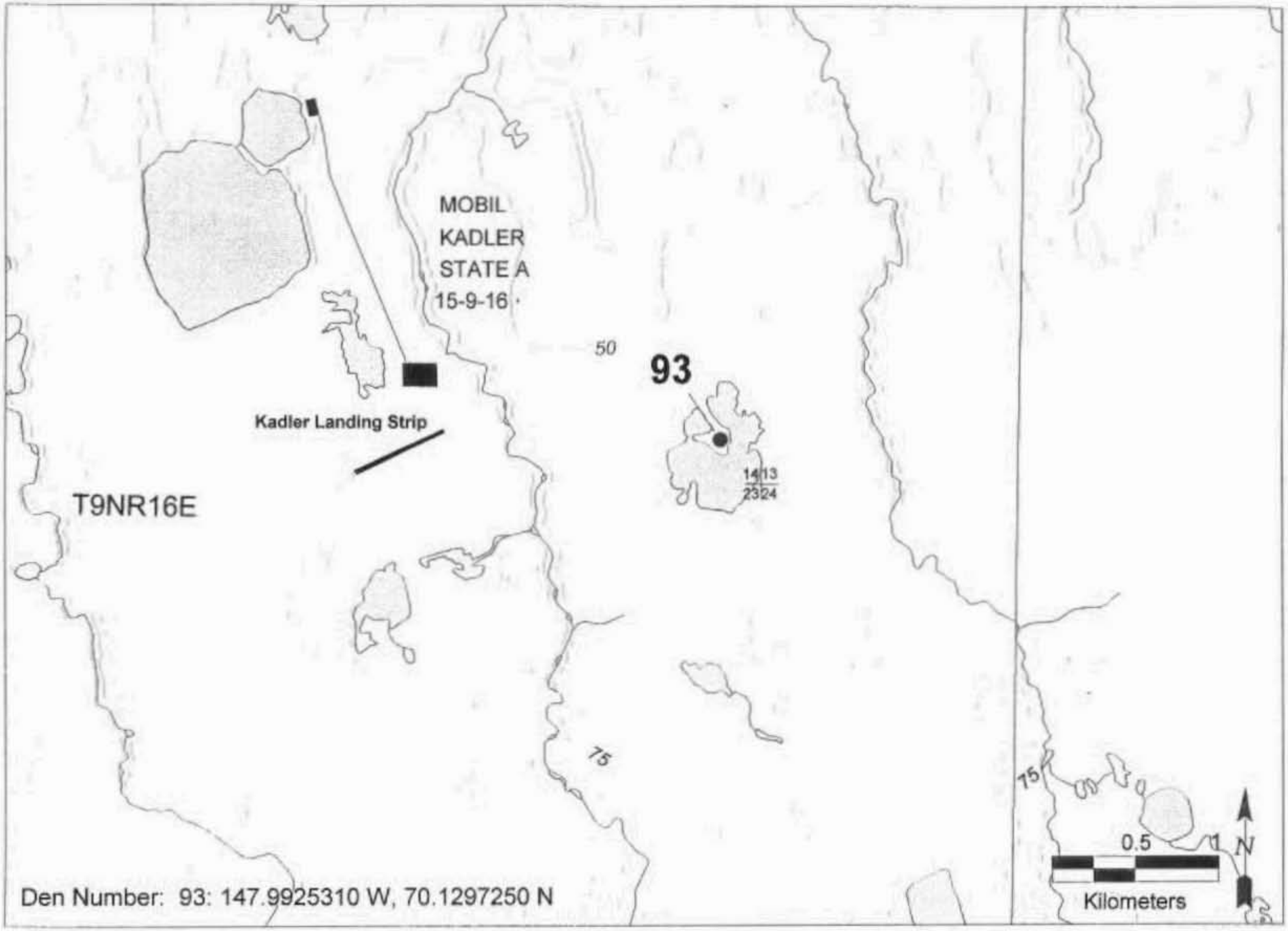

Figure A9. Locations of Arctic fox den 93, Beechey Point Quadrangle, Township 9N, Range 16E, Section 14, Alaska.

