SUSITNA HYDROELECTRIC PROJECT

FEASIBILITY REPORT

VOLUME 2

ENVIRONMENTAL REPORT

SECTIONS 1-4

FINAL DRAFT

Prepared for:

ACRES

Prepared by:

Terrestrial Environmental Specialists, Inc.

ALASKA POWER AUTHORITY

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ERRATA

Reference is made in various areas of Volume 2 to Appendix E3. The reader should be referred instead to Reference Report R65.

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PREFACE

Terrestrial Environmental Specialists, Inc. (TES), on behalf of the Alaska Power Authority (the Power Authority) and as a subcontractor to Acres American, Inc. (Acres), is performing environmental studies as part of a feasibility study and, depending on that study's outcome, a license application to the Federal Energy Regulatory Commission (FERC) for the Susitna Hydroelectric Project. The environmental program consists of baseline studies, impact analyses, and mitigation planning, each of which is being conducted in two phases: preceding submission of the Feasibility Report and License Application (Phase I) and following the License Application (Phase II) (Acres American, Inc. 1979, 1980). This report is a summary of the findings of the Phase I studies, which were performed over a two-year period (1980- 1981).

TES acknowledges the substantial input received from its subcontractors and consultants. Principal investigators at the University of Alaska included: Dr. J. McKendrick, Dr. W. Collins, and Dr. D. Helm (Botanical Resources); Dr. P. Gipson, Mr. S. Buskirk, and Mr. W. Hobgood (Furbearers); Dr. B. Kessel and Mr. S. McDonald (Birds and Small Mammals); Dr. E. J. Dixon and Mr. G. Smith (Archeological Resources); and Dr. A. Jubenville, Ms. J. Feyhl, and Ms. P. Powell (Recreation, Aesthetics, and Land Use). Frank Orth & Associates, Inc. (Mr. P. Rogers, Project Manager) performed the socioeconomic study. Consultants to TES included Dr. R. Taber (Big Game), Dr. F. Banfield (Caribou), and Mr. R. Williams, Mr. C. Atkinson and Mr. M. Bell (Fish Resources). Ms. A. Fazekas served as editorial consultant; Ms. C. Page and Mr. M. Goff prepared the graphics. Studies to describe the existing fish and big game ecology were performed by the Alaska Department of Fish and Game (ADF&G) under direct agreement with the Power Authority.

The environmental report sections on Water Use and Quality, Geological and Soil Resources, and Alternatives were prepared by Acres to be combined with those sections prepared by TES. Acres has also prepared Volume I, which describes engineering aspects of the proposed project. In a separate appendix (E3) along with Acres' engineering drawings, are maps prepared by TES to illustrate environmental considerations for the transmission route.

The environmental resources and impacts of transmission facilities between Willow and Healy have been addressed in an independent study by the Power Authority. The proposed route parallels the Alaska Railroad in the vicinity of Gold Creek. Therefore, the Susitna transmission line study, as presented in this feasibility report, has been limited to those areas where additional corridors would be required, namely, from the proposed dams to Gold Creek as well as Willow to Anchorage and Healy to Fairbanks.

1 - GENERAL DESCRIPTION OF THE LOCALE

1.1 - Location

The location of the proposed Susitna Hydroelectric Project is the upper Susitna River, Alaska, approximately 180 km north-northeast of Anchorage and 230 km south-southwest of Fairbanks (Figure 1.1). Two proposed dams would generate electrical power for the railbelt region of Alaska, that is, the corridor surrounding the Alaska Railroad from Seward and Anchorage to Fairbanks. The two proposed dam sites, Watana and Devil Canyon, are 266 and 216 km upstream of the river's mouth at Cook Inlet. The nearest settlements (Gold Creek, Canyon, Chulitna) are along the Alaska Railroad, approximately 18 km from Devil Canyon.

1.2 - Physiography and Topography

The Susitna River basin lies largely within the Coastal Trough province of south-central Alaska, a belt of lowlands extending the length of the Pacific Mountain System and interrupted by the Talkeetna, Clearwater, and Wrangell Mountains (Wahrhaftig 1965). In the vicinity of the proposed impoundments (Figure 1.2), the river cuts a narrow, steep-walled gorge up to 300 m deep through the Clarence Lake Upland and Fog Lakes Upland, areas of broad, rounded summits 900 to 1400 m in elevation. Between these uplands, the gorge cuts through an extension of the Talkeetna Mountains, where rugged peaks are 1200-1900 m high. Downstream of its confluence with the Chulitna and Talkeetna rivers, near Talkeetna, the Susitna traverses the Cook Inlet-Susitna Lowland, a relatively flat region generally less than 150 m in elevation. A portion of the proposed transmission facilities, between Healy and Fairbanks, would follow the narrow valley of the Nenana River through the Northern Foothills of the Alaska Range, traverse the Tanana-Kuskokwim Lowland in a flat region generally less than 200 m in elevation (the Tanana Flats), and then parallel a ridge on the edge of the Yukon-Tanana Upland.

1.3 - Geology and Soils

In its complex geologic history, the upper Susitna River region has undergone uplifting and subsidence, marine deposition, volcanic intrusion, glacial planing and erosion. The Susitna basin lies within the Talkeetna terrain, a zone of moderate seismicity (see Volume I, Section 7). Continuing erosion has removed much of the glacial debris at higher elevations, but very little alluvial deposition has occurred here. The resulting landscape consists of barren bedrock mountains, glacial till-covered plains, and exposed bedrock cliffs in canyons and along streams. Climatic conditions have retarded the development of topsoil. Soils are typical of those formed in cold, wet climates and have developed from glacial till and outwash. They include the acidic, saturated, peaty soils of poorly drained areas; the acidic, relatively infertile soils of the forests; and raw gravels and sands along the river. The upper basin is generally underlaid by discontinuous permafrost.

1.4 - Hydrology

The entire drainage area of the Susitna River is about 50,000 km^2, of which the upper basin above Gold Creek comprises approximately 16,000 km^2 (Figures 1.3 and 1.4). Three glaciers in the Alaska Range feed forks of the Susitna River, which join after about 30 km to flow south through a broad valley for approximately 90 km. The river then flows westward about 140 km through a narrow valley, with the constriction at Devil Canyon creating violent rapids. Numerous small, clear-water tributaries flow steeply to the Susitna in this middle section, several of which cascade over waterfalls as they enter the gorge. As the Susitna curves south past Gold Creek, its gradient gradually decreases. The river is joined about 60 km beyond Gold Creek in the vicinity of Talkeetna by two major rivers, the Chulitna and Talkeetna. From this confluence, the Susitna flows south through braided channels about 130 km, until it empties into Cook Inlet near Anchorage, approximately 450 km from its source.

Most of the annual flow occurs between May and September, when the Susitna is heavily laden with glacial silt. Average summer flows at Gold Creek are 20,250 cubic feet per second (cfs); winter flows average only 2100 cfs. In the winter, the river runs clear. The upper Susitna River (above the confluence with the Chulitna) contributes about 20% of the mean annual flow measured near the river's mouth.

The upper reaches of the Susitna start to freeze up in early October, and by the end of November, the lower river is icebound. Breakup begins in late April or early May, and occasional ice jams may cause the water level to rise as much as six meters.

1.5 - Climate

As in most of Alaska, winters are long, summers are short, and there is considerable variation in daylight between these seasons. Higher elevations in the upper basin are characterized by a continental climate typical of interior Alaska. The lower floodplain falls within a zone of transition between maritime and continental climatic influences (Searby 1968, cited by Hartman and Johnson 1978). From the upper to the lower basin, the climate becomes progressively wetter, with increased cloudiness and more moderate temperatures.

At Talkeetna, which is representative of the lower basin, average annual precipitation is about 71 mm (28 in), of which 68% falls between May and October, and annual snowfall is about 269 mm (106 in). Monthly average temperatures range from -13°C (9°F) in December and January to 14°C (58°F) in July.

1.6 - Vegetation

The Susitna basin occurs within an ecoregion classified by Bailey (1976, 1978) as the Alaska Range Province of the Subarctic Division. The major vegetation types in the upper basin are low mixed shrub, woodland and open black spruce, sedge-grass tundra, mat and cushion tundra, and birch shrub. (Scientific names of plants are listed in Table 3.1) These vegetation types are typical of vast areas of interior Alaska and northern Canada, where plants exhibit slow or stunted growth in response to cold, wet, and short growing seasons. Deciduous and mixed conifer-deciduous forests occur at lower elevations in the upper basin, primarily along the Susitna River, but comprise less than three percent of the upper basin area. These forest types have more robust growth characteristics than the vegetation types at higher elevations and are more comparable to vegetation types occurring on the floodplain farther downstream.

The floodplain of the lower river is characterized by mature and decadent balsam poplar forests, birch-spruce forest, alder thickets, and willow-balsam poplar shrub communities. The willow-balsam poplar shrub and alder communities are the earliest to establish on new gravel bars, followed by balsam poplar forests and, eventually, by birch-spruce forest. The major vegetation types within the proposed transmission corridor from Healy to Fairbanks are closed and open deciduous forests, closed and open mixed forests, and mixed low shrub.

1.7 - Wildlife

Big game in the upper basin include caribou, moose, brown bear, black bear, wolf, and Dall sheep. (Scientific names of these and other wildlife species are listed in Tables 3.8, 3.31 and 3.46.) Caribou migrate through much of the open country in the upper basin, and important calving grounds are present outside of the impoundment zone. Moose are fairly common in the vicinity of the proposed project, but high quality habitat is rather limited. Moose also frequent the floodplain of the lower river, especially in winter. Brown bear occur throughout the project vicinity, while black bear are largely confined to the forested habitat along the river; populations of both species are healthy and productive. Several wolf packs have been noted using the area. Dall sheep generally inhabit areas higher than 900 m in elevation.

Furbearer species of the upper basin include red fox, wolverine, pine marten, mink, river otter, short-tailed weasel, least weasel, lynx, muskrat, and beaver. Beavers become increasingly more evident farther downstream. Sixteen species of small mammals that are characteristic of interior Alaska are known to occur in the upper basin.

Bird populations of the upper basin are typical of interior Alaska but sparse in comparison to those of more temperate regions. Generally, the forest and woodland habitats support higher densities of birds than do other habitats. In regional perspective, ponds and lakes in the vicinity of the proposed impoundments support relatively few waterbirds. Ravens and raptors, including bald and golden eagles, are conspicuous in the upper basin. Bald eagles also nest along the lower river.

1.8 - Fish

Anadromous fish in the Susitna basin include all five species of Pacific salmon: pink (humpback); chum (dog); coho (silver); sockeye (red); and chinook (king) salmon. (Scientific names of fish are listed in Table 3.48.) Salmon migrate up the Susitna to spawn in tributary streams, sloughs, and side channels below Devil Canyon. Surveys to date indicate that salmon are unable to ascend the Devil Canyon rapids and are thus prevented from migrating farther into the upper basin. Anadromous smelt (eulachon) are known to migrate into the lower Susitna River, and Bering cisco have recently been discovered.

Grayling abound in the clear-water tributaries of the upper basin; these populations are relatively unexploited. Grayling as well as lake trout also inhabit many lakes. The mainstem Susitna has populations of burbot and round whitefish, often associated with the mouths of clear-water tributaries. Dolly Varden, humpback whitefish, sculpin, sticklebacks, and long-nosed suckers have also been found in the drainage. Rainbow trout, like the anadromous species, have not been found above Devil Canyon.

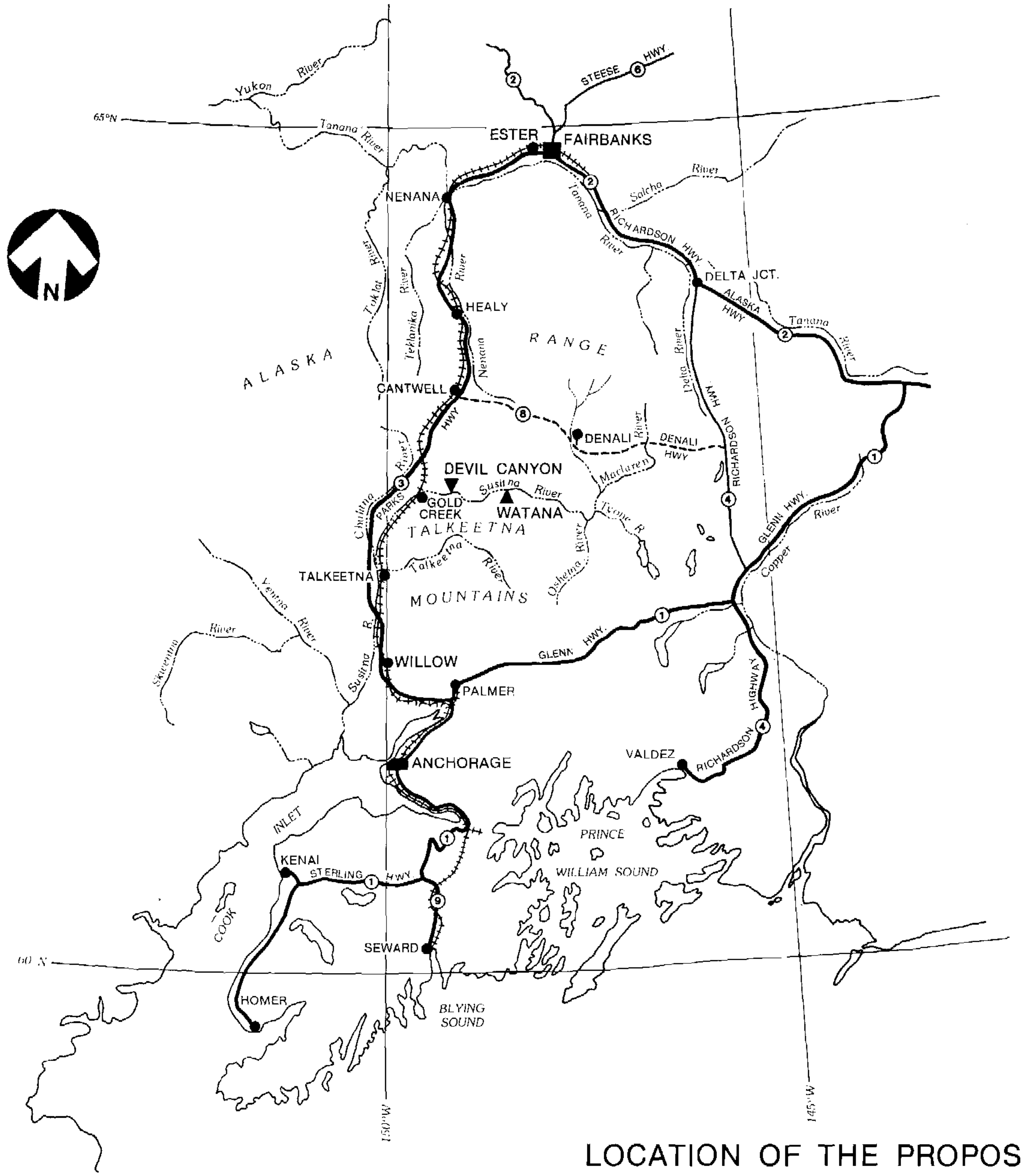
1.9 - Land Use

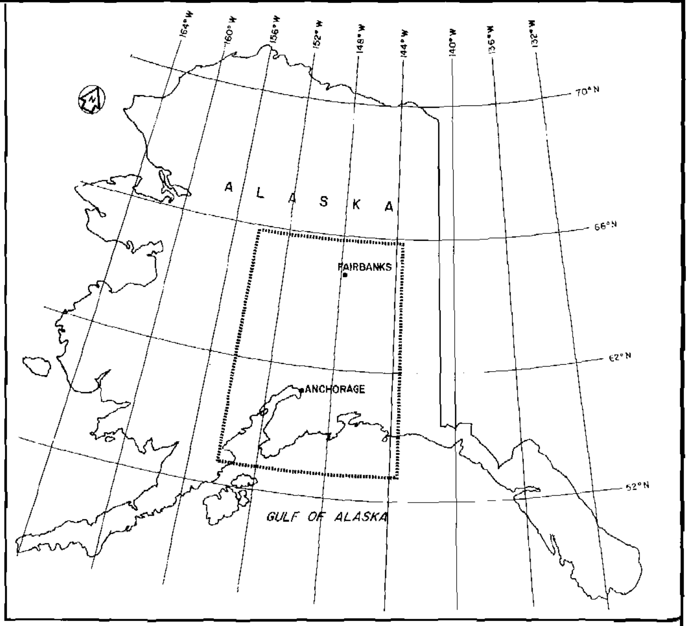
Because of limited access, the project area in the upper basin has retained a wilderness character. There are no roads to the project vicinity, but there are several off-road vehicle and sled trails. Although rough, dirt landing-strips for light planes are not uncommon, floatplanes provide the principal means of access via the many lakes in the upper basin.

Perhaps the most significant land use over the past three decades has been the study of hydropower potential of the Susitna River. The area is also used by hunters, white-water enthusiasts, fishermen, trappers, and miners. A few wilderness recreation lodges and private cabins, single and in small clusters, are scattered throughout the basin, especially on the larger lakes.

Most of the lands in the project area and on the south side of the river have been selected by the Natives under the Alaska Native Claims Settlement Act. Lands to the north are generally federal and are managed by the Bureau of Land Management. The State has selected some lands on the north side of the river, and there are many small, scattered private holdings in the upper basin.

The transmission corridors outside the dam and impoundment areas (Willow to Anchorage and Healy to Fairbanks) traverse lands with a somewhat higher degree of use. Most of the land within the corridors, however, is undeveloped.