AF_den93.wor

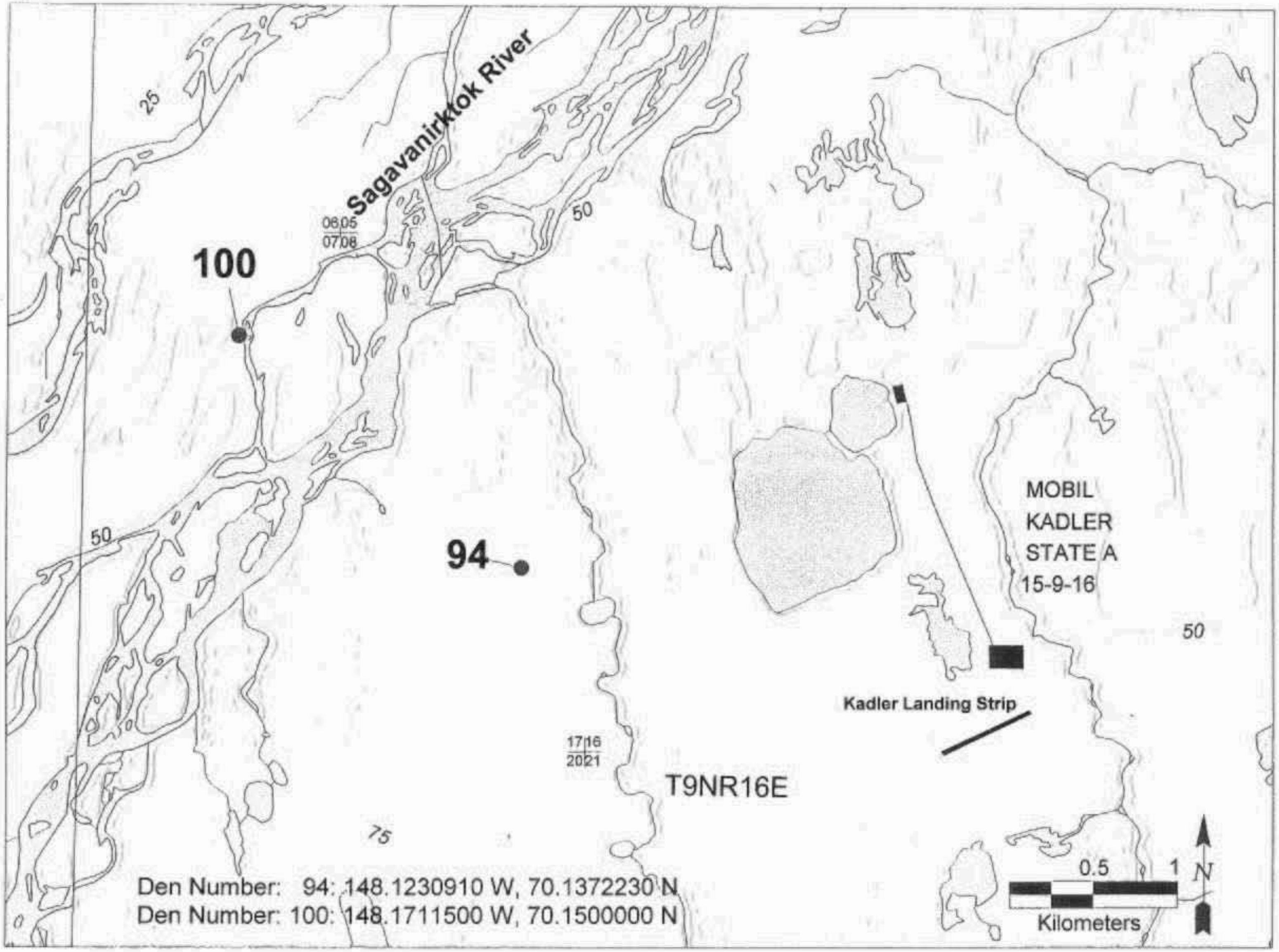

Figure A10. Locations of Arctic fox den 94 (Beechey Point Quadrangle, Township 9N, Range 16E, Section 17), and fox den 100 (Beechey Point Quadrangle, Township 9N, Range 16E, Section 7), Alaska.

AF_den94_100.wor

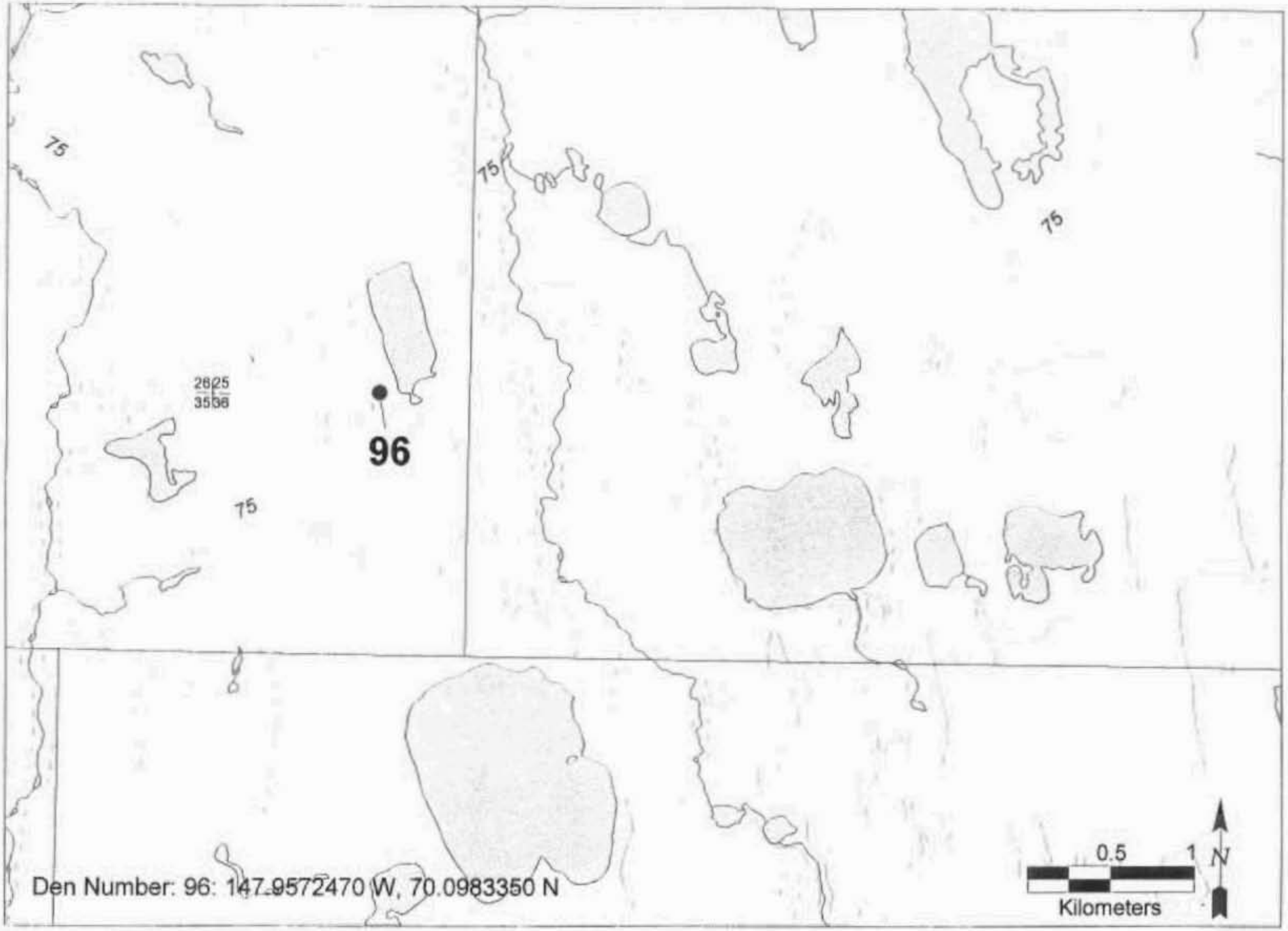

Figure A11. Locations of Arctic fox den 96, Beechey Point Quadrangle, Township 9N, Range 16E, Section 25, Alaska.

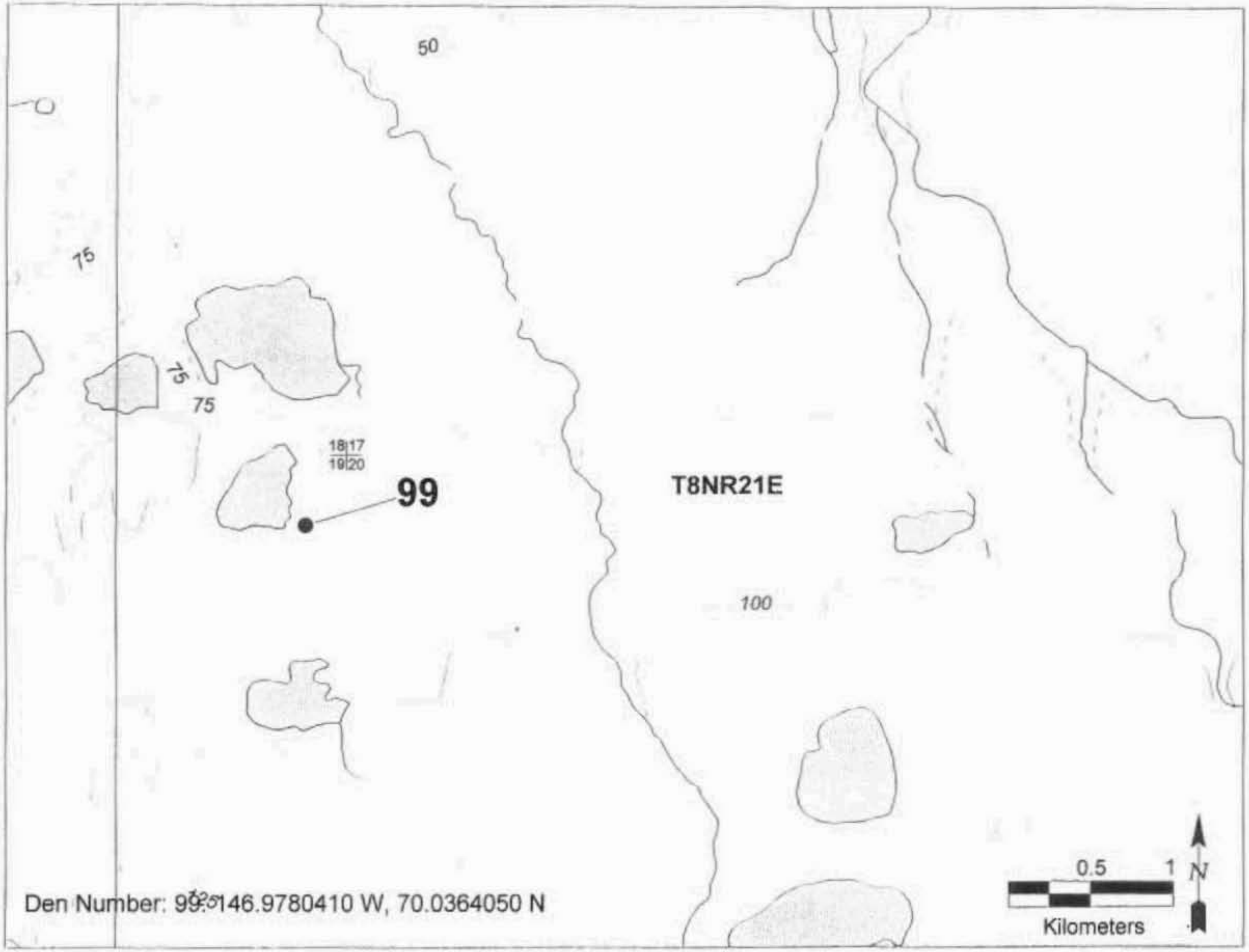

Figure A12. Locations of Arctic fox den 99, Beechey Point Quadrangle, Township 8N, Range 21E, Section 19, Alaska.