LEGEND

- PRIMARY PAVED UNDIVIDED HIGHWAY
- SECONDARY PAVED UNDIVIDED HIGHWAY
- SECONDARY GRAVEL HIGHWAY
- RAILROAD
- WATERWAY
- ▲ DAM SITES

SCALE 0 – 40 Miles; 0 – 60 Kilometers

LOCATION OF THE PROPOSED SUSITNA HYDROELECTRIC PROJECT

PREPARED BY TES / ACRES

FIGURE 1.1

ACRES

Watana, View Upstream

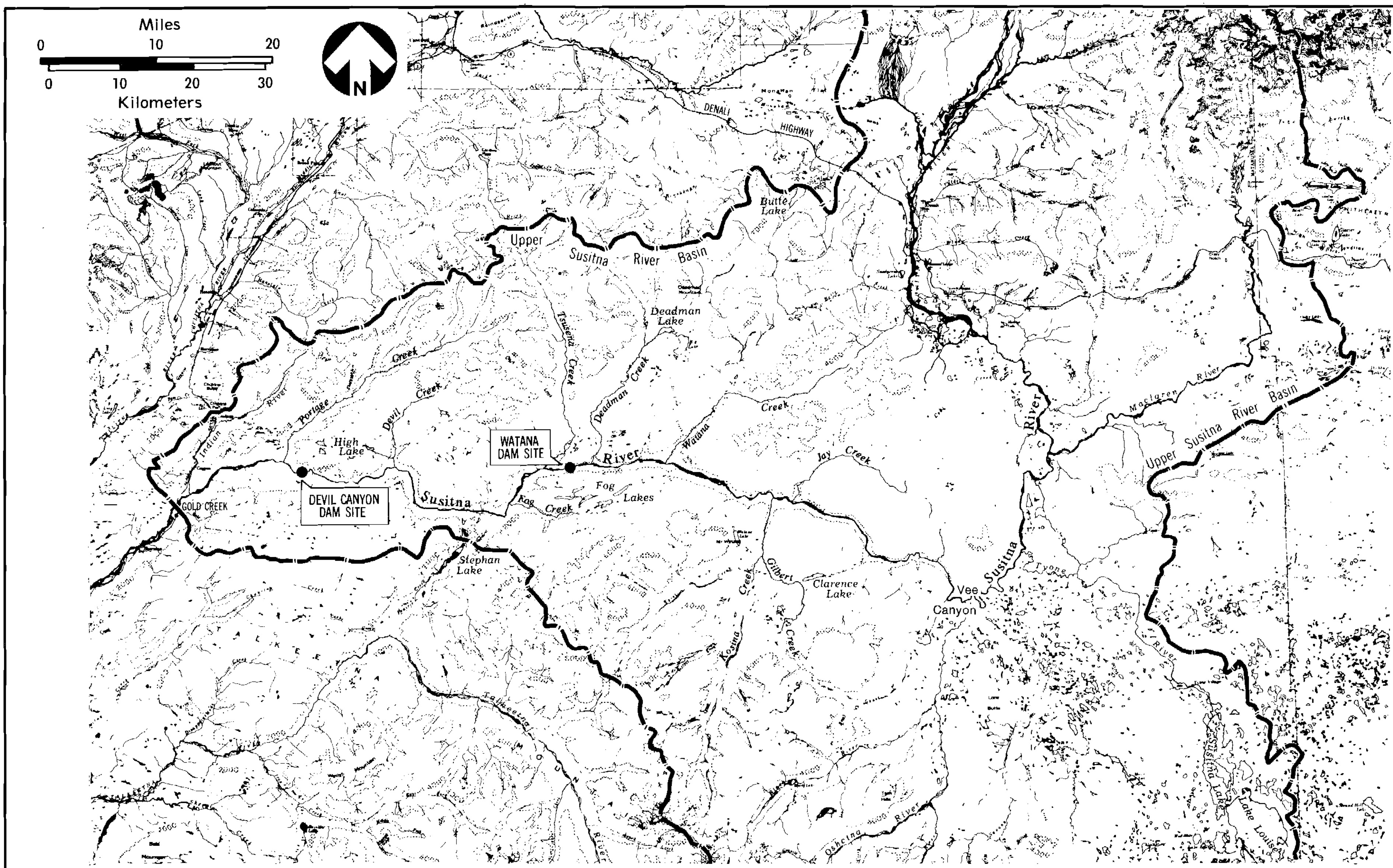
Devil Canyon, View Upstream

VICINITIES OF THE PROPOSED
DAM SITES, SUSITNA HYDROELECTRIC PROJECT

PREPARED BY TES

FIGURE 1.2

ACRES



UPPER SUSITNA RIVER BASIN

PREPARED BY TES

FIGURE 1.3

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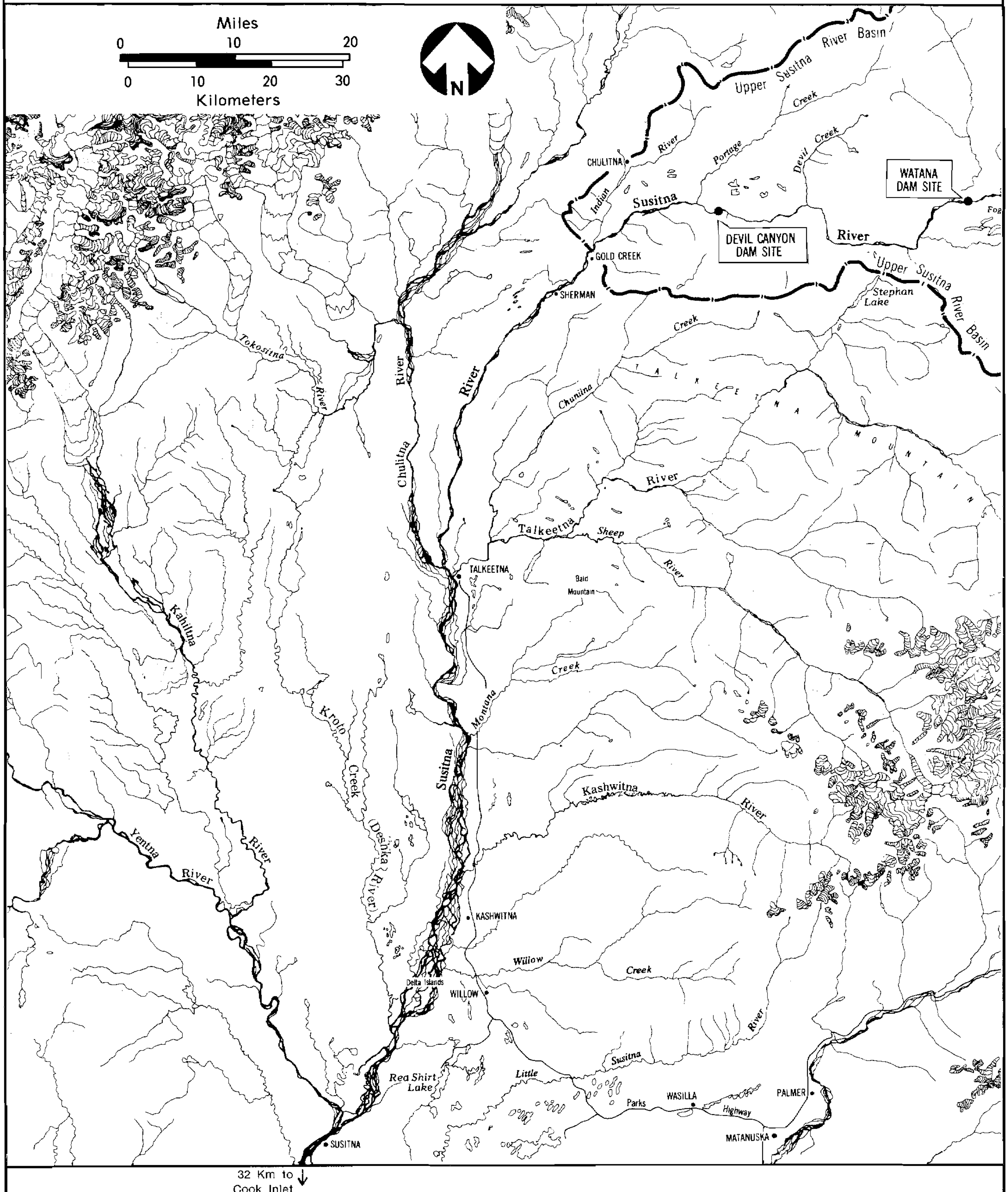


LOWER SUSITNA RIVER DRAINAGE

PREPARED BY TES

FIGURE 1.4

ACRES

2 - WATER USE AND QUALITY

This section deals with the identification of existing uses of water in the Susitna River Basin and the potential impact of the proposed Susitna project on those uses. A review of the current status of water rights is presented together with a discussion of current and projected water quality aspects of the watercourses in the project area.

2.1 - Water Use

Water rights pertaining to the use of water in Alaska are administered by the Alaska Department of Natural Resources (DNR). The legal documents protecting water rights are certificates, permits, and applications. Certificates are issued by the DNR for water rights that have been perfected, i.e., the water is being beneficially used. Permits are issued for water rights that are awaiting final approval following the construction of structures necessary to use the water. Applications to develop water rights are prioritized by the date of appropriation. However, approval depends on the development and perfection of the water right as well as adjudication of the quantity requested to protect prior appropriations.

DNR's Water Management Section has computer files on all certificates, permits, and applications pending. These files are updated monthly and contain the following information:

- Water rights identification number and standard industrial code classification number for each type of water use associated with that water right;

- The quantity of water appropriated and diverted, expressed as cubic feet per second (cfs), gallons per day (gpd), acre-feet per year (ac-ft/yr), or full flow;

- The source (stream or river, spring, well) and well depth;

- The priority date and number of days during the year that the water is used;

- The latitude/longitude coordinates for the point of diversion and point of use, and the quarter section of the township where this occurs;

- The legal status (certificate, permit, or pending) of the water right; and

- The appropriator's name.

(a) Current Susitna Basin Status

DNR's Water Management Section staff has undertaken a search of computer files and generated a printout reflecting all data that had been coded as of September 10, 1981. To facilitate the search, they selected township grids for 17 different segments of the Susitna River Basin.

As the first step to interpreting the data, the 17 township grids were mapped at scale 1:250,000 and transferred to a 1:1,000,000 map.

This map was reviewed with DNR Water Management Section staff. Corrections and additions were made, and the Susitna reservoir township grid was included. No other townships were considered necessary for the search at this time (Doggett 1981; Janke 1981; Prokosch 1981).

To interpret the types of water appropriations identified on the computer printout, the listing that DNR developed from the standard industrial code was obtained (Mack 1981). Six of the township grids contained no data: Kashwitna, Sheep Creek, Talkeetna, Tokositna, Happy, and Alexander Creek. Summary tables were developed for the remaining township grids. Each table provides information on certificates, permits, and applications pending. For each type of water right, as described by the standard industrial code classification, the amount of surface water or ground water appropriated is expressed in cfs, gpd, or ac-ft/yr. The number of days in the year that the water right is "active" is noted, and the total amount of water which has been appropriated is tabulated for each type of use.

From this total, a summary was prepared (Table 2.1) listing the total amount of surface water and ground water appropriated in each township grid in cfs and equivalent ac-ft/yr. Cfs expresses the total amount of water as a flow rate, and equivalent ac-ft/yr expresses that same amount of water as an annual storage volume.

Finally, a 1:250,000 scale overlay was produced which identified the specific location of each recorded right along the mainstem Susitna River corridor. This overlay was placed on a similar scale USGS topographic map for the purpose of identifying potential areas of concern.

(b) Potential Areas of Concern

Five areas were identified where appropriations existed within the vicinity (less than one mile) of the mainstem Susitna River. Two areas were examined further on a 1:63,360 overlay and topographic map. The potential areas of concern were subdivided into the mainstem Susitna corridor and other areas.

(i) Mainstem Susitna Corridor

The mainstem Susitna corridor encompasses 30 townships, from the proposed impoundment area at Devil Canyon downstream to the Cook Inlet estuary. Existing surface and ground water appropriations are primarily for singlefamily and multi-family homes (Table 2.1). A small amount of water is used year-round for watering livestock. Only 0.153 cfs or 50 ac-ft/yr of surface water has been appropriated for all purposes (Table 2.2). Water appropriations in other areas are even less significant. On a seasonal basis, the greatest usage occurs during summer months for irrigating lawns, gardens, and crops. The largest single use of surface water is for placer gold operations.

As listed in Table 2.3, there are only five areas where water appropriations are located within one mile of the mainstem Susitna River. No surface water diversions are recorded that draw water directly from the Susitna River or its adjoining side channels and sloughs. Immediately downstream from the Delta Islands, on the west bank of the Susitna River, a single-family dwelling has a certificate for 650 gpd of ground water from a well of unlisted depth. The certificate includes 0.5 ac-ft/yr for crop irrigation for three months. About six miles below Talkeetna, and 0.25 miles inland from the west bank of the Susitna River, a single-family dwelling has a certificate for 500 gpd of ground water from a 90-foot-deep well. In Talkeetna, ground water from three shallow (20-, 27-, and 34-foot) wells have been appropriated for a single-family dwelling (500 gpd), the grade school (910 gpd), and the fire station (500 gpd). In the vicinity of Chase, between miles 235 and 236 of the Alaska Railroad, several unnamed streams, lakes, and creeks have been appropriated for single-family dwellings (1,250 gpd), lawn and garden irrigation (100 gpd), and crops (1 ac-ft/yr). In the vicinity of Sherman, at mile 258 of the Alaska Railroad, Sherman Creek and an unnamed stream have been appropriated for two single-family dwellings (325 gpd) and lawn and garden irrigation (50 gpd).

(ii) Other Areas

Data on existing water rights for the remaining township grids in the Susitna River basin are summarized in Table 2.2. The major uses of surface water occur in the Kahiltna and Willow Creek township grids. This water is used on a seasonal basis for mining operations. Water appropriations are 125 cfs, or 37,000 ac-ft/yr, in the Kahiltna area and 18.3 cfs, or 5,660 ac-ft/yr, in the Willow Creek area.

(c) Impacts of Susitna Project

Post-project water surface elevations for the mainstem river below Talkeetna are expected to be approximately three feet higher during winter months and from one half to one and one half feet lower during the summer months (R&M Consultants). Such a moderate range of fluctuation is not expected to adversely affect the ground water zones being tapped by the two small-capacity domestic wells in the Delta Islands and Tapper Creek areas. The surface water appropriations at Sherman are 50 to 100 feet above the present elevation of the Susitna River and would not be influenced by changes in water surface elevation of the Susitna River.

The three shallow wells (20 to 34-foot depth) recorded in Talkeetna are approximately 1.5 miles downstream from the confluence of the Chulitna and Susitna rivers and 0.13 miles downstream from the confluence of the Talkeetna River. From all visual indications the Talkeetna River appears to be upgradient and the principal recharge source for these wells. It appears that the water surface elevation of the Susitna River could be influencing the ground water level by providing the downgradient base elevation for the water table. However, the anticipated maximum decrease in average monthly water surface elevations of the Susitna River near Talkeetna will be approximately three feet. At worst, the water surface elevations of the local water table will be reduced one foot (R&M Consultants).

In the vicinity of Chase, all surface water appropriations are from small tributary streams and lakes at an elevation of 450 to 500. The Susitna River is approximately 0.25 miles from the nearest appropriation and is at an elevation of approximately 400. The anticipated changes in water surface elevation for the mainstem Susitna River near Chase are unlikely to have any effect on these surface water diversions from small streams or lakes located 50 to 100 feet above the river on the hillsides.

In summary, examination of state agency files indicated the major, although small, users of surface water occur along the Kahiltna and Willow Creek township grids. No surface water withdrawals from the Susitna River are recorded. Ground water appropriations along the mainstem Susitna River corridor are minimal, both in terms of number of users and total amount of water withdrawn. The analysis of topographic maps and overlays showing the specific locations of the appropriations along the mainstem Susitna River corridor indicated that neither surface water diversions from small tributaries nor shallow wells in the corridor area are likely to be affected by operation of the proposed project.

2.2 - Water Quality

This section presents a discussion of present water quality conditions in the Susitna River and potential impact of the proposed project.

(a) Present Conditions

The Susitna River is characterized by wide seasonal fluctuations in discharge. Breakup occurs in late April or early May, resulting in an increase in river flows with peak flows occurring in June. Discharge varies throughout the summer, depending on temperature and rainfall. Flows decline during the fall and winter and are at minimum level in March. Basin and runoff characteristics appear in Table 2.4.

The wide seasonal fluctuations in discharge, along with the glacial character of the river, have a significant effect on water quality. Suspended sediment concentrations and turbidity levels are low during late fall and winter, but sharply increase at breakup and remain high throughout summer during the glacial melt period. Dissolved solids concentrations and conductivity values are high during low flow periods and low during the high summer flows.

(i) Availability of Data

Existing water quality data have been compiled for the mainstem Susitna River from stations located at Denali, Vee Canyon, Gold Creek, Sunshine, and Susitna Station. Data from two Susitna River tributaries, Chulitna and Talkeetna Rivers, have also been compiled. The periods of record for each station are presented below:

Station	Period of Record	Agency
Denali (D)	4/9/57 - 5/19/81	USGS
Vee Canyon (V)	7/6/62 - 5/11/81	USGS
	6/19/80 - 10/8/81	R&M
Gold Creek (G)	6/22/49 - 7/21/81	USGS
	8/8/80 - 10/8/81	R&M
Chulitna (C)	4/5/58 - 3/25/81	USGS
Talkeetna (T)	4/29/54 - 10/4/77	USGS
Sunshine (S)	7/2/71 - 7/23/81	USGS
Susitna Station (SS)	8/17/55 - 8/12/81	USGS

Data have been compiled according to three seasons: breakup, summer, and winter. Breakup is usually short and extends from the time ice begins to break up until recession of spring runoff. Summer extends from the end of breakup until the water temperature drops to essentially 0°C in the fall, and winter is the period from the end of summer to breakup. Detection limits for various water quality perameters appear in Table 2.5.

(ii) Water Quality Standards

The water quality guidelines and criteria used in this evaluation were established from the following references:

- ADEC, 1979. Water Quality Standards. Alaska Department of Environmental Conservation, Juneau, Alaska, 334 pp.

- EPA, 1976. Quality Criteria For Water. U.S. Environmental Protection Agency, Washington, D.C., 255 pp.

- McNeely, R.N., V.P. Neimanis, and L. Dwyer, 1979. Water Quality Sourcebook-- A Guide to Water Quality Parameters. Environment Canada, Inland Waters Directorate, Water Quality Branch, Ottawa, Canada, 88 pp.

- Sitting, Marshall, 1981. Handbook of Toxic and Hazardous Chemicals. Noyes Publications, Park Ridge, New Jersey, 729 pp.

- EPA, 1980. Water Quality Criteria Documents; Availability. Environmental Protection Agency, Federal Register, 45, 79318-79379 (November 28, 1980).

The guidelines or criteria used for the parameters were chosen based on a priority system. Alaska Water Quality Standards were the first choice, followed by criteria presented in EPA's Quality Criteria for Water. If a criterion expressed as a specific concentration was not presented in the above two references, the other cited references were consulted.

A second priority system was used for selecting the guidelines or criteria presented for each parameter. This was required because the various references presented above cite levels of parameters that provide for the protection of identified water uses, such as (1) the propagation of fish and other aquatic organisms, (2) water supply for drinking, food preparation, industrial processes, and agriculture, and (3) water recreation. The first priority, therefore, was to present the guidelines or criteria that apply to the protection of freshwater aquatic organisms. The second priority was to present levels of parameters that are acceptable for water supply, and the third priority was to present other guidelines or criteria, if available. It should be noted that water quality standards set criteria which limit man-induced pollution to protect identified water uses. Although the Susitna River Hydroelectric Project is a pristine area, some parameters exceeded their respective criterion.

As noted in Table 2.6, criteria for three parameters are suggested rather than legally mandated or have otherwise been set at a level which natural waters usually do not exceed. The criteria for aluminum and bismuth have been suggested on the basis of human health effects. The criterion for total organic carbon (TOC) was established at 3 mg/l because water containing less than this concentration have been observed to be relatively clean. However, streams in Alaska receiving tundra runoff commonly exceed this level. The maximum TOC concentration reported herein, 20 mg/l, is likely the result of natural conditions. The criterion for manganese was established to protect water supplies. The criteria presented in the remaining parameters appearing in Table 2.6 are established by law for the protection of freshwater aquatic organisms. The water quality standards apply to man-made alterations and constitute the degree of degradation which may not be exceeded. Because there are no industries, no significant agricultural areas, and no major cities adjacent to the Susitna, Talkeetna, and Chulitna Rivers, the measured levels of these parameters are considered to be a natural condition. Also, these rivers support diverse populations of fish and other aquatic life. Consequently, it is concluded that the parameters exceeding their criteria have little, if any, detrimental effect on aquatic organisms.

(iii) Evaluation of Current Conditions

The results of the analyses indicate the Susitna River is a fastflowing, cold-water stream of the calcium bicarbonate type containing soft to moderately hard water during breakup and in the summer and moderately hard water in the winter. Nutrient concentrations, namely nitrate and orthophosphate, exist in low-to-moderate concentrations. Dissolved oxygen concentrations typically remain high, averaging about 12 mg/l during the summer and 13 mg/l during winter. Percentage saturation of dissolved oxygen always exceeds 80 percent but averages near 100 percent in the summer, and in the winter saturation levels decline slightly from the summer levels. Typically, pH values range between 7 and 8 and exhibit a wider range in the summer compared to the winter. During summer, pH occasionally drops below 7, which is attributed to tundra runoff. True color, also resulting from tundra runoff, displays a wider range during summer than winter.