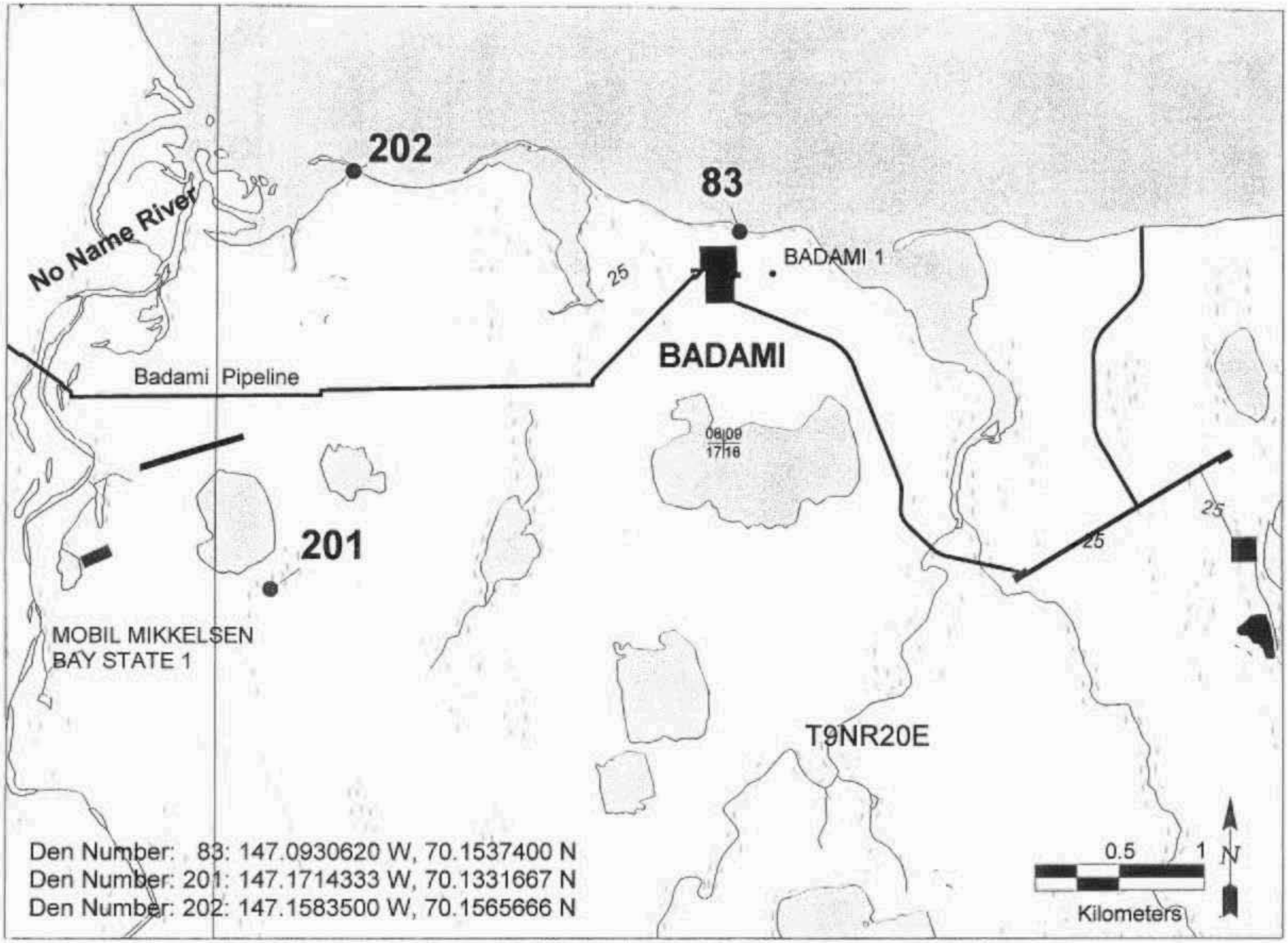

Figure A13. Locations of Arctic fox den 83 (Beechey Point Quadrangle, Township 9N, Range 20E, Section 9), fox den 201 (Beechey Point Quadrangle, Township 9N, Range 20E, Section 18), and fox den 202 (Beechey Point Quadrangle, Township 9N, Range 20E, Section 6), Alaska.

AF_den201_202_83.wor

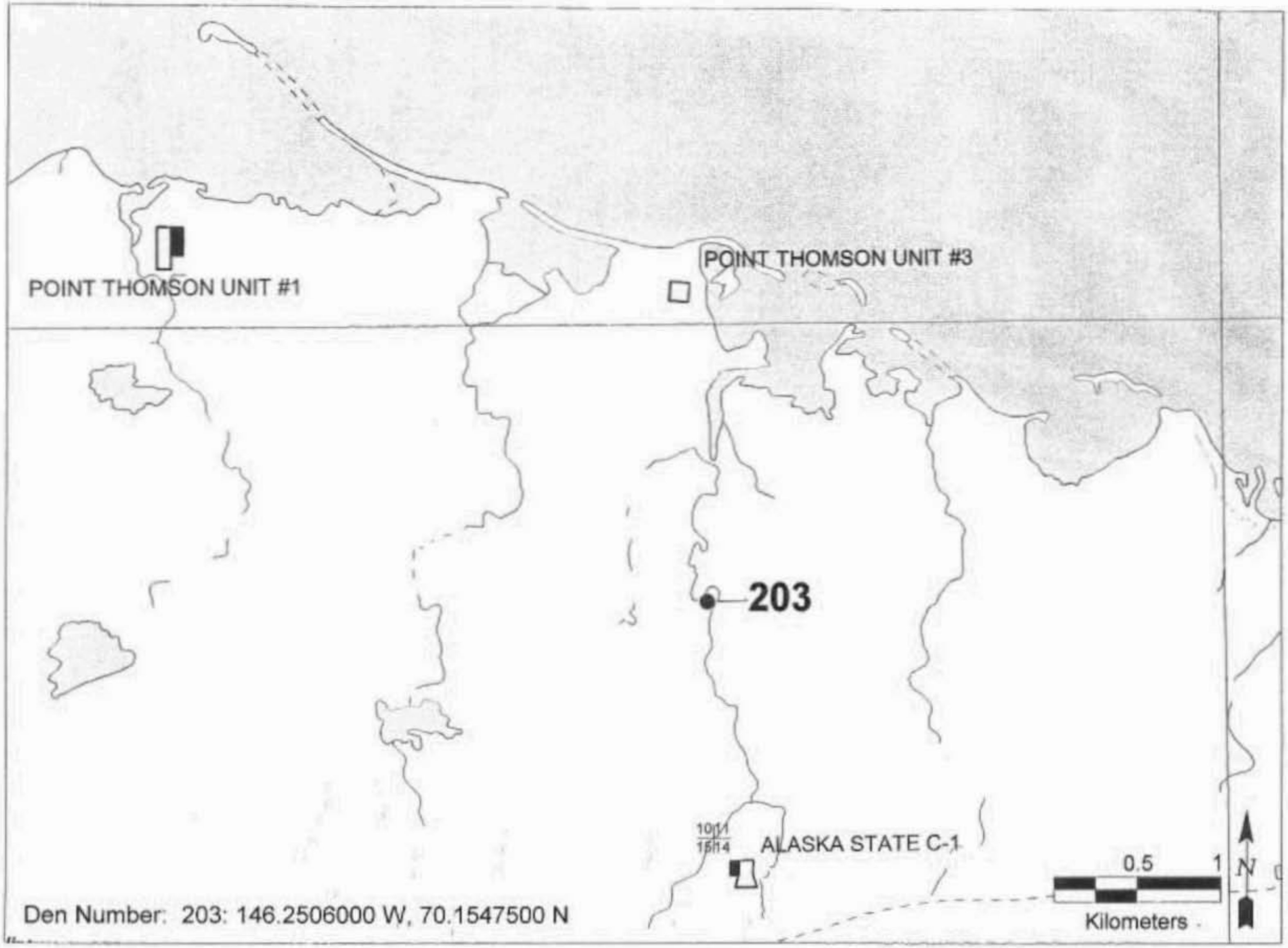

Figure A14. Locations of Arctic fox den 203, Flaxman Island Quadrangle, Township 9N, Range 23E, Section 10, Alaska.

AF_den203.wor

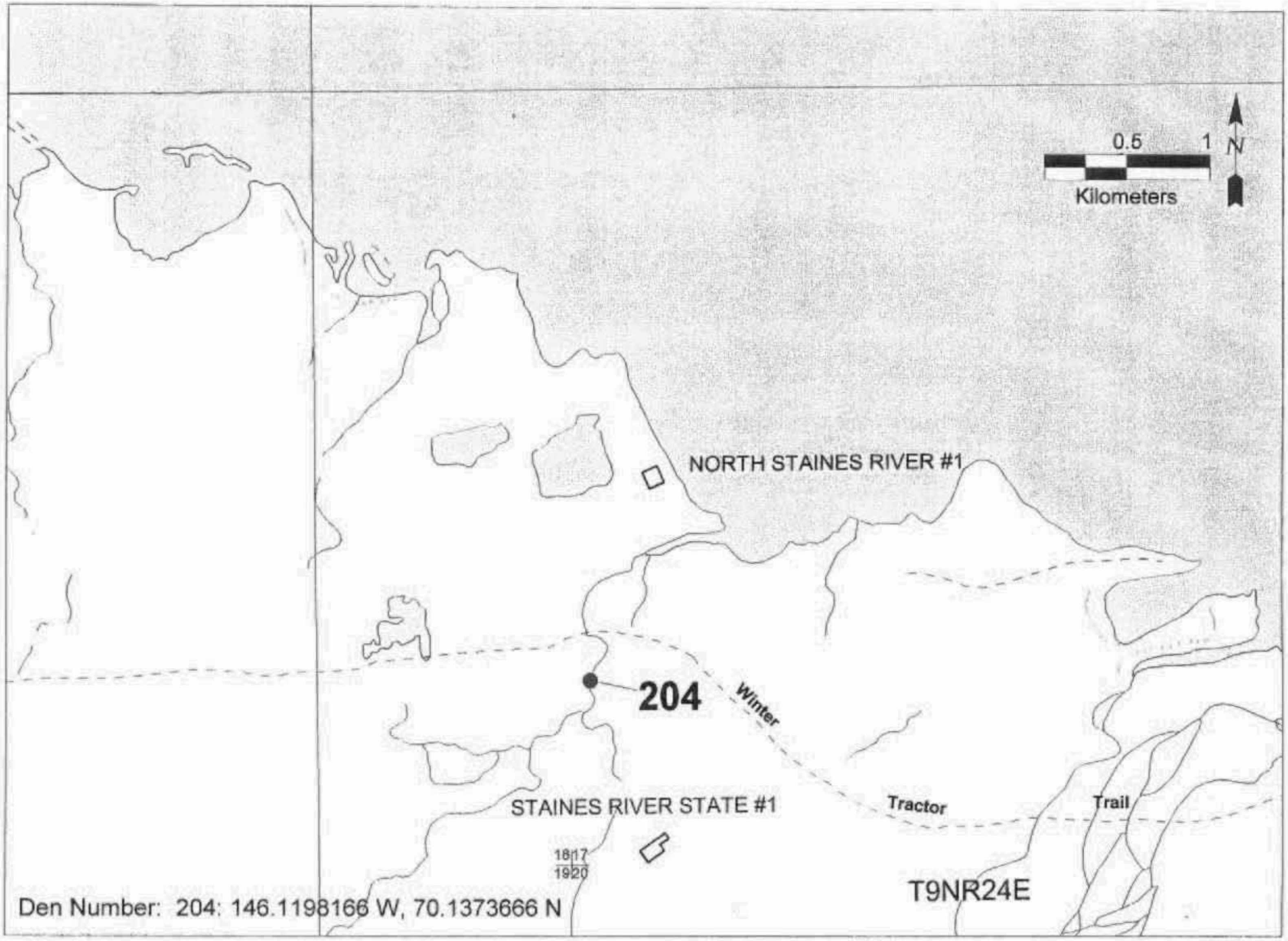

Figure A15. Locations of Arctic fox den 204, Flaxman Island Quadrangle, Township 9N, Range 24E, Section 17, Alaska.