Color levels in the vicinity of the damsites have been measured as high as 40 color units. Temperature remains at or near 0°C during winter, and the summer maximum is 13°C. Alkalinity concentrations, with bicarbonate as the dominant anion, are low to moderate during summer and moderate to high during winter. The buffering capacity of the river is relatively low on occasion.

The concentrations of many trace elements monitored in the river were low or within the range characteristics of natural waters. However, the concentrations of some trace elements exceeded water quality guidelines for the protection of freshwater aquatic organisms. These concentrations are the result of natural processes because there are no man-induced sources of these elements in the Susitna River Basin.

Concentrations of organic pesticides and herbicides, uranium, and gross alpha radioactivity were either less than their respective detection limits or were below levels considered to be potentially harmful.

It is worthy to note that the range displayed in the figures' pH and color are typical for streams in Alaska receiving tundra runoff. It is not uncommon for pH to be 6.5 (the criterion) or slightly less and color to be as high as 100 color units (the maximum reported herein). It should also be noted that the four highest levels of percentage saturation of dissolved oxygen are probably in error. If these data are eliminated, all the dissolved oxygen percentage saturation values are less than the criterion of 110 percent.

Figures 2.1 through 2.41 depict the result of the analysis for all physical parameters and inorganic and non-metallic parameters. Data summaries for metals which exceeded their criteria are also presented.

(b) Parameters Exceeding Criteria and Aberrant Data

This section presents a summary of the parameters that have exceeded their criteria (Table 2.6), a discussion of aberrant data, and a list of parameters that exhibited values less than their respective detection limits.

A number of parameters listed in Table 2.6, exceeded their respective criteria. The implications of this to freshwater aquatic organisms are related to the rationale behind the criteria and to the fact that the Susitna River is largely unaffected by man's activity.

The identification of aberrant data was considered because of the extreme values manifested by some parameters. The following parameters were suspected of having aberrant data:

(i) D.O. and Saturation

The high values measured at Gold Creek during summer exceeded the criterion. The four highest values measured by R&M (116, 115, 114, and 113 percent saturation) are probably in error because of a faulty barometer and should be eliminated from the data set. R&M's fifth highest value was similar to the USGS's highest values of 106, 104, 103, and 102 percent saturation.

(ii) Free Carbon Dioxide

The five highest values measured by R&M at Gold Creek during summer were 36, 35, 20, 16, and 16 mg/l. The two highest values may be aberrant, but there are no acceptable reasons to eliminate them.

(iii) Ortho-Phosphate

One high value, 0.49 mg/l, measured at Vee Canyon during summer appears unrealistic and should be eliminated. The next highest value was 0.1 mg/l. The high value measured at Talkeetna during breakup may also be unrealistic, but there are no data with which to compare this value, so it should stand.

(iv) Phosphorus

The high value of 0.49 mg/l measured at Vee Canyon during summer is likely to be aberrant because the next highest is 0.1 mg/l. Likewise, a high value of 0.36 mg/l is significantly different from the next highest value of 0.05 mg/l measured at Susitna Station during winter. It is recommended that both of the high values be eliminated.

(v) Turbidity

The five highest turbidity values measured at Susitna Station during summer were 790, 590, 430, 430, and 260 NTU. There is no reason to eliminate any of these values.

(vi) Total Organic Carbon

The four concentrations measured at Gold Creek during winter are 39, 34, 27, and 5.5 mg/l, and one measurement at Vee Canyon during winter was 23 mg/l. Although the four high values appear unrealistic, there is no apparent reason to eliminate them.

(c) Impacts of Susitna Project

Construction of hydroelectric dams and their reservoirs has a profound effect on the water regime of downstream river reaches. Since the rate of reservoir water outflow is controlled, the downstream reach is no longer subject to the fluctuations of a normal river regime with the consequence that the flow generally becomes less variable throughout the year (Turkheim 1975). Under currently proposed operating conditions, the Watana and Devil Canyon dams will significantly affect the average monthly flows at Gold Creek. The minimum flow regime is significantly increased and peak flows are decreased. The decrease in spring flood magnitude, especially during the initial impoundment, may result in negative effects on the downstream environment. It is reasonable to expect that the interference with natural Susitna River flows will cause some changes in streams and branches, adjacent wetlands, and ground water levels for some distance downstream from the dams.

The number of upstream hydrologic effects are few compared to at-reservoir and downstream effects. Due to an aggradation process whereby reservoir waters are backlogged or increased in an upstream direction, the reservoir can increase the amount of evaporation from a river (Turkheim 1975). However, the amount of evaporation from the river will be a small percentage of the total evaporation from the Watana and Devil Canyon reservoirs which will in itself be insignificant.

The principal impacts requiring consideration relate to sedimentation, temperature, dissolved oxygen, dissolved solids, and dissolved nitrogen.

(i) Turbidity and Sedimentation

When a turbulent, sediment-laden stream such as the Susitna River enters a reservoir, quiescent conditions will allow much of the material to settle to the bottom. Weiss and Love substantiate the reduction of turbidity by impoundment of sediment-laden waters in reservoirs (Weiss, Francisco, and Lenat 1973; Simmons 1972; Love 1961). According to reservoir sedimentation studies, 95-100 percent of sediment entering Watana reservoir would settle, even shortly after filling of the reservoir starts. The Devil Canyon reservoir would have a slightly lower trap efficiency than Watana due to its smaller volume. However, most sediment will be deposited in Watana, the upstream reservoir. Turbidity levels and suspended solids concentration downstream from the reservoir will decrease sharply during the summer months due to the sediment trapping characteristics of the reservoirs. It is likely that the turbidity of water released during winter will be substantially reduced from summer conditions as suspended sediment in near-surface waters should rapidly settle once the reservoir ice cover forms and essentially quiescent conditions occur.

Sedimentation affects other water quality parameters besides turbidity and suspended solids. Color (Drachev 1962), particulate phosphorus (Wright, Soltero 1973), dead microorganisms such as plankton and algae (Erickson, Reynolds 1969), and precipitated chemicals (Mortimer 1941; Mortimer 1942) are removed in the sedimentation process. Consequently, color levels and total phosphorus concentrations ought to be reduced in and downstream from the reservoir. Metal concentrations, such as iron, manganese, and some of the trace elements, will also be reduced as they are precipitated and settled to the bottom. Leaching under anaerobic conditions will cause some of these compounds to redissolve into the water near the reservoir bottom. However, if the deposited material is inorganic, it can form a mat on the reservoir bottom, thereby effectively blocking leachate from entering the water column (Nech 1967). This is expected to occur in the Watana reservoir but is likely to be a minor factor in the Devil Canyon reservoir.

(ii) Temperature

The range and seasonal variation in temperature of the Susitna River will change after impoundment. An impoundment study revealed that the reservoir not only reduced the magnitude of variation in temperature but also changed the time period of the high and low temperatures (Bolke and Waddell 1975). This will also be the case for the Susitna River, where pre-project temperatures generally range from 0°C to 13°C with the lows occurring in October/November through March/April and the highs in July or August. After closure, the temperature range will be reduced and low temperatures will occur in November through March. The period of highest temperature will be July and August, as is the pre-project case. Reservoirs releasing water from the surface are "heat exporter" reservoirs (Turkheim 1975), and both Susitna River reservoirs fall into this category.

(iii) Dissolved Oxygen

Thermal stratification is not likely to occur in either reservoir, but a temperature gradient will exist. It is expected that vertical mixing will occur in the spring as a result of the large input of water, wind effects, and surface water warming. This will result in the transport of oxygen from the surface, where reaeration occurs, throughout the top 60 to 100 feet of the reservoir, where biologic and chemical processes use oxygen.

(iv) Dissolved Solids

Anaerobic bottom conditions can harm aquatic life and cause the reduction and release of undesirable chemicals into the water (Fish 1959). The leaching process which is more efficient under anaerobic conditions, degrades bottom water quality by releasing such chemicals as alkalinity, iron, manganese (Symons 1969), hydrogen sulfide, and nutrients (Turkheim 1975). Also, leaching problems become more severe as the organic content in the soils increases. The potential for leaching at the Watana reservoir should decline in time as the inorganic, glacial sediment carried in by the river settles and blankets the reservoir bottom. The products of leaching are not anticipated to be abundant enough to affect more than a small layer of water near the reservoir bottoms. Also, leaching products will not degrade downstream water quality over the long-term because water will be released at or near the surface. A shortterm increase in dissolved solids, conductivity, and most of the major ions may be evident immediately after closure of the dam. Other reservoir studies have shown that the highest concentration of all major ions, except magnesium, occurred immediately after impoundment (Bolke and Waddell 1975). The increase in concentration was attributed to the initial inundation and leaching of rocks and soils in the reservoir area.

Although evaporation has been noted to cause the dissolved solids concentrations to increase (Symons 1969; Love 1961), this potential effect on water quality at the Watana and Devil Canyon reservoirs is not significant. The average annual evaporation predicted for May through September at Watana is 10.0 inches; at Devil Canyon it is 11.1 inches. There is no evaporation during the period of ice cover from October through April. The percentage of the reservoirs lost to evaporation during summer will be 0.3 percent at Watana and 0.6 percent at Devil Canyon. A less than 1 percent increase in concentration of most water quality parameters is not significant. Local effects may be noted from evaporation and sublimation may cause some water loss creating local effects. These are not anticipated to be significant.

Both Watana and Devil Canyon reservoirs will release water from at or near the surface and therefore have the potential to become nutrient traps, resulting in eutraphic conditions. The major criteria for eutrophiation to occur include nutrient concentrations, algae populations, solar radiation and the effects of reservoir processes.

(v) Dissolved Nitrogen

The critical concentration of nitrogen in a lake at the begining of the growing season above which excessive algae blooms may be expected to occur is 0.2 - 0.3 mg/l when phosphorus concentrations are from 0.01 to 0.02 mg/l (Mackenthun 1960). Phosphorus is reported to be the controlling nutrient and blooms could be expected if the level exceeded 0.01 mg/l (Symons 1969). The pre-project concentrations of nitrogen and phosphorus measured at Vee Canyon, upstream from the proposed reservoir locations, have exceeded the critical concentration levels cited above. These critical concentration levels were developed from work done in temperate regions, and may not be applicable in the subarctic. In a study of the nutrient chemistry of a large, deep subarctic lake, nitrogen and phosphorus concentration were similar to those measured at Vee Canyon (LaPerrerie, Tilsworth, and Casper 1978). The lake studied was not eutrophic, and the peak algal biomass and productivity occurred under the spring ice rather than in the summer. It was also predicted that a large number of cottages could be added around the lake without euthrophic conditions developing. Based on this work, it is likely that Watana and Devil Canyon reservoirs will be mesotrophic to oligotrophic, providing sufficient nutrients for fish life, but not so much as to become eutrophic.

Nitrogen supersaturation of water below a dam is possible at certain seasons, extending an unknown distance downstream (Turkheim 1975). This is certainly a possibility below both dams. However, the ultimate impact of nitrogen supersaturation is its effect on fish. Nitrogen supersaturation problems will be solved structurally through the use of fixed-cone valves, to dispense discharged flows, thereby eliminating plunging spills up to the 1:50-year flood. Portage Creek is essentially the upstream limit for spawning salmon. Consequently, water supersaturated with nitrogen leaving the dams must travel through Devil Canyon before reaching an important fisheries area. It is reasonable to expect that post-project nitrogen supersaturation levels will be the same as the pre-project levels at the downstream end of Devil Canyon.

(vi) Summary

Impoundment of the Susitna River will change its water quality. The following parameters will exhibit reductions in values in the reservoir and downstream reaches as compared to the pre-project levels: suspended solids, turbidity, color, nutrients, iron, manganese, and some trace elements. Both reservoirs will be heat exporters and the downstream reaches of the river will exhibit a reduced magnitude of seasonal temperature variation. Dissolved oxygen concentrations will remain high, at or near saturation, in the upper levels of both reservoirs and downstream in the river. Dissolved oxygen concentrations will likely be reduced in the hypolimnion if a stable stratification develops. The potential for eutrophication to develop in either reservoir is low.

Although water quality changes will be effected by the project, none of these changes will be significantly adverse, and many changes may be beneficial. A possible exception to this is the downstream temperature change.

TABLE 2.1: SUSITNA TOWNSHIP GRID

TYPE	SURFACE WATER APPROPRIATIONS cfs	gpd	ac-ft/yr	DAYS OF USE	GROUND WATER APPROPRIATIONS cfs	gpd	ac-ft/yr	DAYS OF USE
Certificates								
Single-family dwelling		4,500		365		5,440		365
		75		214				
2 to 4 unit housing						1,200		365
Grade Schools						910		334
Fire protection						500		365
Animals		63.5		365		94		365
Lawn and garden irrigation		200		184				
		100		153			.5	60
General Crops			12.5	153			5.5	91
Total		4,938.5	12.5			8,144	6.0	
Permits								
Single-family dwelling		250		365				
Vegetables			1	153				
Total		250	1					
Pending								
Single-family dwelling		75		365		1,000		365
						250		214
Lawn and garden irrigation		50		183				
Placer gold	.1			184				
Total	.1	125				1,250		
TOTAL	.1	5,313.5	13.5			9,394	6.0	

TABLE 2.2: SUMMARY OF WATER APPROPRIATION*

TOWNSHIP GRID	SURFACE WATER EQUIVALENT		GROUND WATER EQUIVALENT	
	cfs	ac-ft/yr	cfs	ac-ft/yr
Susitna	.153	50.0	.0498	16.3
Fish Creek	.000116	.021	.003	2.24
Willow Creek	18.3	5,660	.153	128
Little Willow Creek	.00613	1.42	.00190	1.37
Montana Creek	.0196	7.85	.366	264
Chulina	.00322	.797	.000831	.601
Susitna Reservoir	.00465	3.36		
Chulitna			.00329	2.38
Kroto-Trapper Creek	.0564	10.7		
Kahiltna	125	37,000		
Yentna	.00155	.565		
Skwentna	.00551	1.90	.000775	5.60

* Figures from Table 2.1 all converted to cfs and ac-ft/yr equivalents as follows:

1 gpd = .00000155 cfs
1 cfs = 1.98 ac-ft/day

TABLE 2.3: WATER APPROPRIATIONS WITHIN ONE MILE OF THE SUSITNA RIVER

LOCATION*	ADDITIONAL NUMBER	TYPE	SOURCE (DEPTH)	AMOUNT	DAYS OF USE
CERTIFICATE					
T19N R5W	45156	Single-family dwelling	well (?)	650 gpd	365
		general crops	same source	.5 ac-ft/yr	91
T25N R5W	43981	Single-family dwelling	well (90 ft)	500 gpd	365
T26N R5W	78895	Single-family dwelling	well (20 ft)	500 gpd	365
	200540	Grade school	well (27 ft)	910 gpd	334
	209233	Fire station	well (34 ft)	500 gpd	365
T27N R5W	200180	Single-family dwelling	unnamed stream	200 gpd	365
		Lawn & garden irrigation	same source	100 gpd	153
	200515	Single-family dwelling	unnamed lake	500 gpd	365
	206633	Single-family dwelling	unnamed lake	75 gpd	365
	206930	Single-family dwelling	unnamed lake	250 gpd	365
	206931	Single-family dwelling	unnamed lake	250 gpd	365
PERMIT					
	206929	General crops	unnamed creek	1 ac-ft/yr	153
T30N R3W	206735	Single-family dwelling	unnamed stream	250 gpd	365
PENDING					
	209866	Single-family dwelling	Sherman Creek	75 gpd	365
		Lawn & garden irrigation	same source	50 gpd	183

*All locations are within the Seward Meridian.

TABLE 2.4: BASIN AND RUNOFF CHARACTERISTICS

	Watana*	Devil Canyon*	Gold Creek**
Drainage Area, Mi^2	5,180	5,810	6,160
Average Annual Flow, cfs	7,860	8,960	9,647
Maximum Average Monthly Flow, cfs	23,100	26,200	27,900
Minimum Average Monthly Flow, cfs	890	1,030	1,100

*Data supplied by Steve Bredthauer, R&M Consultants, Inc.
**USGS 1981

TABLE 2.5: DETECTION LIMITS FOR WATER QUALITY PARAMETERS

	R&M Detection Limit[1]	U.S.G.S Detection Limit[5]
Field Parameters		
Dissolved Oxygen	0.1	-
Percent Saturation	1	-
pH, pH Units	±0.01	-
Conductivity, umhos/cm @ 25°C	1	-
Temperature, °C	0.1	-
Free Carbon Dioxide	1	-
Alkalinity, as $CaCO_3$	2	-
Settleable Solids, ml/l	0.1	-
Laboratory Parameters		
Ammonia Nitrogen	0.05	.01
Organic Nitrogen	0.1	-
Kjeldahl Nitrogen	0.1	.1
Nitrate Nitrogen	0.1	.01
Nitrite Nitrogen	0.01	.01
Total Nitrogen	0.1	.01
Ortho-Phosphate	0.01	.01
Total Phosphorus	0.01	.01
Chemical Oxygen Demand	1	-
Chloride	0.2	.01
Color	1	1
Hardness	1	-
Sulfate	1	.05
Total Dissolved Solids[2]	1	1
Total Suspended Solids[3]	1	1
Turbidity	0.05	1
Uranium	0.075	-
Gross Alpha, picocurie/liter	3	-
Total Organic Carbon	1.0	-
Total Inorganic Carbon	1.0	-
Organic Chemicals		
- Endrin	0.0002	.00001
- Lindane	0.004	.00001
- Methoxychlor	0.1	.00001
- Toxaphene	0.005	.001
- 2, 4-D	0.1	.00001
- 2, 4, 5-TP Silvex	0.01	.00001
ICAP Scan[4]		
- Ag, Silver	0.05	.001
- Al, Aluminum	0.05	.01
- As, Arsenic	0.10	.001
- Au, Gold	0.05	-
- B, Boron	0.05	.01
- Ba, Barium	0.05	.1
- Bi, Bismuth	0.05	-
- Ca, Calcium	0.05	.01
- Cd, Cadmium	0.01	.001
- Co, Cobalt	0.05	.001
- Cr, Chromium	0.05	.001

TABLE 2.5: DETECTION LIMITS FOR WATER QUALITY PARAMETERS (Cont'd)

	R&M Detection Limit(1)	U.S.G.S Detection Limit(5)
Laboratory Parameters (Cont'd)		
- Cu, Copper	0.05	.001
- Fe, Iron	0.05	.01
- Hg, Mercury	0.1	.0001
- K, Potassium	0.05	.1
- Mg, Magnesium	0.05	.1
- Mn, Manganese	0.05	.001
- Mo, Molybdenum	0.05	.001
- Na, Sodium	0.05	.1
- Ni, Nickel	0.05	.001
- Pb, Lead	0.05	.001
- Pt, Platinum	0.05	-
- Sb, Antimony	0.10	.001
- Se, Selenium	0.10	.001
- Si, Silicon	0.05	-
- Sn, Tin	0.10	.1
- Sr, Strontium	0.05	.01
- Ti, Titanium	0.05	-
- W, Tungsten	1.0	-
- V, Vanadium	0.05	-
- Zn, Zinc	0.05	.01
- Zr, Zirconium	0.05	-

(1) All values are expressed in mg/l unless otherwise noted.

(2) TDS - (filterable) material that passes through a standard glass fiber filter and remains after evaporation (SM p 93).

(3) TSS - (nonfilterable) material required on a standard glass fiber filter after filtration of a well-mixed sample.