AF_den204.wor

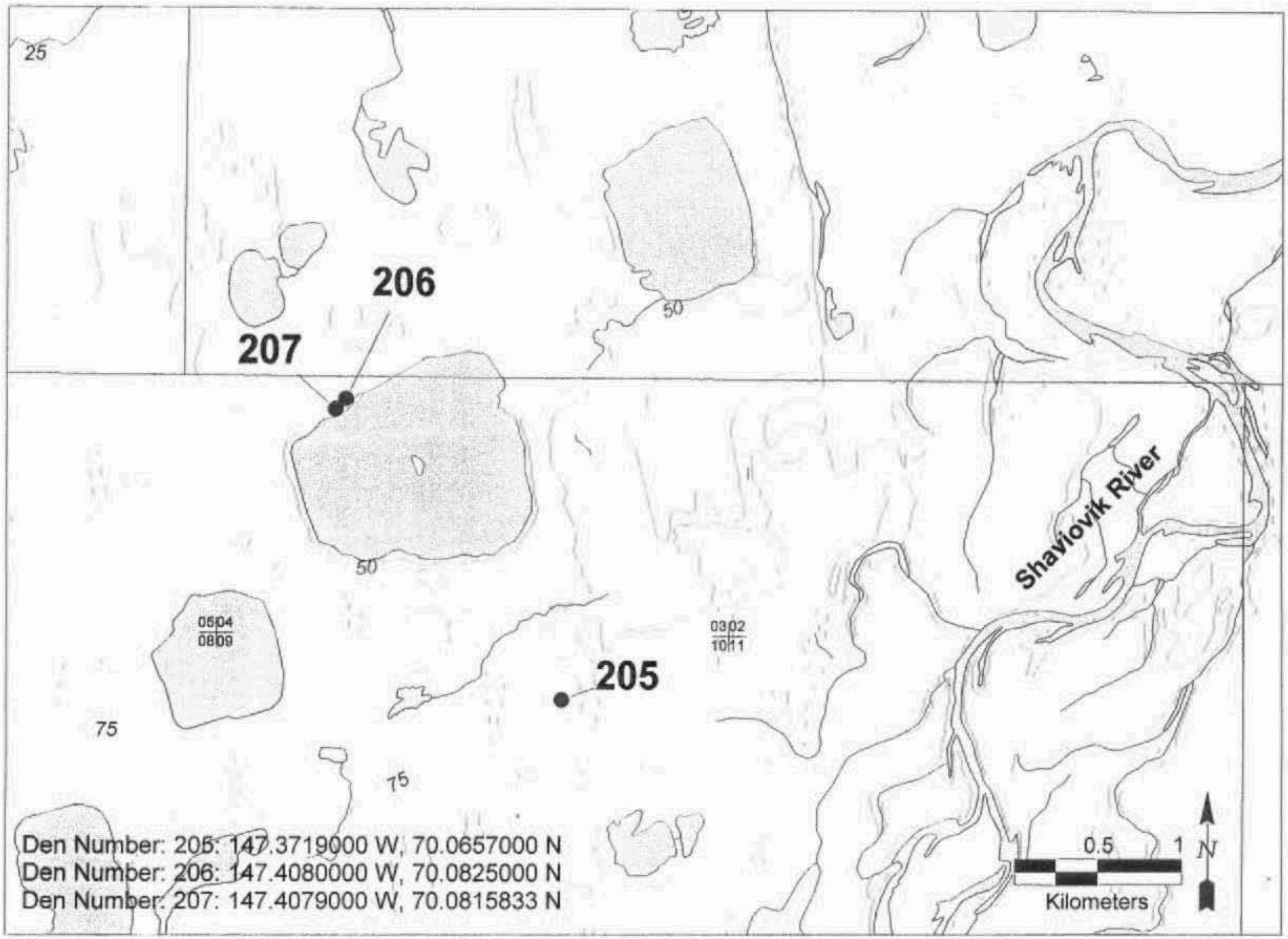

Figure A16. Locations of Arctic fox den 205 (Beechey Point Quadrangle, Township 8N, Range 19E, Section 10), fox den 206 (Beechey Point Quadrangle, Township 8N, Range 19E, Section 4), and fox den 207 (Beechey Point Quadrangle, Township 8N, Range 19E, Section 4), Alaska.

AF_den205_206_207.wor

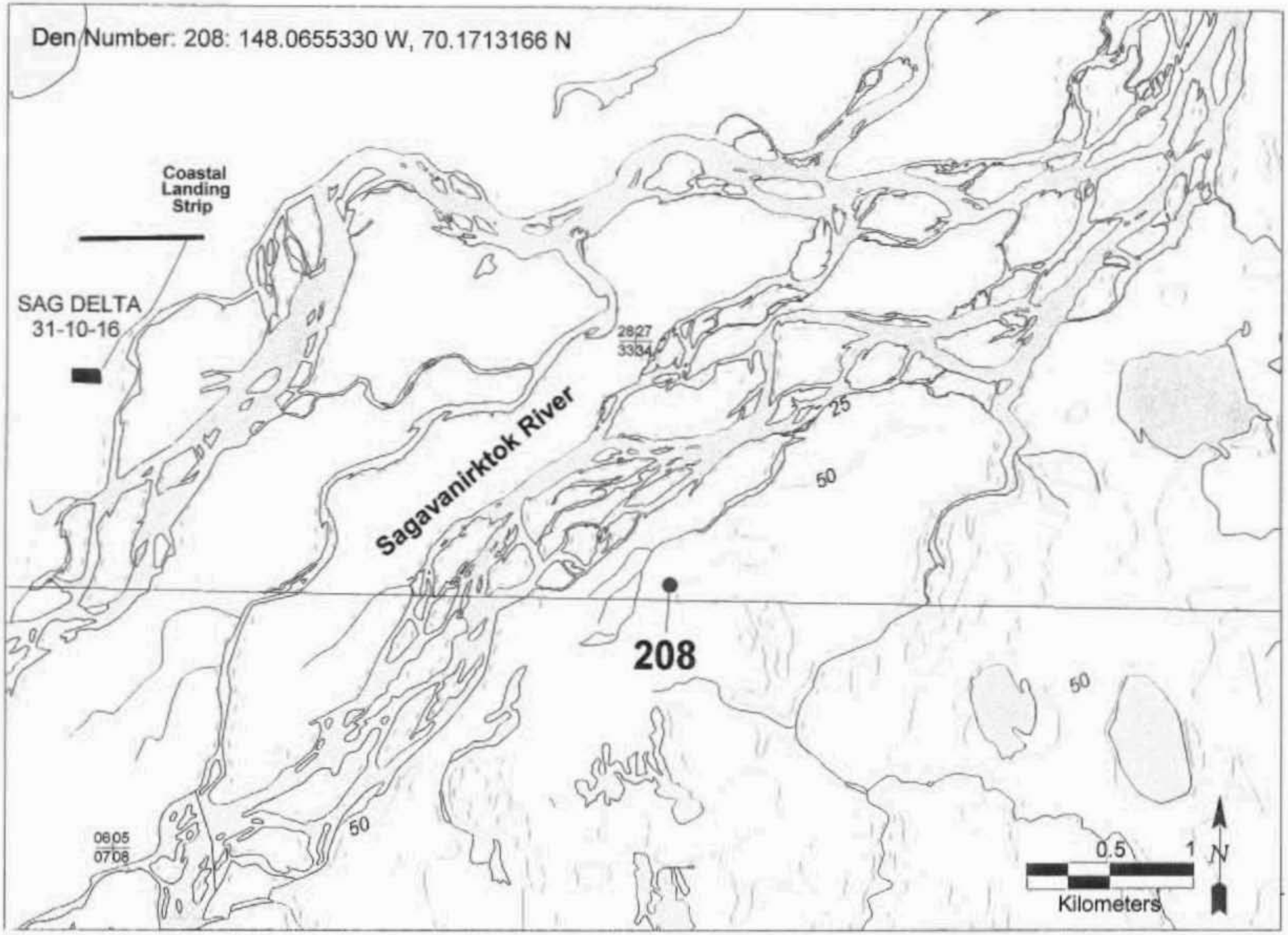

Figure A17. Locations of Arctic fox den 208, Beechey Point Quadrangle, Township 10N, Range 16E, Section 34, Alaska.