(4) ICAP SCAN - thirty two (32) element computerized scan in parts/million (Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Pt, Sb, Se, Si, Sn, Sr, Ti, V, W, Zn, Zr).

(5) U.S.G.S detection limits are taken from "1982 Water Quality Laboratory Services Catalog" U.S.G.S. Open-File Report 81-1016. The limits used are the limits for the most precise test available.

TABLE 2.6: PARAMETERS EXCEEDING CRITERIA BY STATION AND SEASON

PARAMETER	STATION	SEASON	CRITERIA
D.O. % Saturation	G	S	L
pH	T G	S, W, B B	L
Color	T, S	S	L
Phosphorus, Total (d)	V, G, T, S, SS	S, W, B	L
Total Organic Carbon	G, SS V, G, SS SS	S W B	S
Aluminum (d) Aluminum (t)	V, G G, S, SS	S, W S	S
Bismuth (d)	V, G G	S W	S
Cadmium (d)	T, SS SS	S, W B	L
Cadmium (t)	G, T, S SS T, SS	S W, B	
Copper (d)	T, SS T SS	S W B	A
Copper (t)	G, T, S, SS T, S, SS T, SS	S W	
Iron (d) Iron (t)	D, V, C G, T, S, SS T	S S B	L
Lead (t)	G, T, S, SS T, SS	S W, B	A
Manganese (d) Manganese (t)	D, V, G, C G, T, S T, SS	S S B	L
Mercury (d)	G, S S	S W	L
Mercury (t)	G, T, S, SS T, S, SS T, SS	S W B	
Nickel (t)	G, S, SS	S	A
Zinc (d) Zinc (t)	V G, S, SS T, S, SS SS	S S W B	A

Stations

D - Denali
V - Vee Canyon
G - Gold Creek
C - Chulitna
T - Talkeetna
S - Sunshine
SS - Susitna Station

Seasons

S - Summer
W - Winter
B - Breakup

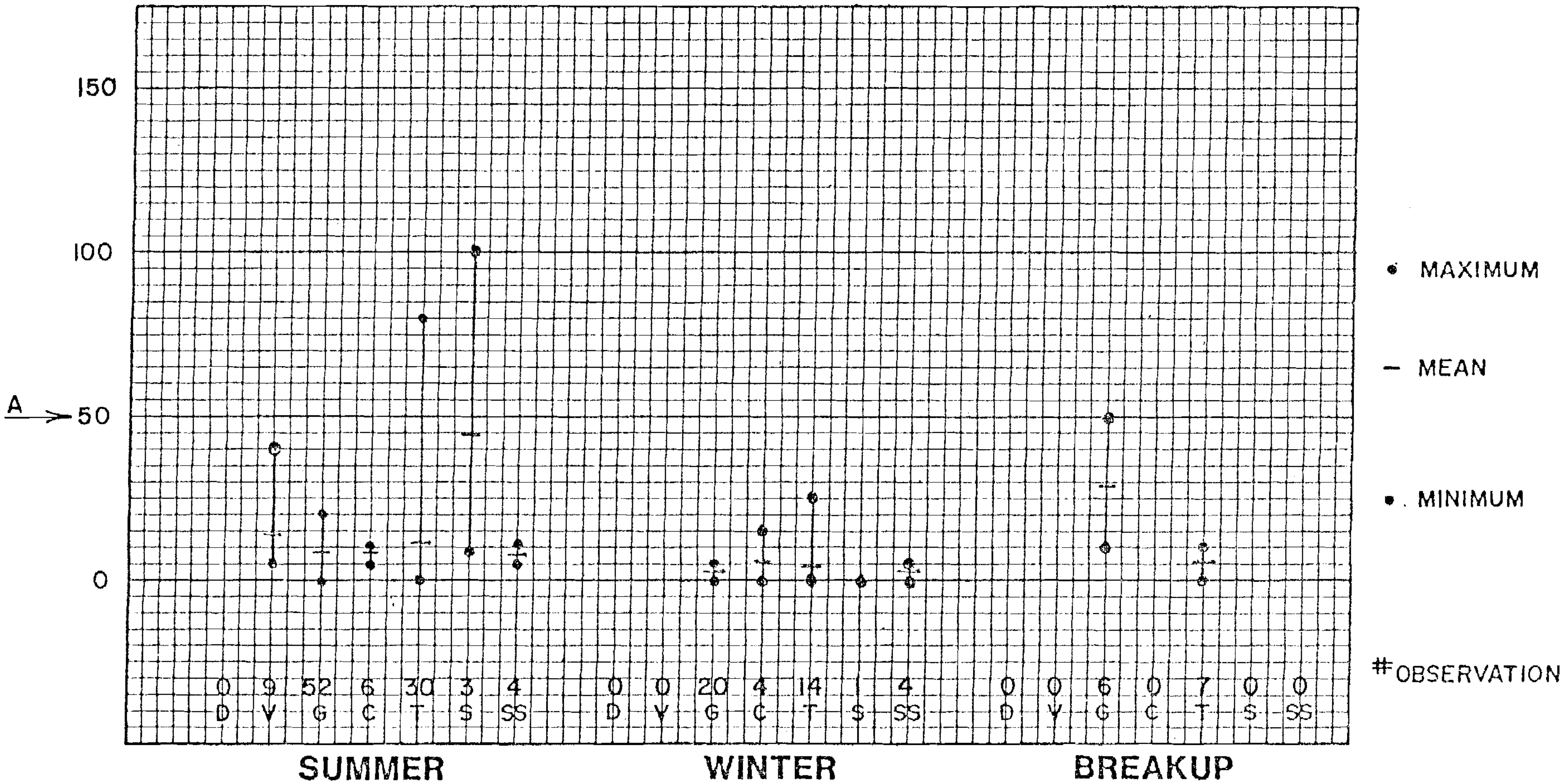
Criteria

L - Established by law as per Alaska Water Quality Standards

S - Criteria that have been suggested but are now law, or levels which natural waters usually do not exceed

A - Alternate level to 0.02 of the 96-hour LC_{50} determined through bioassay

PARAMETER: TRUE COLOR, PLATINUM COBALT UNIT



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

Shall not exceed 50 units (ADEC, 1979)

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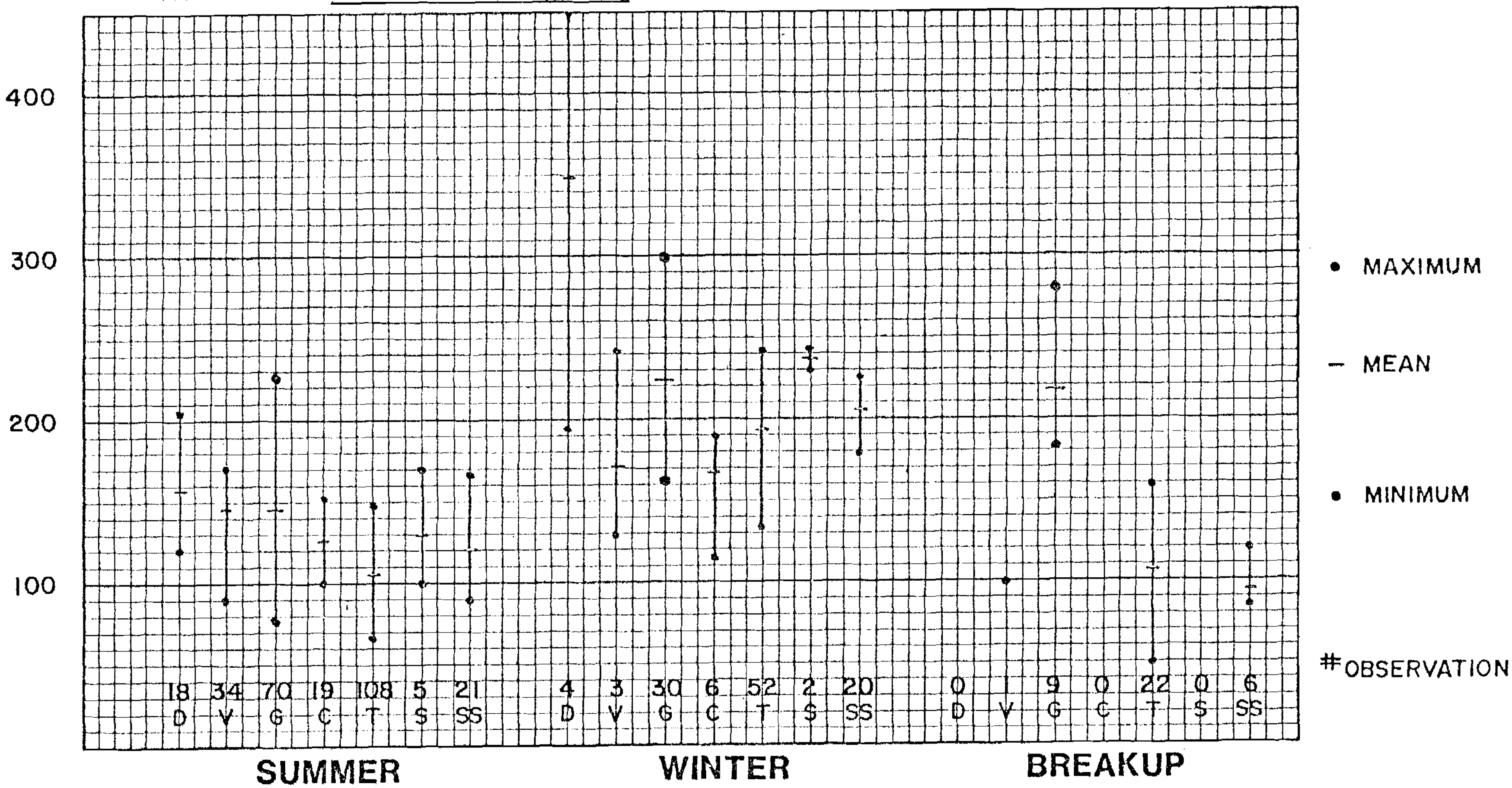
DATA SUMMARY - COLOR

FIGURE 2.1

PARAMETER: CONDUCTIVITY, μmhos/cm @ 25°C



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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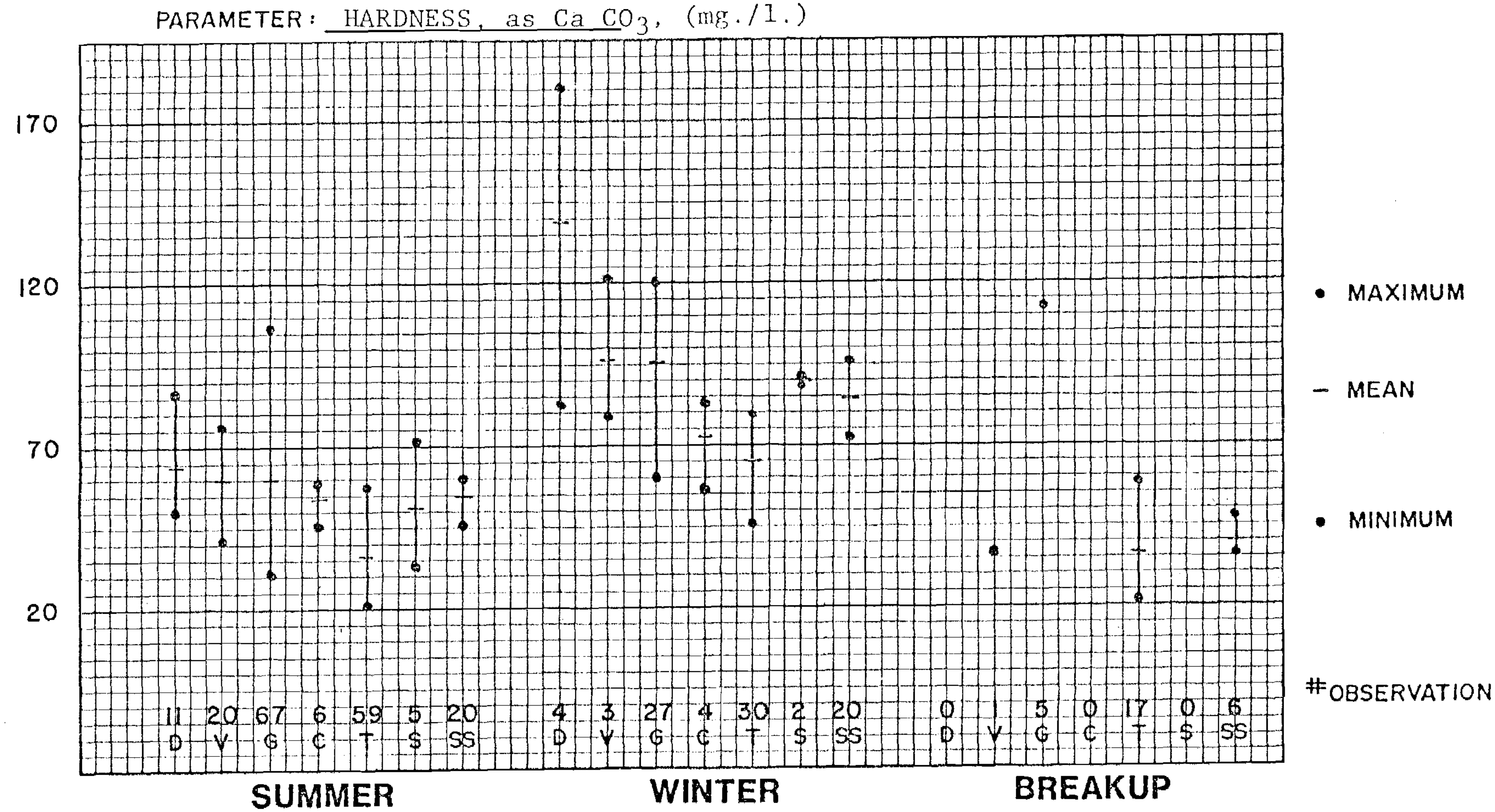
DATA SUMMARY - CONDUCTIVITY

FIGURE 2.2



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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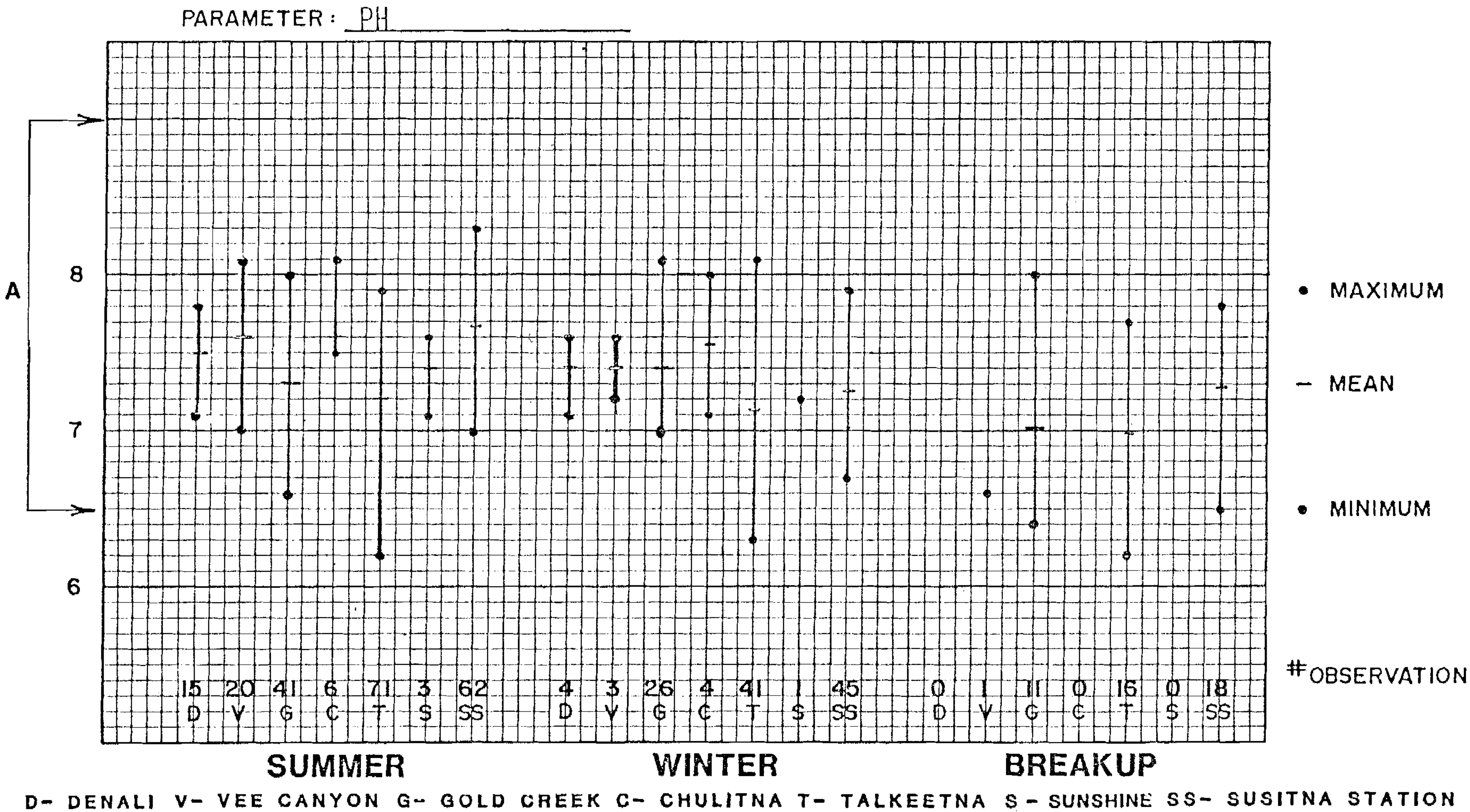
DATA SUMMARY - HARDNESS

FIGURE 2.3



A. Not less than 6.5 or greater than 9.0. Shall not vary more than 0.5 pH unit from natural condition (ADEC, 1979).

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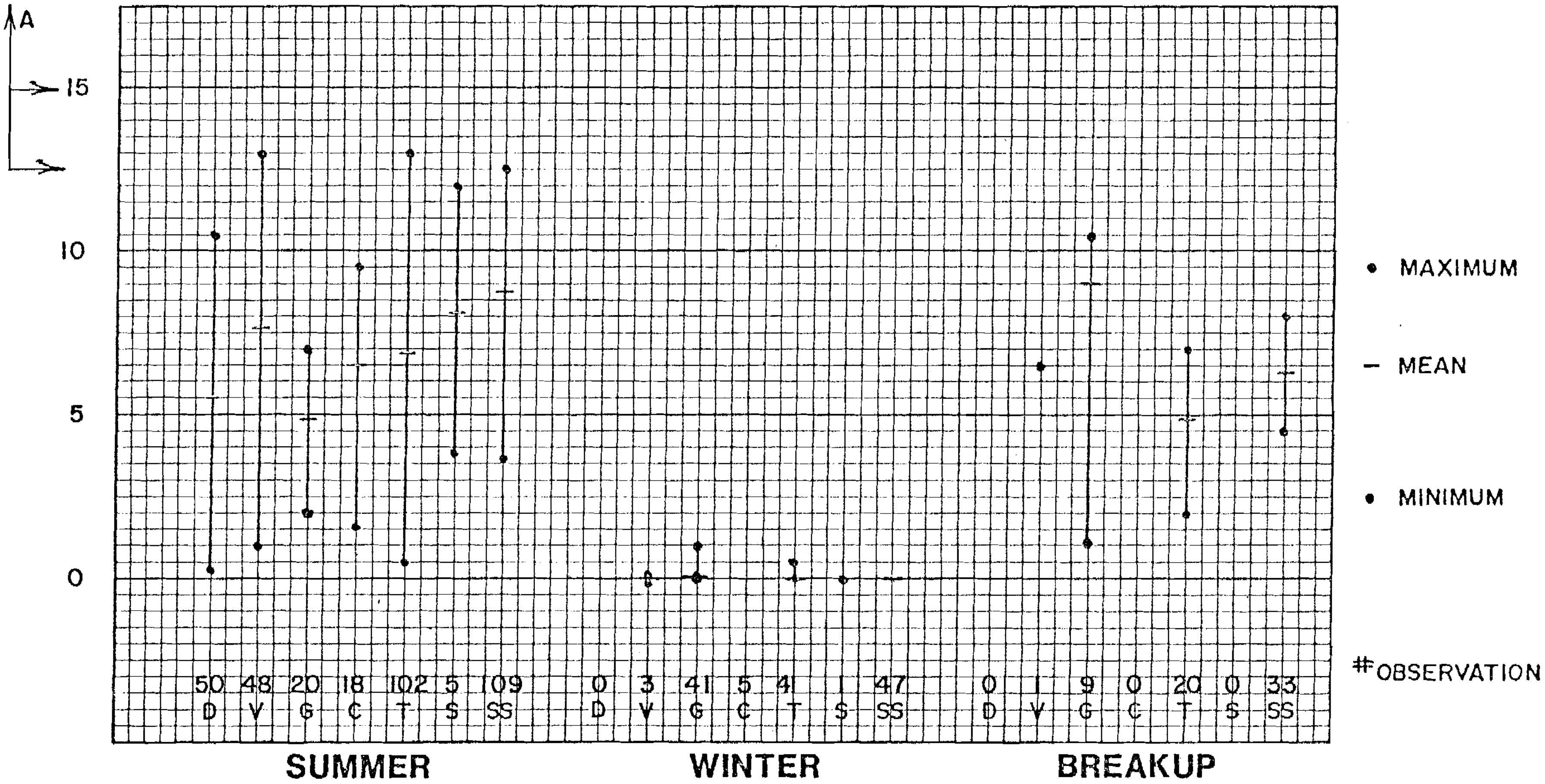
DATA SUMMARY - PH

FIGURE 2.4

PARAMETER: TEMPERATURE, °C



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Shall not exceed 20°C at any time. The following maximum temperature shall not be exceeded where applicable: migration routes and rearing areas--15°C, spawning areas and egg and fry incubation--13°C (ADEC,1979)

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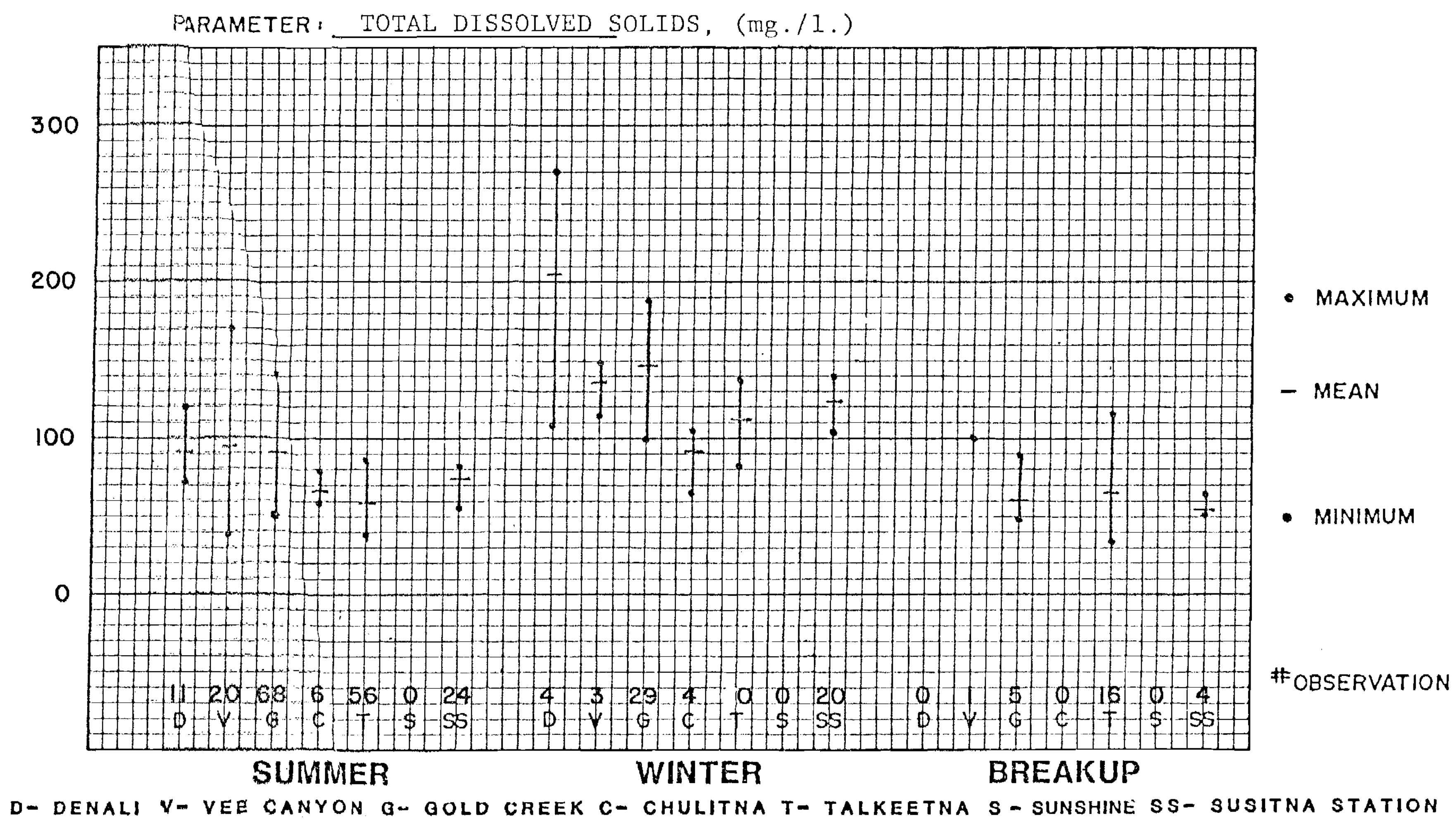
DATA SUMMARY -TEMPERATURE

FIGURE 2.5



A. 1,500 mg/1 (ADEC, 1979)

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DATA SUMMARY - TOTAL DISSOLVED SOLIDS

FIGURE 2.6

PARAMETER: TOTAL SUSPENDED SOLIDS, (mg./l.)

D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No measurable increase above natural conditions (ADEC,1979).

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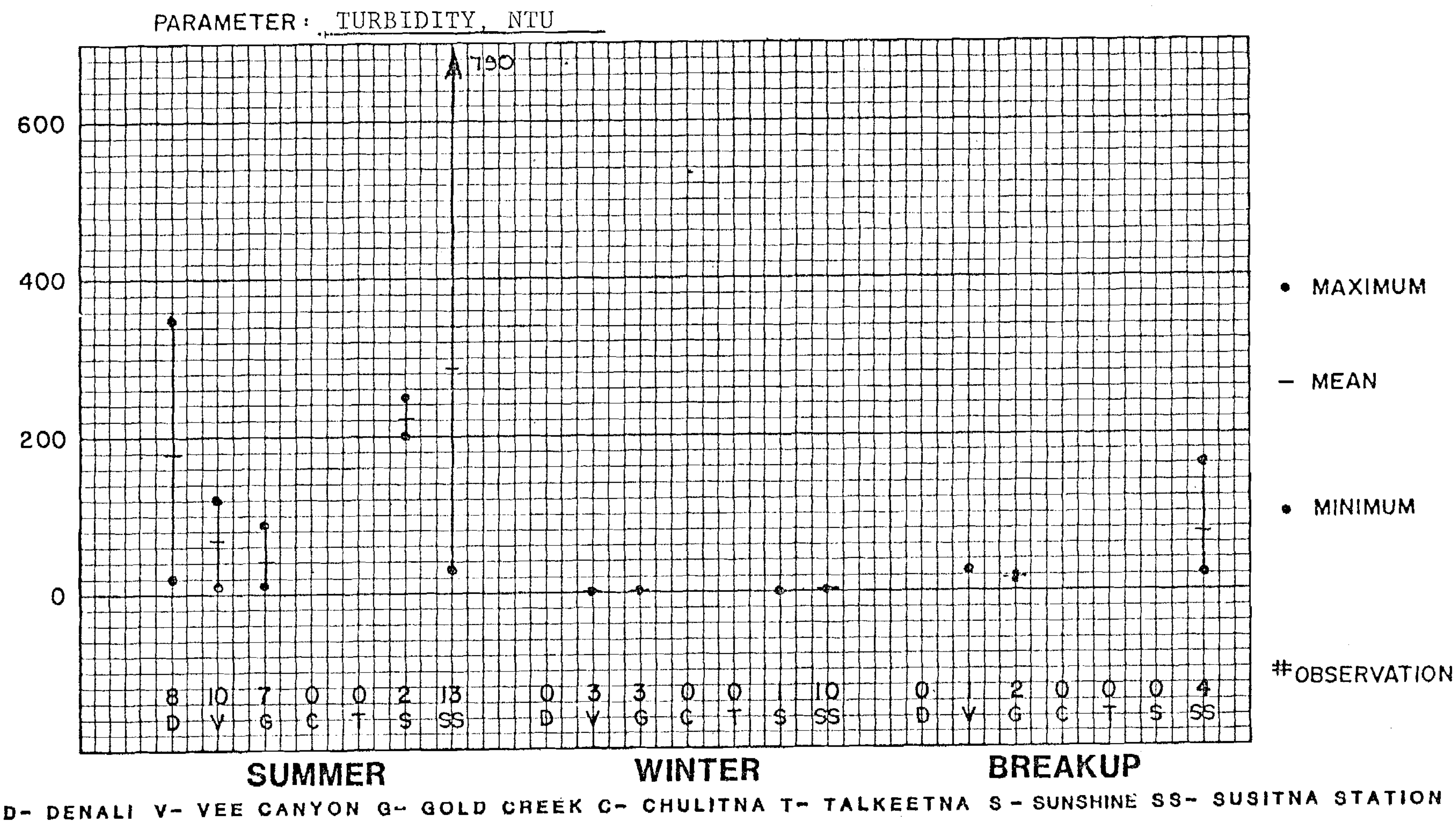
DATA SUMMARY - TOTAL SUSPENDED SOLIDS

FIGURE 2.7



Shall not exceed 25 NTU above natural conditions (ADEC, 1979)

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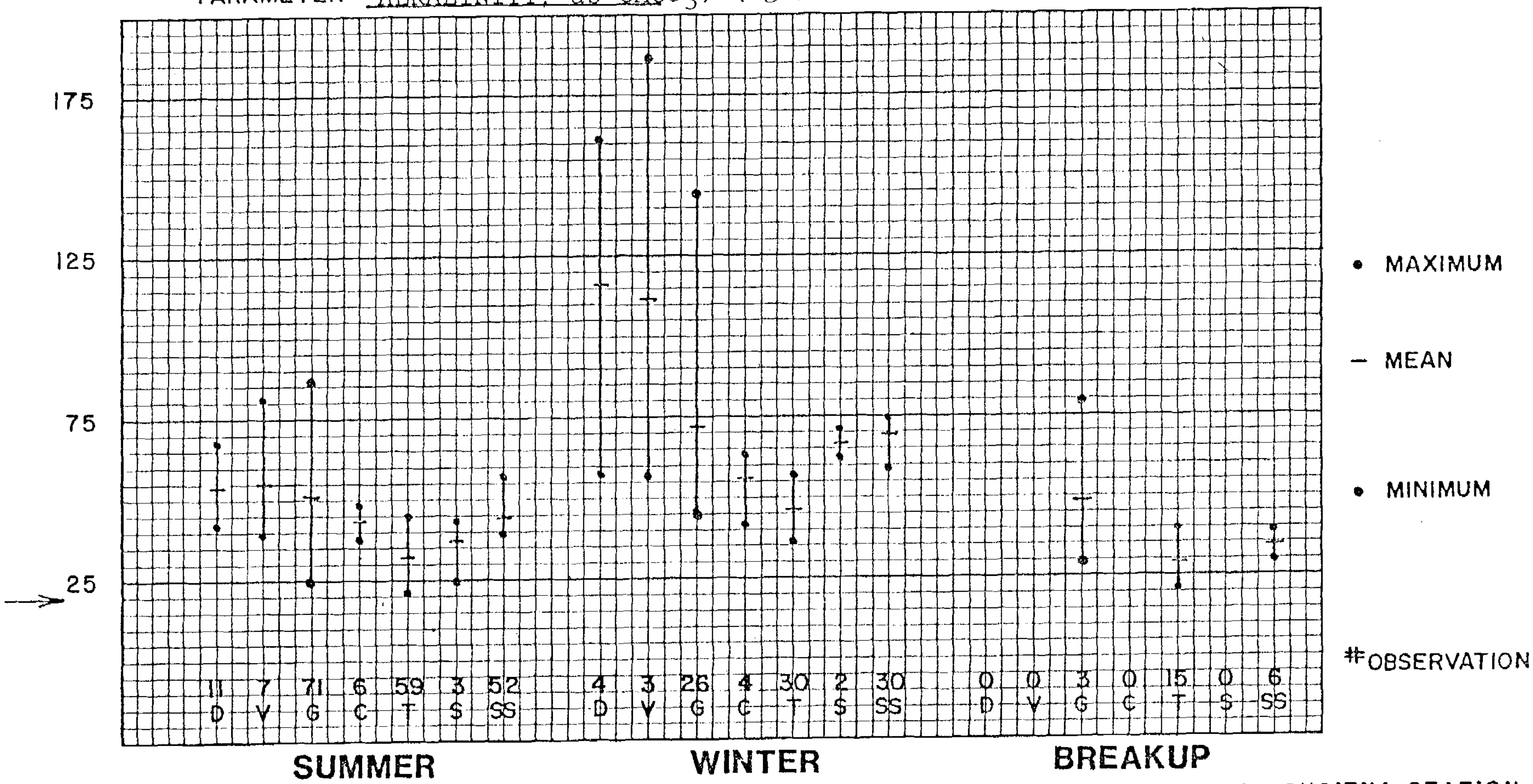
DATA SUMMARY - TURBIDITY

FIGURE 2.8

PARAMETER: ALKALINITY, as $CaCO_3$, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

20mg/l or more except where natural conditions are less. (EPA, 1976).

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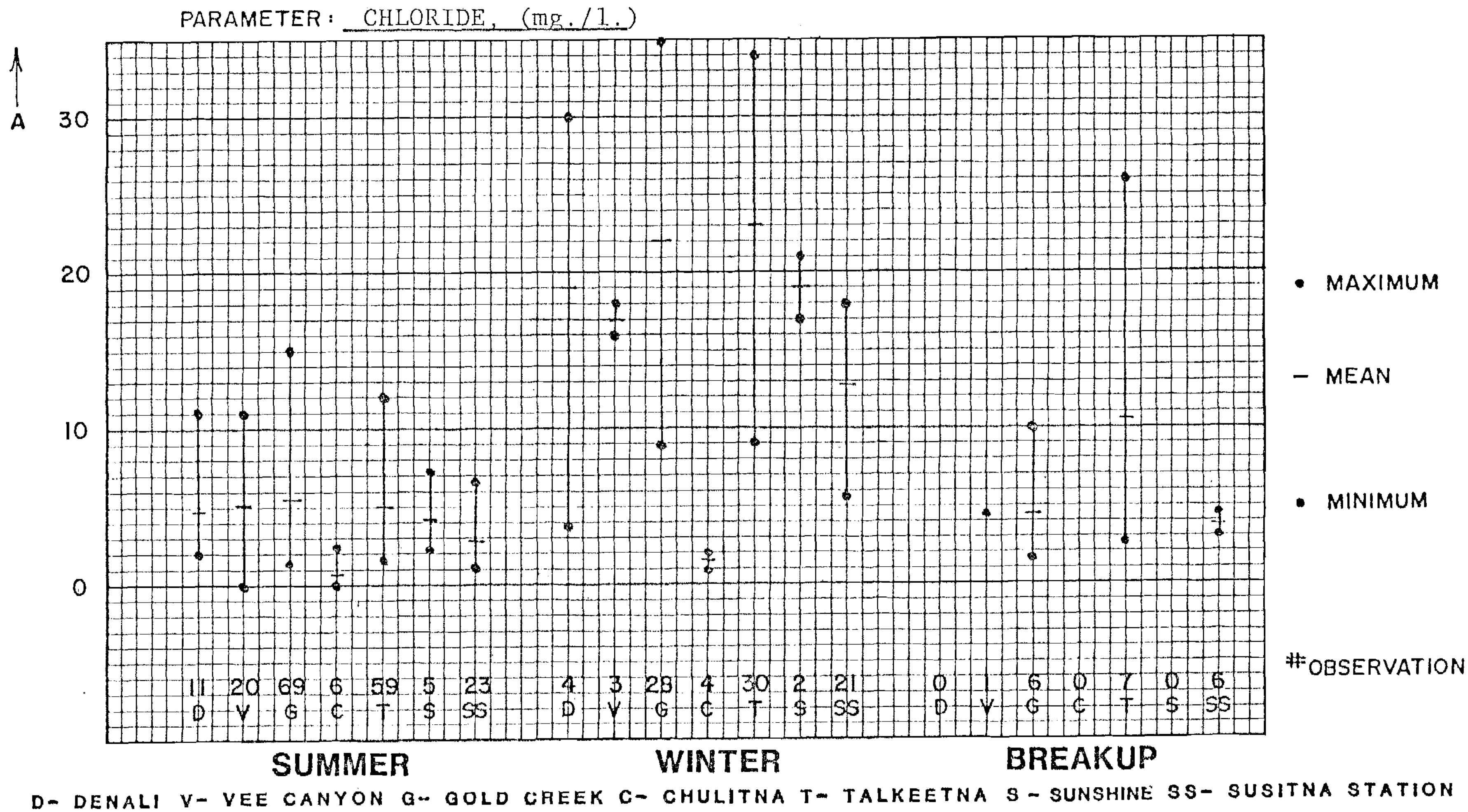
DATA SUMMARY - ALKALINITY

FIGURE 2.9



Less than 200 mg/l (ADEC, 1979)

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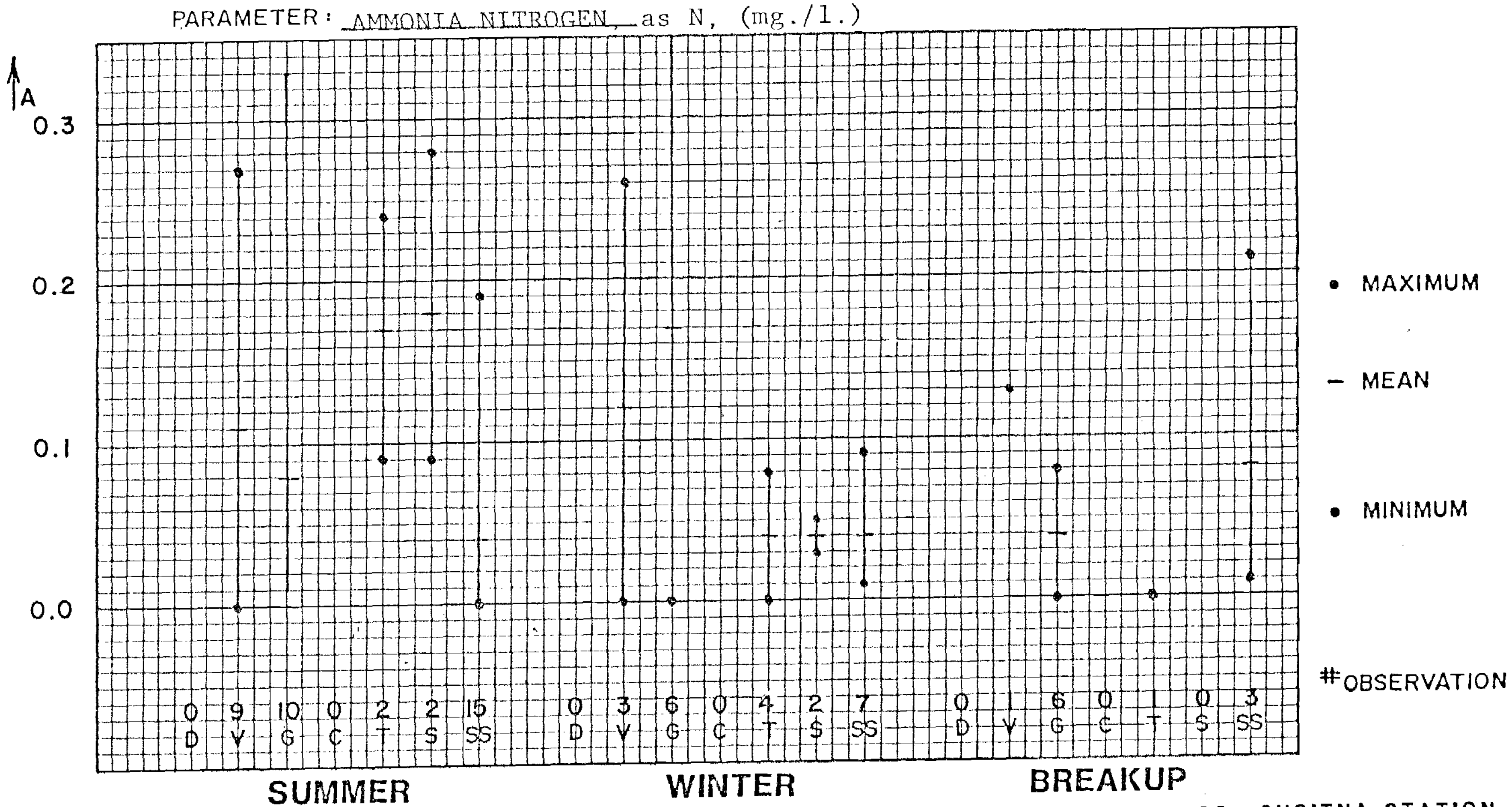
DATA SUMMARY - CHLORIDE

FIGURE 2.10



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.02mg/l as un-ionized ammonia (EPA, 1976). Data appearing above are total dissolved ammonia. The concentration of un-ionized ammonia is pH and temperature dependant. The maximum ammonia nitrogen concentration appearing in this figure is less than the stated criterion.