AF_den208.wor

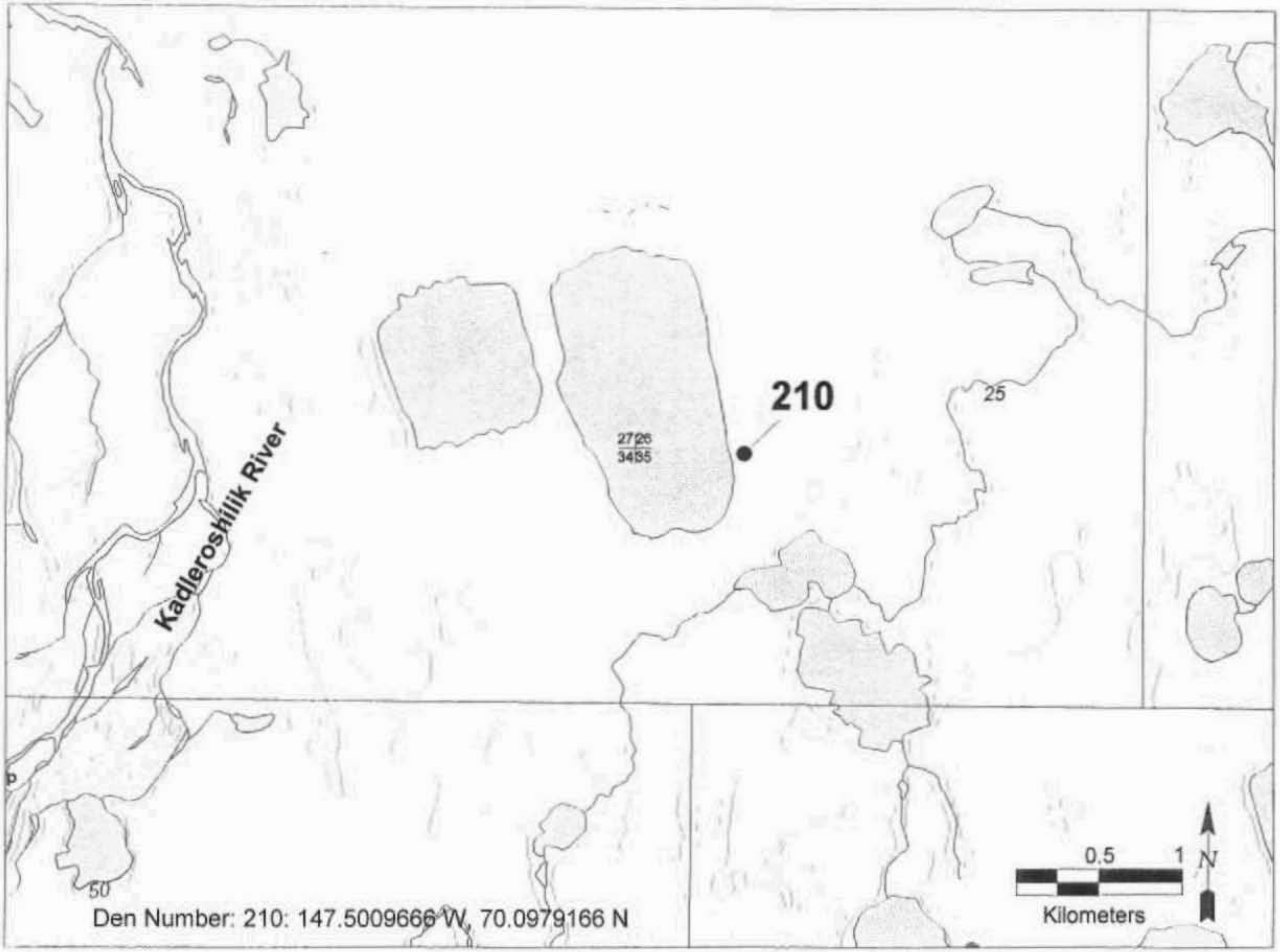

Figure A18. Locations of Arctic fox den 210, Beechey Point Quadrangle, Township 9N, Range 18E, Section 35, Alaska.

AF_den210.wor

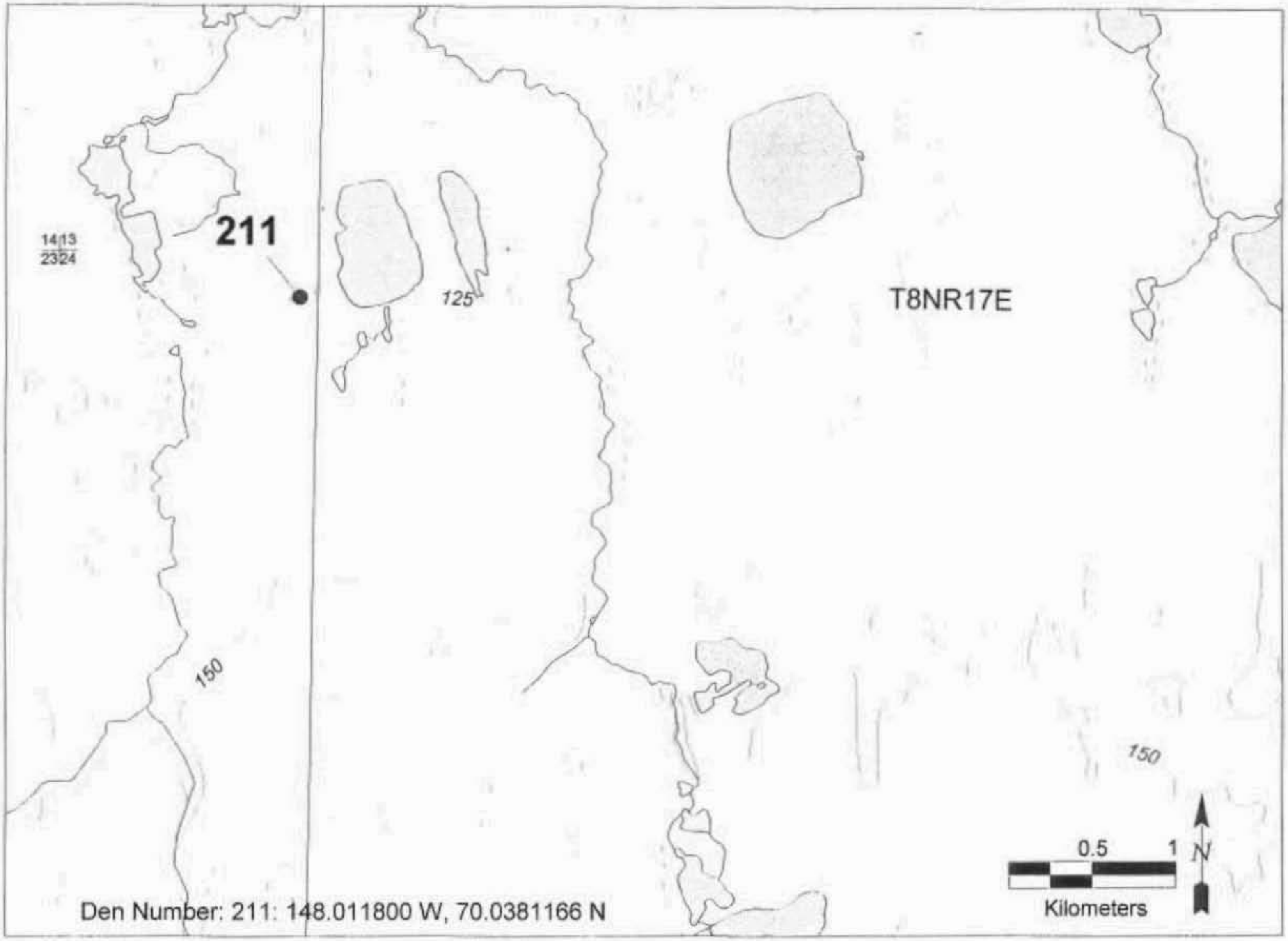

Figure A19. Locations of Arctic fox den 211, Beechey Point Quadrangle, Township 8N, Range 16E, Section 24, Alaska.