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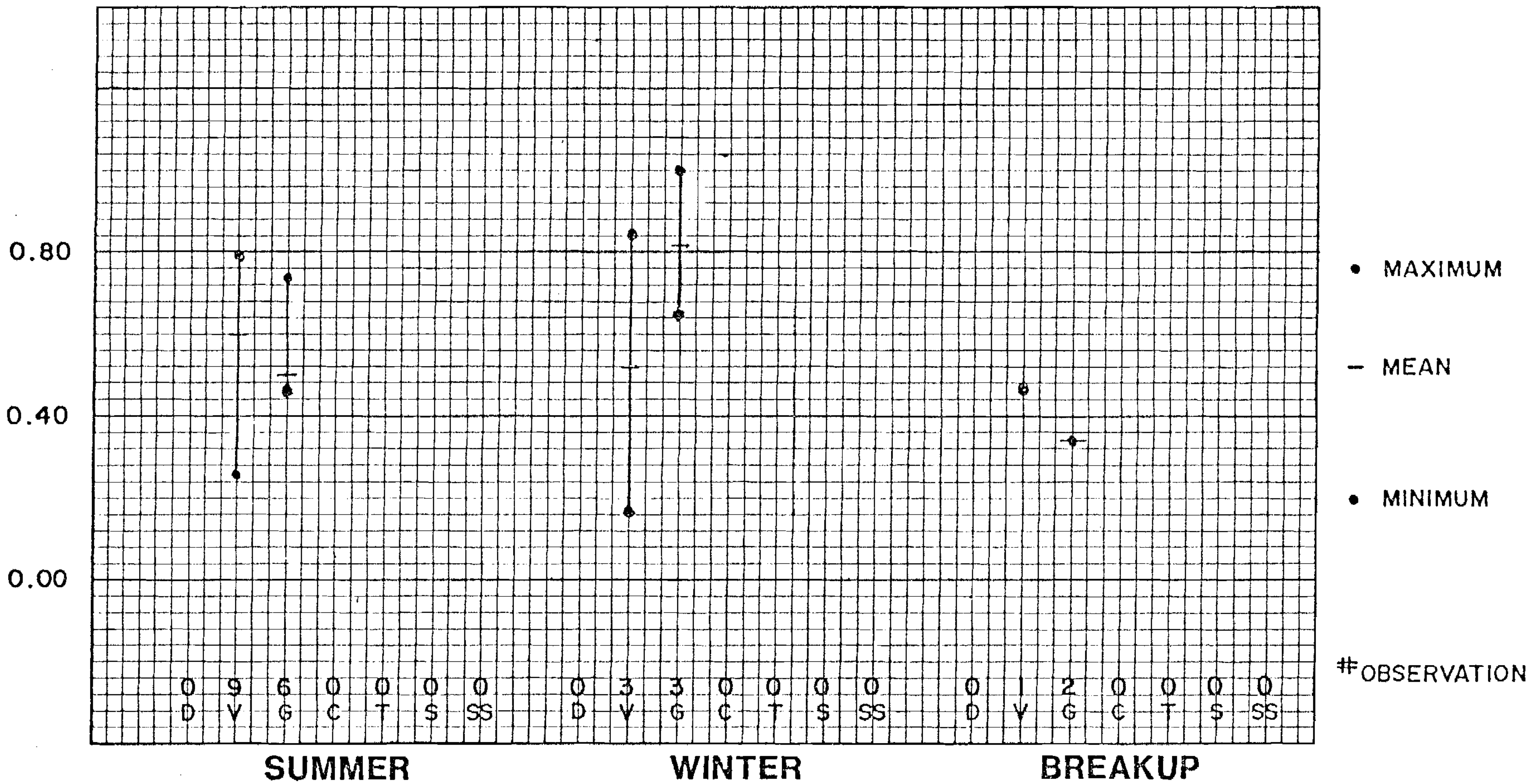
DATA SUMMARY - AMMONIA NITROGEN

FIGURE 2.11

PARAMETER: KJELDAHL NITROGEN, as N, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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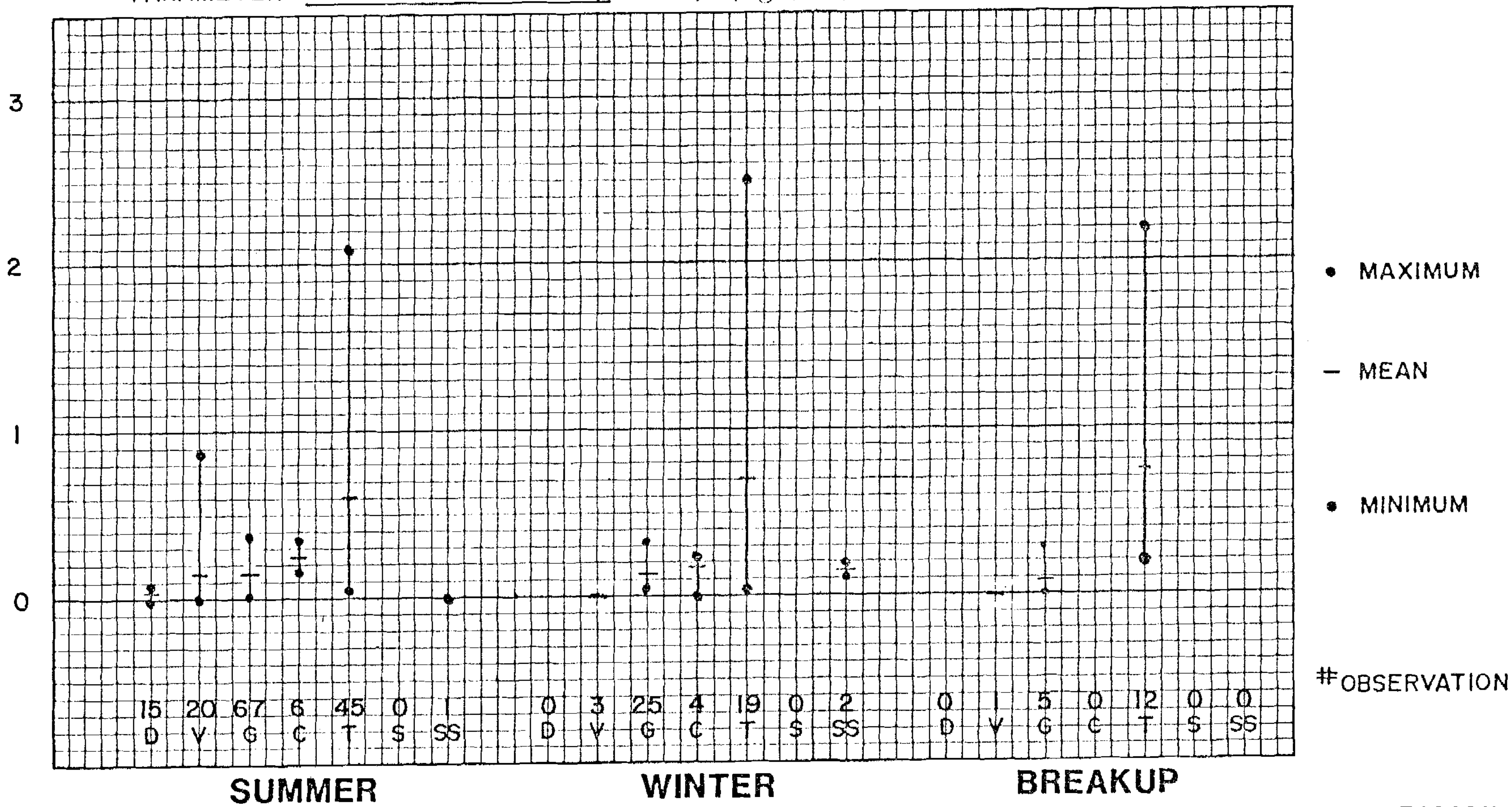
DATA SUMMARY - KJELDAHL NITROGEN

FIGURE 2.12

PARAMETER: NITRATE NITROGEN, as N, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

Less than 10 mg/l (water supply). (EPA, 1976).

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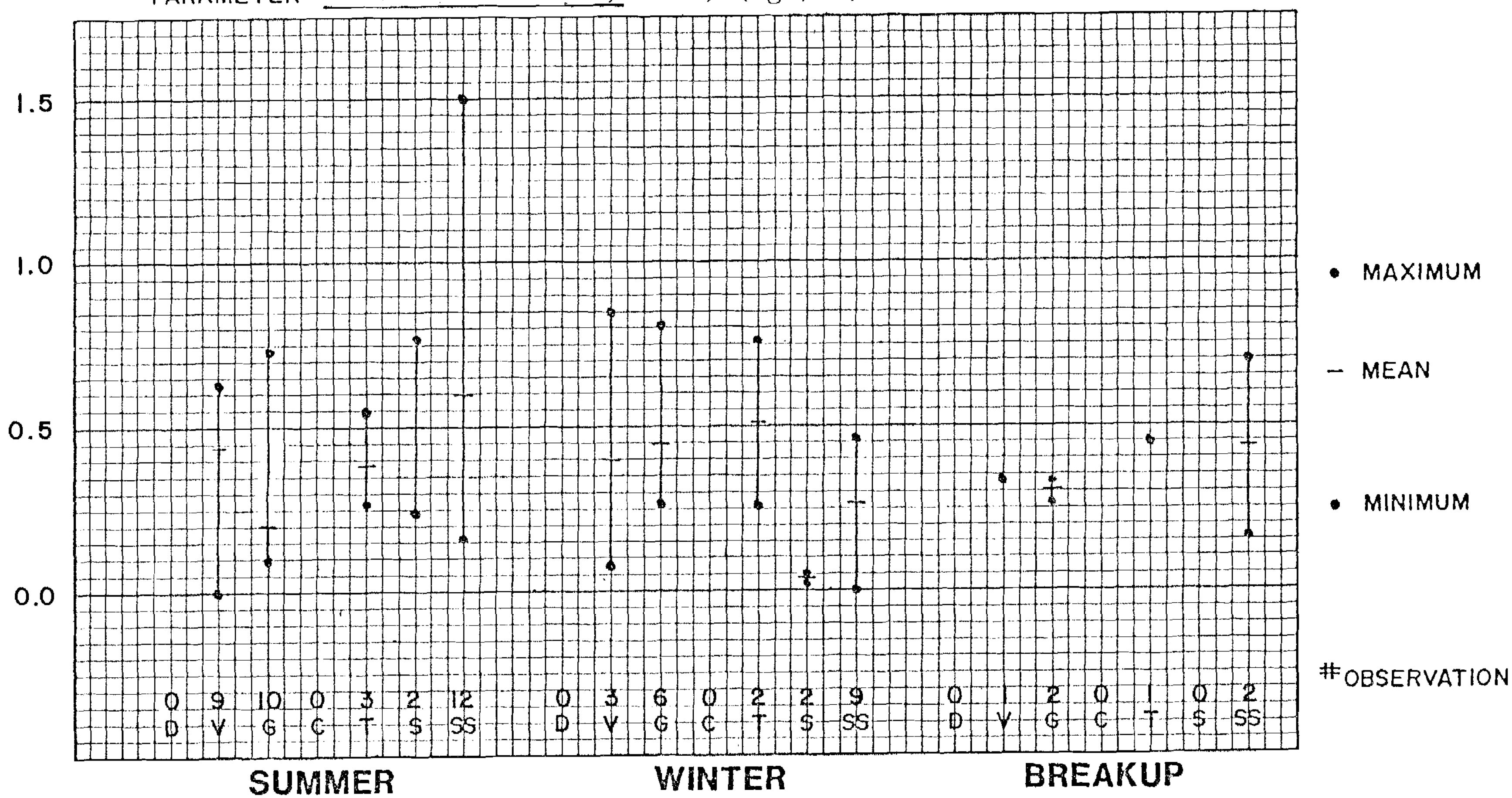
DATA SUMMARY - NITRATE NITROGEN

FIGURE 2.13

PARAMETER: ORGANIC NITROGEN, as N, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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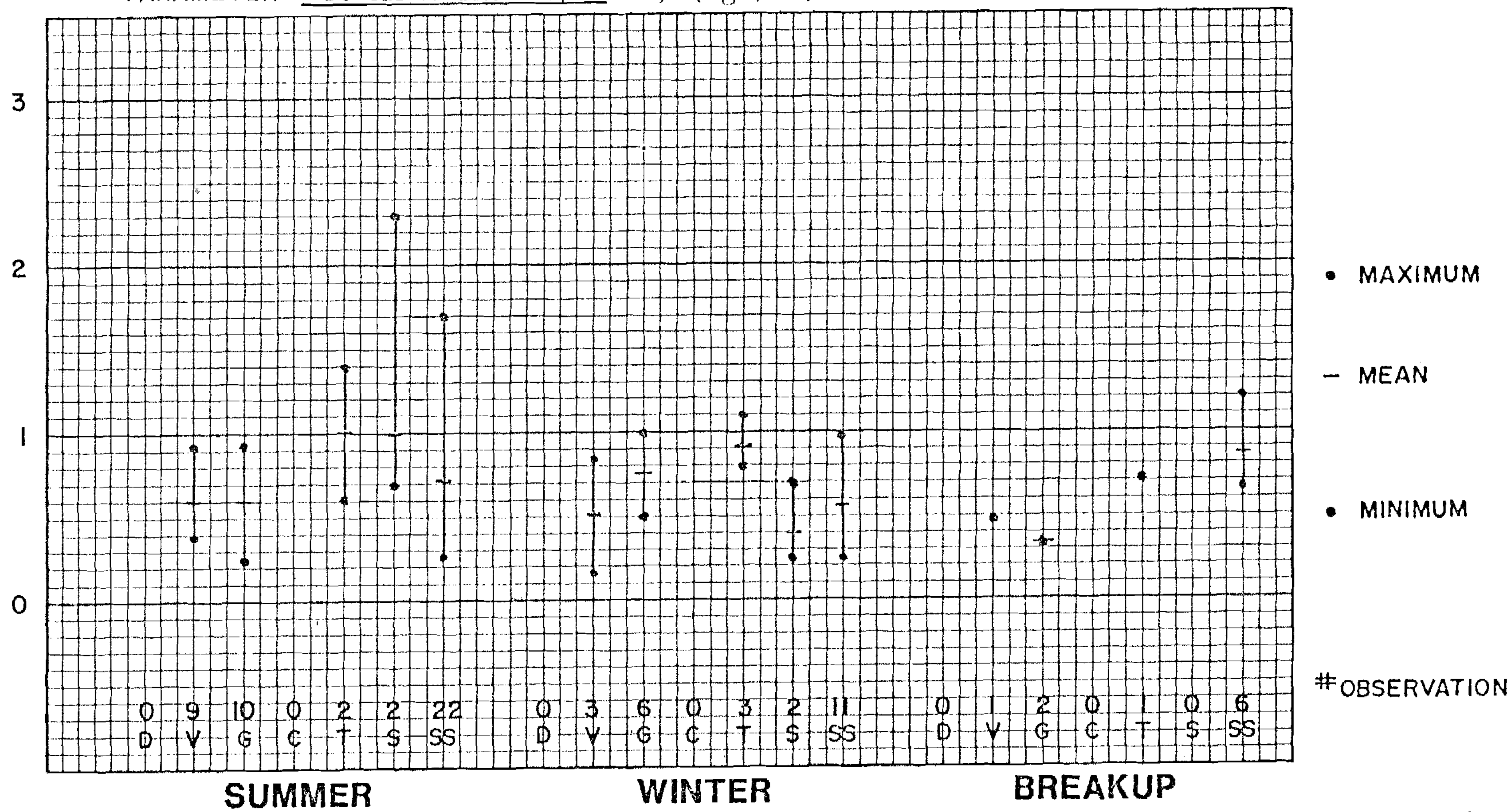
DATA SUMMARY - ORGANIC NITROGEN

FIGURE 2.14

PARAMETER: TOTAL NITROGEN, as N, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S- SUNSHINE SS- SUSITNA STATION

No criterion established

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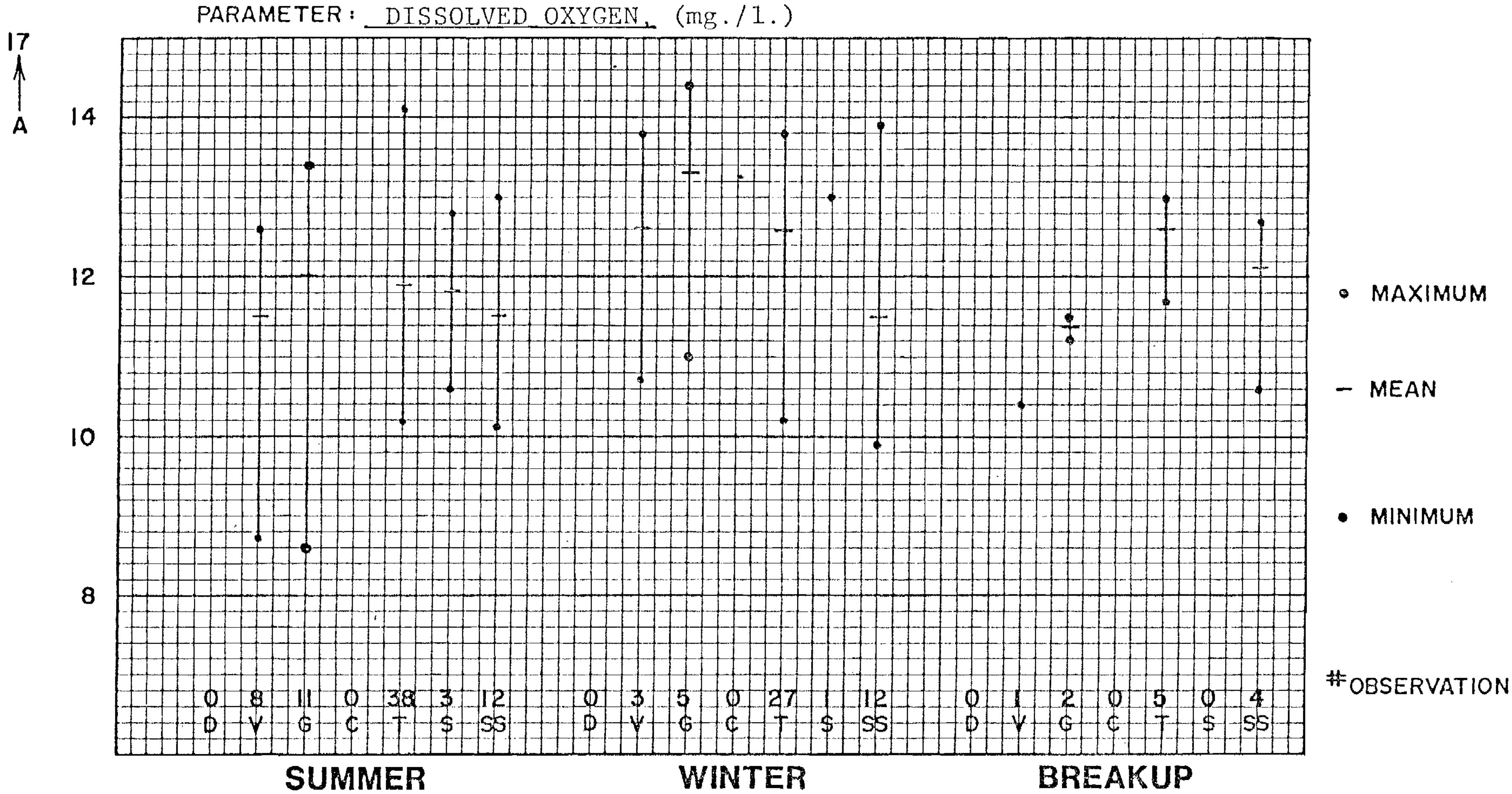
DATA SUMMARY - TOTAL NITROGEN

FIGURE 2.15



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Greater than 7mg/l, but in no case shall D.O. exceed 17mg/l (ADEC, 1979).

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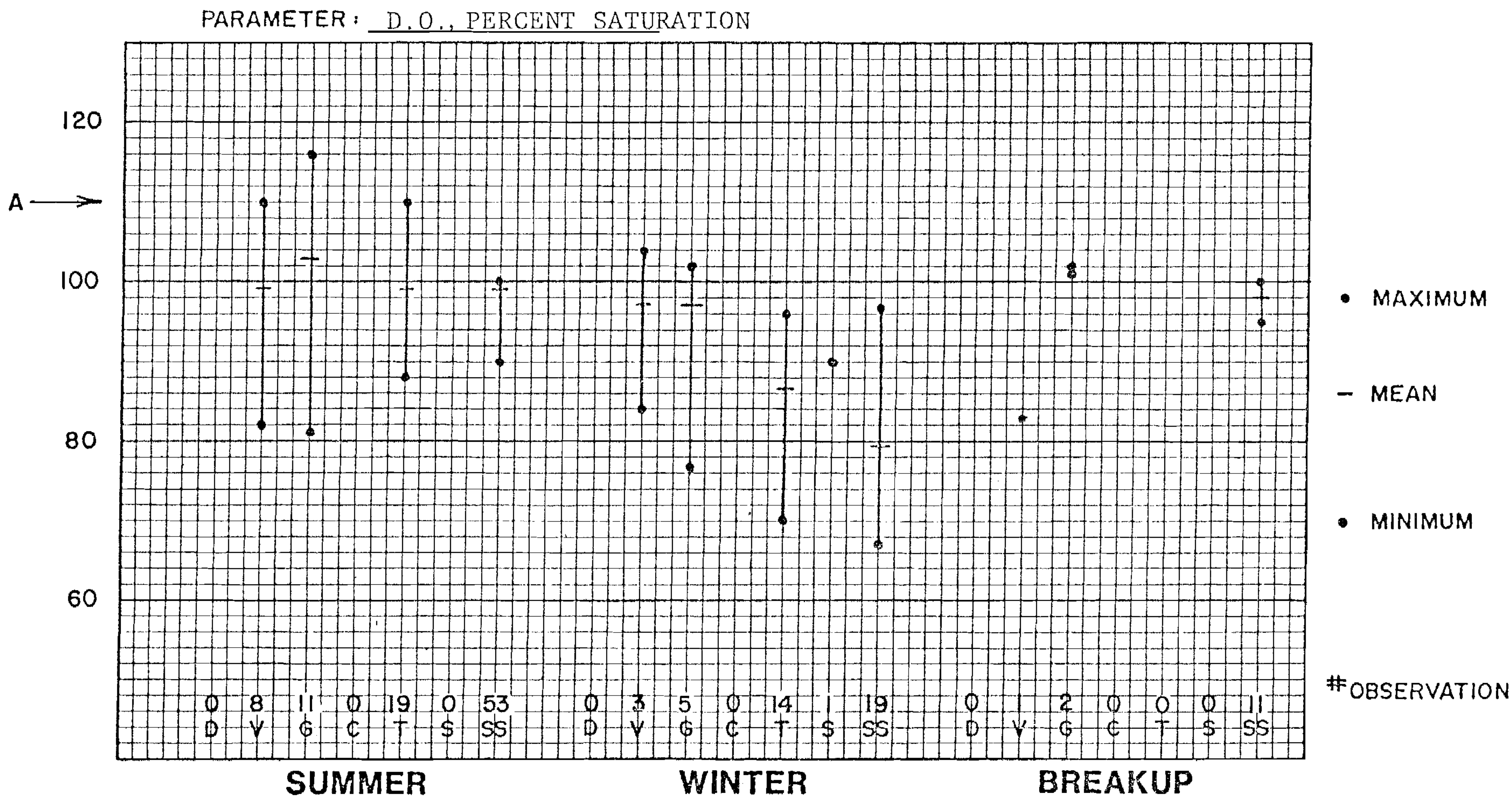
DATA SUMMARY - OXYGEN, DISSOLVED

FIGURE 2.16



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. The concentration of total disolved gas shall not exceed 110% saturation at any point. (ADEC, 1979).

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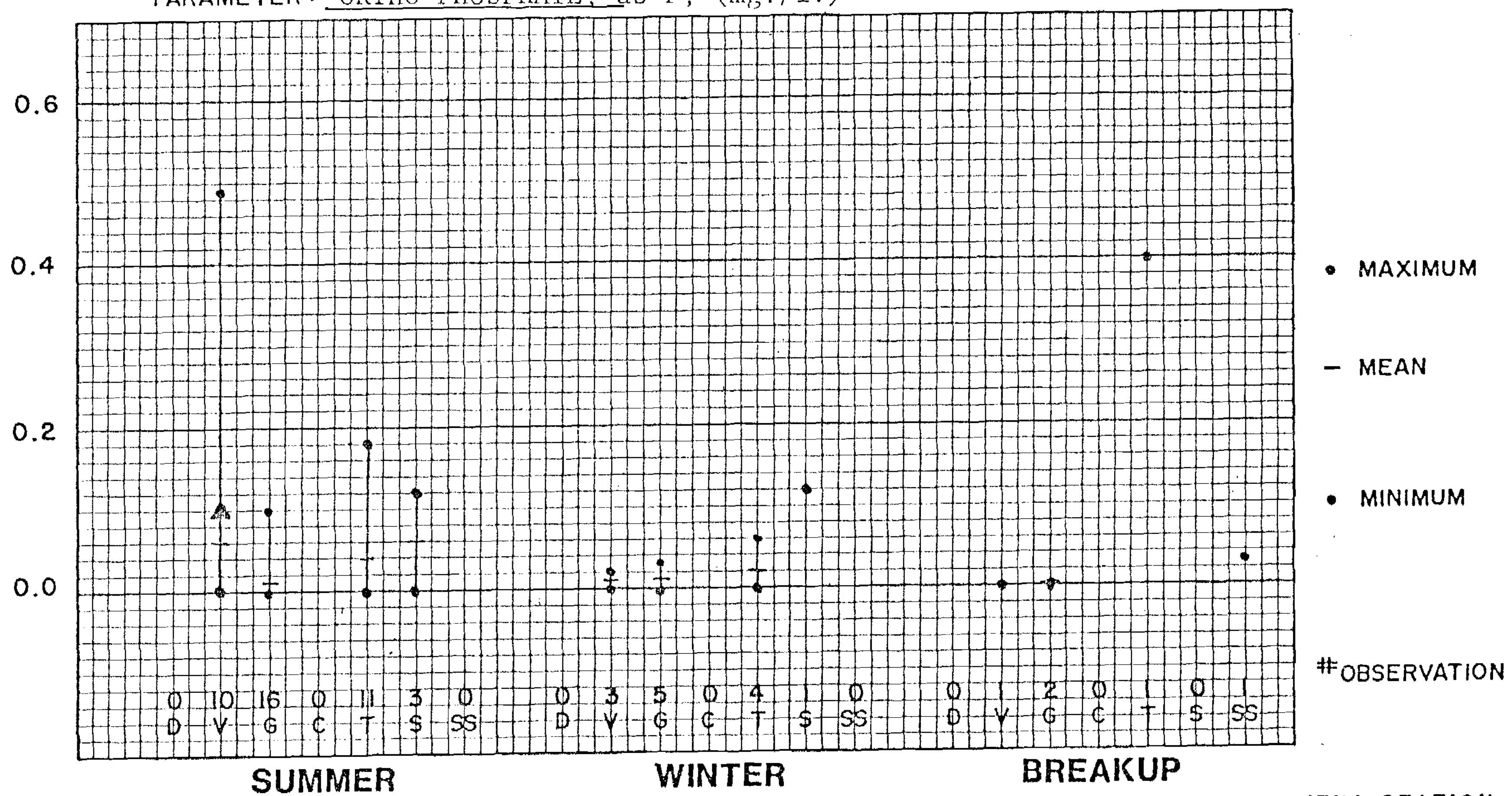
DATA SUMMARY - D.O., % SATURATION

FIGURE 2.17

PARAMETER: ORTHO PHOSPHATE, as P, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S- SUNSHINE SS- SUSITNA STATION

No criterion established

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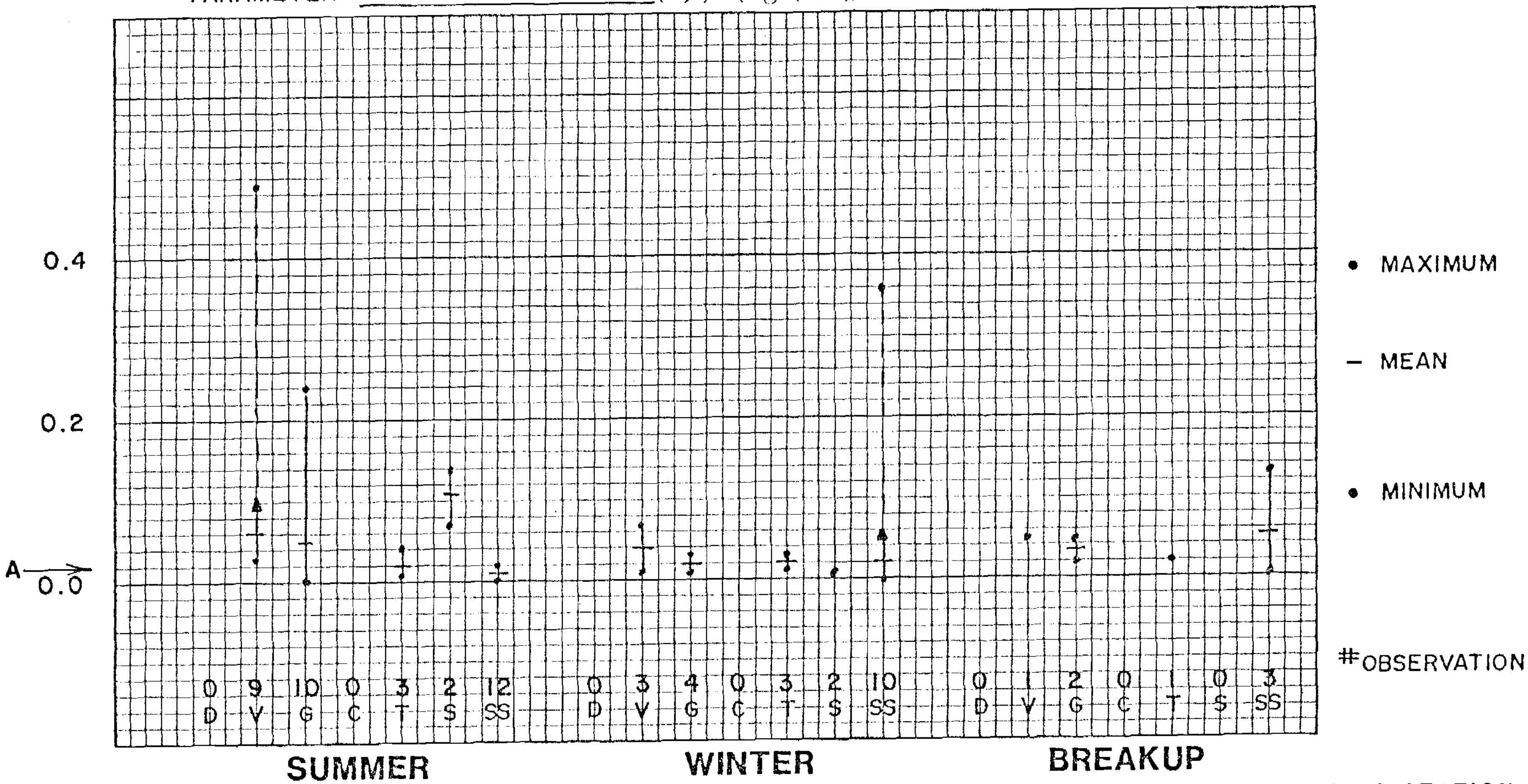
DATA SUMMARY - ORTHO PHOSPHATE

FIGURE 2.18

PARAMETER: DIS. PHOSPHORUS (P), (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S- SUNSHINE SS- SUSITNA STATION

A. Less than 0.01 mg/l for elemental phosphorus (EPA, 1976)

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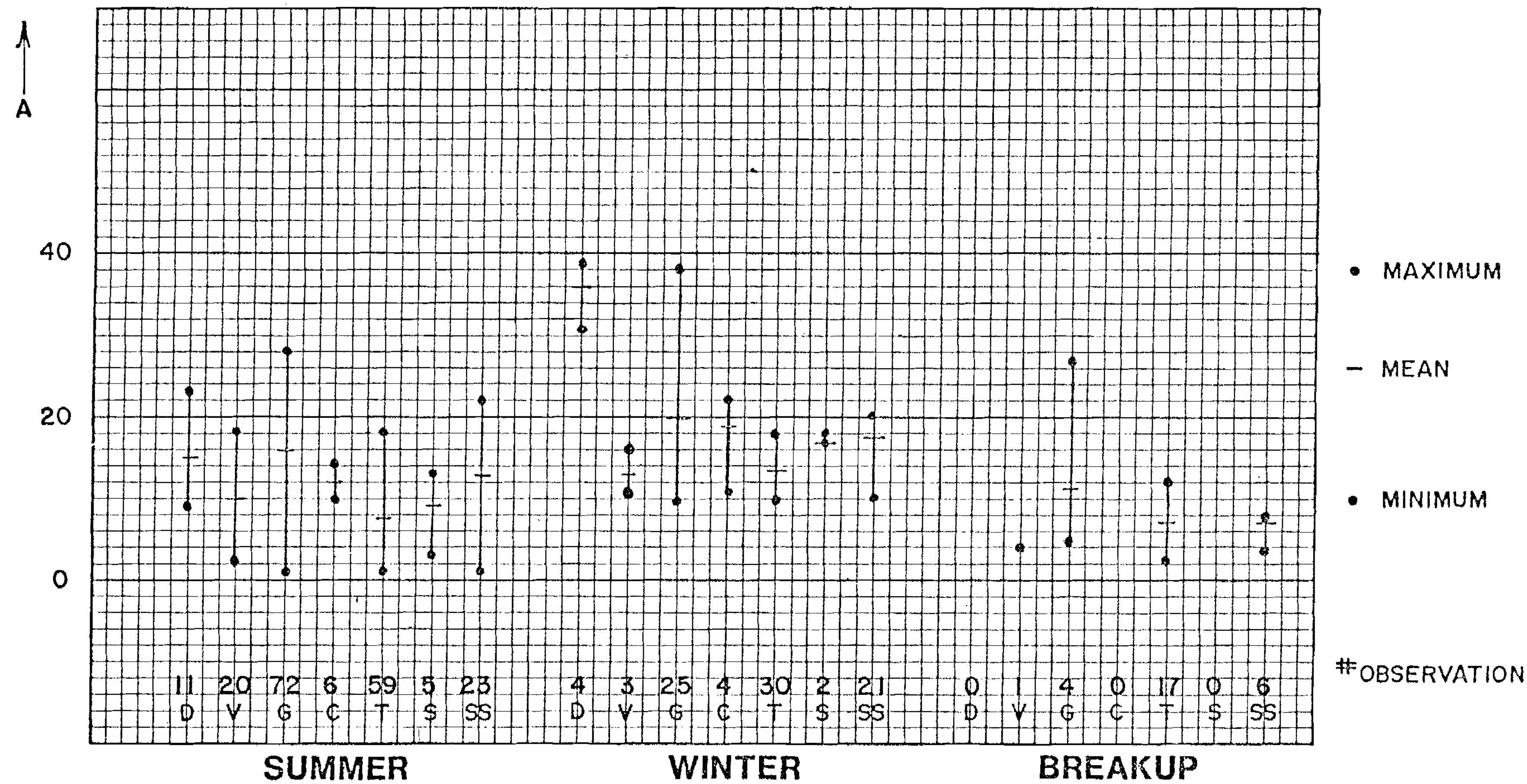
DATA SUMMARY - PHOSPHORUS

FIGURE 2.19

PARAMETER: SULFATE, (mg./l.)