AF_den211.wor

APPENDIX B.

Arctic Fox Den History

Table B1. Arctic fox den site locations and history of occupancy in the Badami and Point Thomson Study Areas, Alaska, between 1973 and 1999.

Den No.	Study Site	Longitude (°W)	Latitude (°N)	1972	1979	1983	1991	1992	1993	1999
34	Badami	147.8728160	70.2016740	U	A	U	A	A	U	I
70	Badami	147.8789240	70.1816730	U	U	U	U	I	U	I
82	Badami	147.2261210	70.1530720	U	U	U	U	A	U	I
83	Badami	147.0930620	70.1537400	U	U	U	U	A	U	A
84	Badami	147.1191947	70.1091820	U	U	U	U	A	U	I
85	Badami	147.7250240	70.1394520	U	U	U	U	A	U	I
87	Badami	147.4194620	70.1630690	U	U	U	U	A	U	A
88	Badami	147.5191900	70.1777900	U	U	U	U	A	U	A
89	Badami	147.1727730	70.0608470	U	U	U	U	I	U	A/I
90	Badami	147.4394470	70.0550090	U	U	U	U	I	U	A
91	Badami	147.6900160	70.0905620	U	U	U	U	I	U	A/I
92	Badami	147.8069720	70.1494510	U	U	U	U	I	U	I
93	Badami	147.9925310	70.1297250	U	U	U	U	A	U	A
94	Badami	148.1230910	70.1372230	U	U	U	U	I	U	I
96	Badami	147.9572470	70.0983350	U	U	U	U	I	U	I
99	Badami	146.9780410	70.0364050	U	U	U	U	I	U	I
100	Badami	148.1711500	70.1500000	U	U	U	U	A	U	I
201	Badami	147.1714333	70.1331667	?	?	?	?	?	?	A
202	Badami	147.1583500	70.1565666	?	?	?	?	?	?	A
203	Pt. Thomson	146.2506000	70.1547500	U	U	A	U	U	U	A
204	Pt. Thomson	146.1198166	70.1373666	U	U	I	U	U	U	A/I
205	Badami	147.3719000	70.0657000	I	U	U	U	U	U	I
206	Badami	147.4080000	70.0825000	I	U	U	U	U	U	I
207	Badami	147.4079000	70.0815833	U	U	U	U	U	U	I
208	Badami	148.0655330	70.1713166	A	U	U	U	U	U	I
209	Badami	147.4659333	70.0702333	I	U	U	U	U	U	A
210	Badami	147.5009666	70.0979166	I	U	U	U	U	U	I
211	Badami	148.0118000	70.0381166	A	U	U	U	U	U	A

APPENDIX C.

Vegetation categories for the Badami Development Area and the Point Thomson Development Area

Table C1. Summary of area by Level C vegetation categories (Walker 1983) for the Badami Development Area (Shick and Noel 1995) and the Point Thomson Unit Area (Noel and Funk 1999). The Badami Development Area comprised 3% (61 km^2 of 1700 km^2) and the Point Thomson Unit Area comprised 8% (133 km^2 of 1700 km^2) of the 1999 Arctic fox denning study area.

Vegetation Category	Description	Badami Development Area (% Area)	Point Thomson Unit Area (% Area)
Ia. (Water)	(ponds, lakes, rivers, streams, saltwater)	24.0%	44.3%
IIb. (Aquatic Graminoid Tundra)	(emergent vegetation)	0.6%	0.5%
IId. (Water/Tundra Complex)	(pond complex with emergent vegetation)	0.3%	0.5%
IIIa. (Wet Sedge Tundra)		2.1%	3.0%
IIIb. (Wet Graminoid Tundra)	(wet saline tundra, saltmarsh)	0.6%	1.2%
IIIc. (Wet Sedge Tundra/Water Complex)	(pond complex, no emergent vegetation)	0.9%	0.5%
IIId. (Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex)	(wet patterned-ground complex)	8.4%	17.1%
IIIe. (Wet Sedge/Moist Sedge, Barren Complex)	(wet frost-scar tundra complex)	0.0%	0.5%
IVa. (Moist Sedge, Dwarf Shrub/Wet Graminoid Tundra Complex)	(moist patterned ground complex)	22.9%	10.3%
Va. (Moist Sedge, Dwarf Shrub Tundra)		28.6%	11.5%
Vc. (Dry, Dwarf Shrub, Crustose Lichen Tundra)	(Dryas tundra, pingos, river bars)	0.0%	2.0%
Vd. (Dry, Dwarf Shrub, Fruticose Lichen Tundra)	(dry acidic tundra)	5.2%	0.3%
Ve. (Moist Graminoid, Dwarf Shrub Tundra/Barren Complex)	(frost-scar tundra complex)	1.3%	3.6%
IXb. (Dry Barren/Dwarf Shrub, Forb Grass Complex)	(forb rich river bars)	1.3%	0.5%
IXc. (Dry Barren/Forb Complex)	(active river channels)	0.4%	0.0%
IXe. (Dry Barren/Grass Complex)	(coastal sand dune grassland)	0.0%	0.6%
IXh. (Wet Barren/Wet Sedge Tundra Complex)	(barren/saline tundra complex, saltmarsh)	0.1%	1.7%
IXi. (Dry Barren/Forb, Graminoid Complex)	(coastal barrens)	0.4%	0.5%
Xa. (River Gravels)		0.2%	0.0%
Xe. (Gravel Roads and Pads)		0.1%	0.2%
BS. (Barren Sand/Gravel)	(coastal beaches)	0.4%	0.0%
XIa. (Wet Mud)	(drained lakes and ponds)	2.0%	1.1%
XIc. (Bare Peat)	(barren coastal areas due to storm surges)	0.1%	0.0%