D– DENALI V– VEE CANYON G– GOLD CREEK C– CHULITNA T– TALKEETNA S – SUNSHINE SS– SUSITNA STATION

A. Shall not exceed 200 mg/1. (ADEC, 1979).

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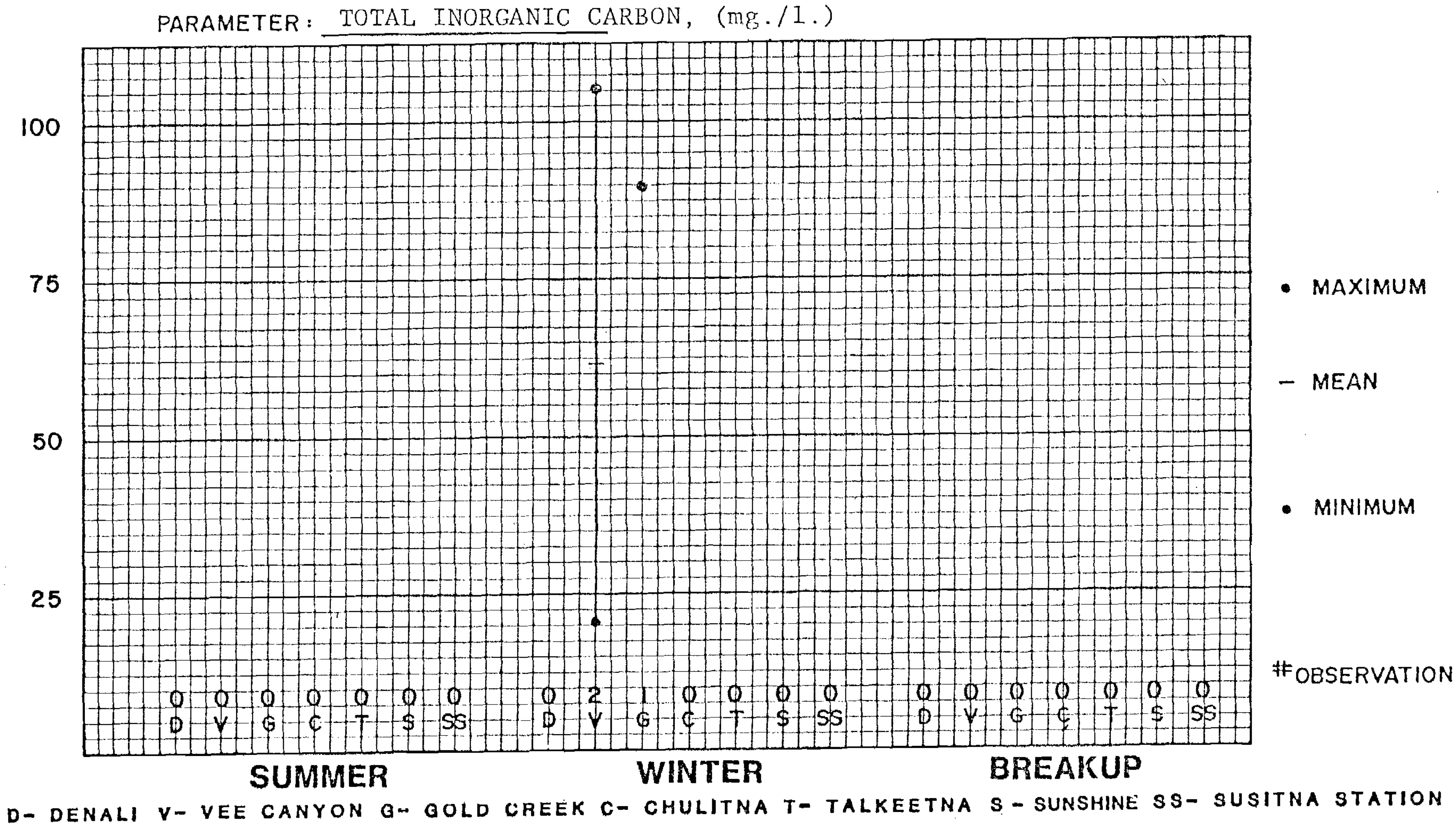
DATA SUMMARY – SULFATE

FIGURE 2.20



No criterion established.

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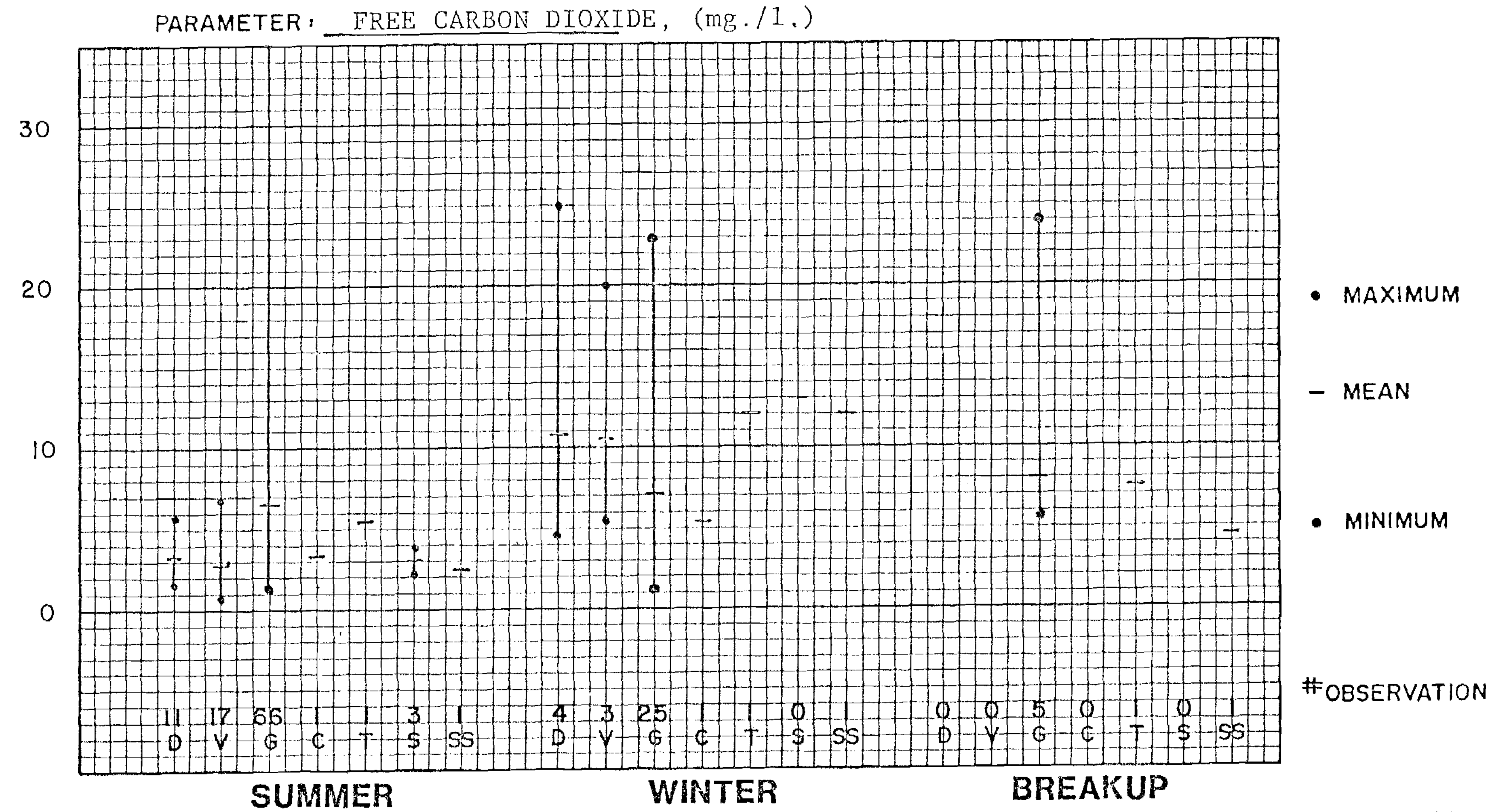
DATA SUMMARY - TOTAL INORGANIC CARBON

FIGURE 2.21



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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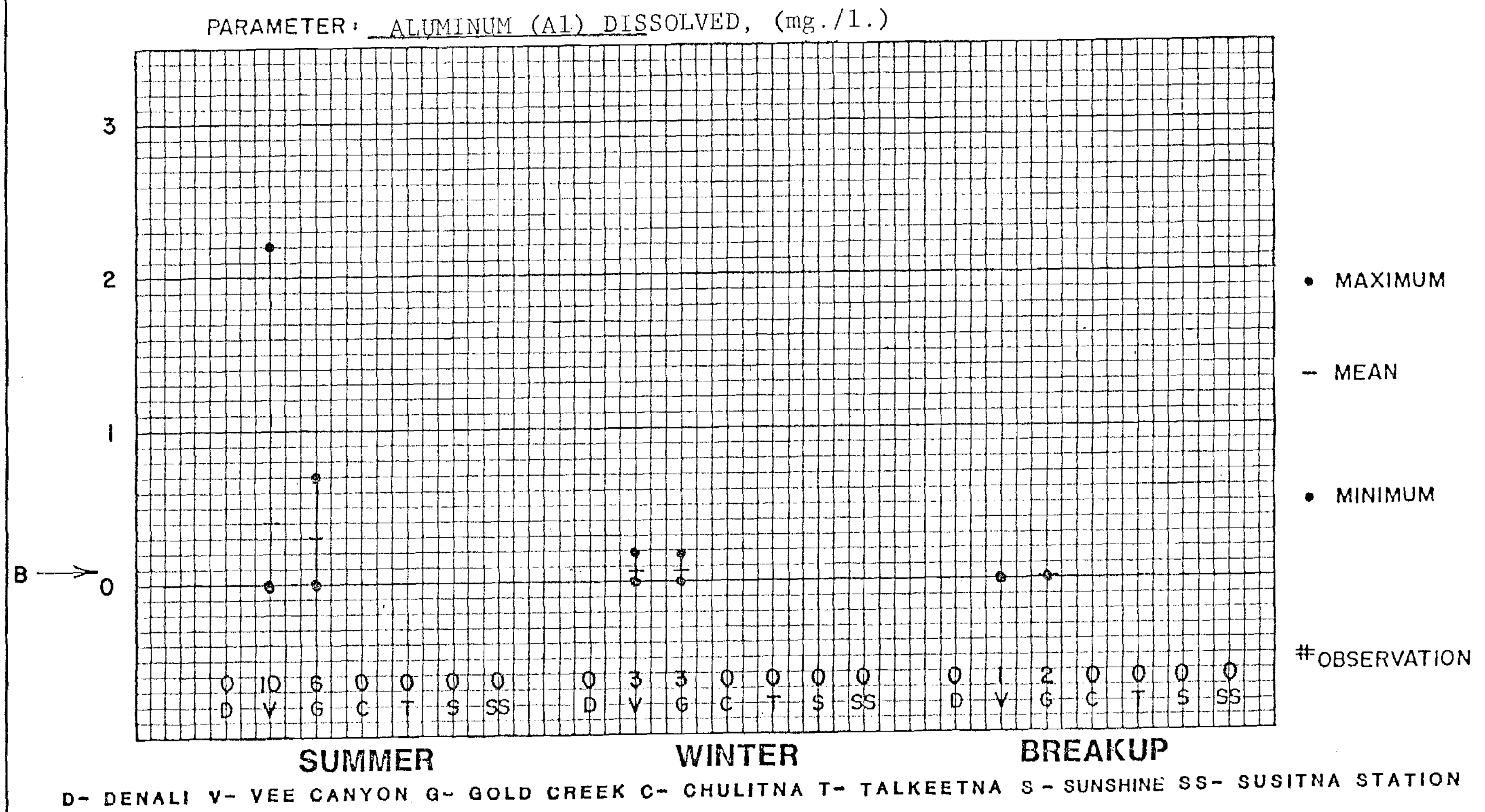
DATA SUMMARY - FREE CARBON DIOXIDE

FIGURE 2.22



A. No criterion established

B. A limit of 0.073 mg/l has been suggested by EPA (Sittig, 1981).

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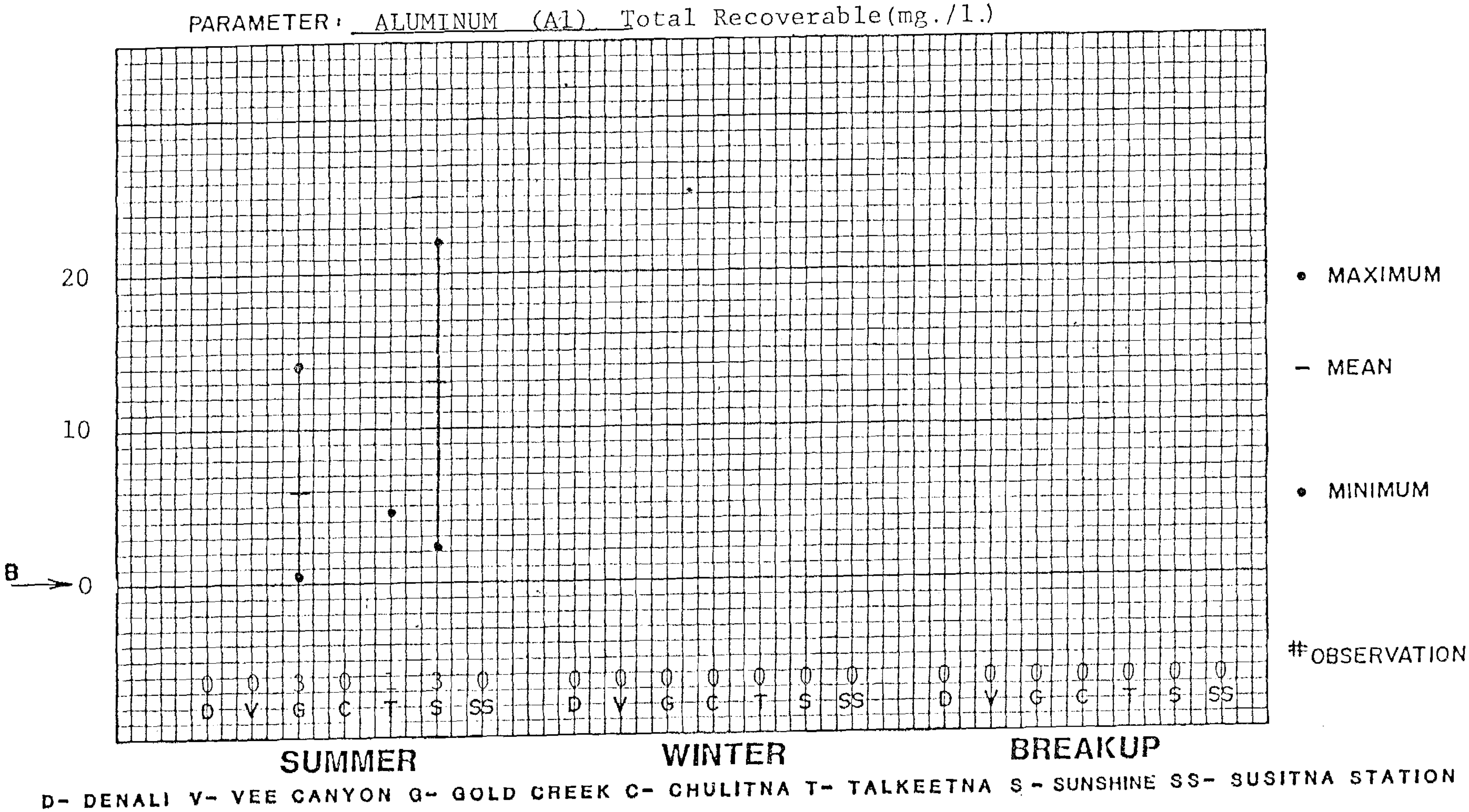
DATA SUMMARY - ALUMINUM (d)

FIGURE 2.23



A. No criterion established

B. A limit of 0.073 mg/l has been suggested by EPA (Sittig, 1981)

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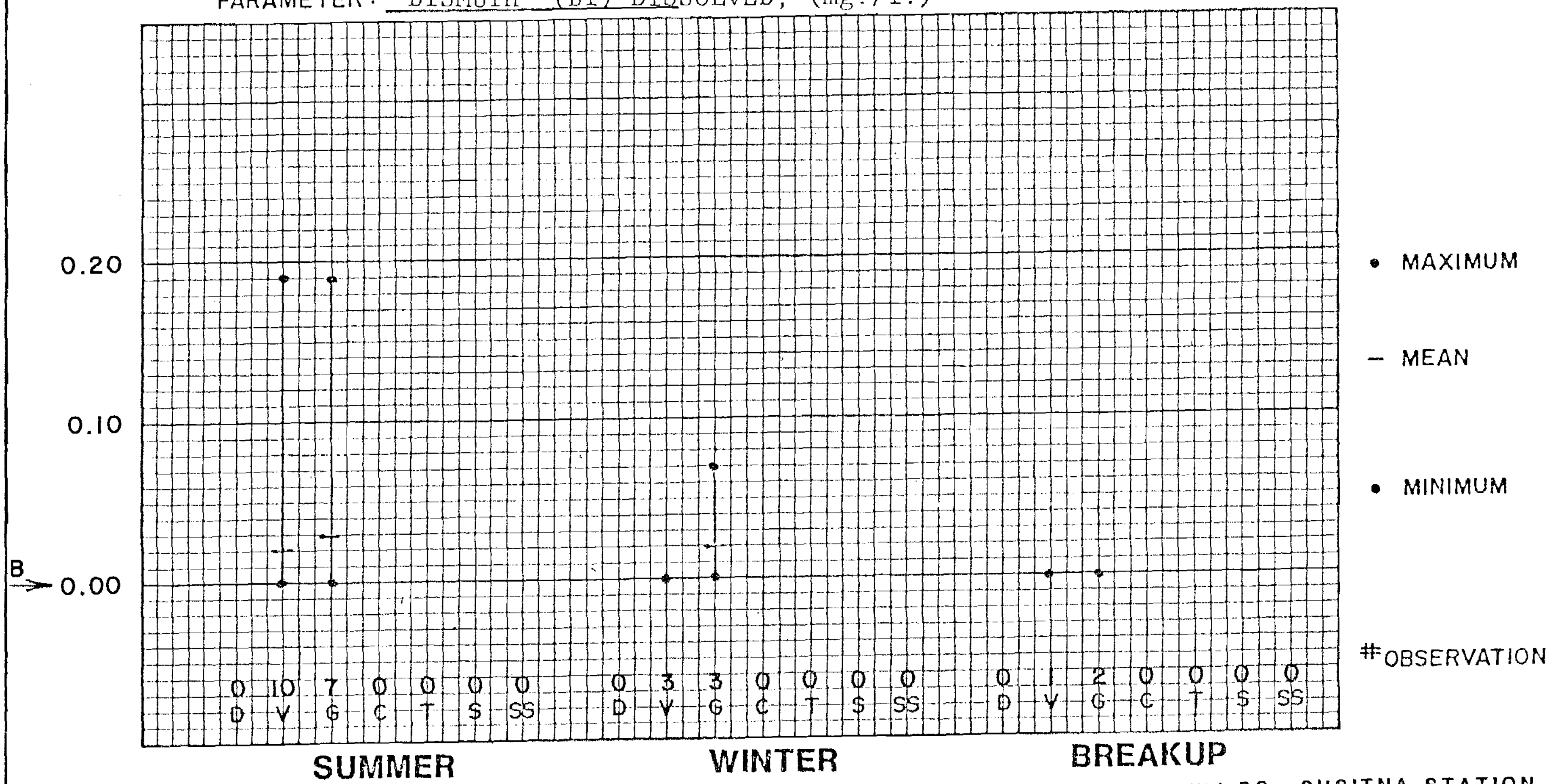
DATA SUMMARY - ALUMINUM (t)

FIGURE 2.24

PARAMETER: BISMUTH (Bi) DISSOLVED, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. No criterion established

B. EPA has suggested an ambient limit of 0.0035 mg/l. (Sittig, 1981).

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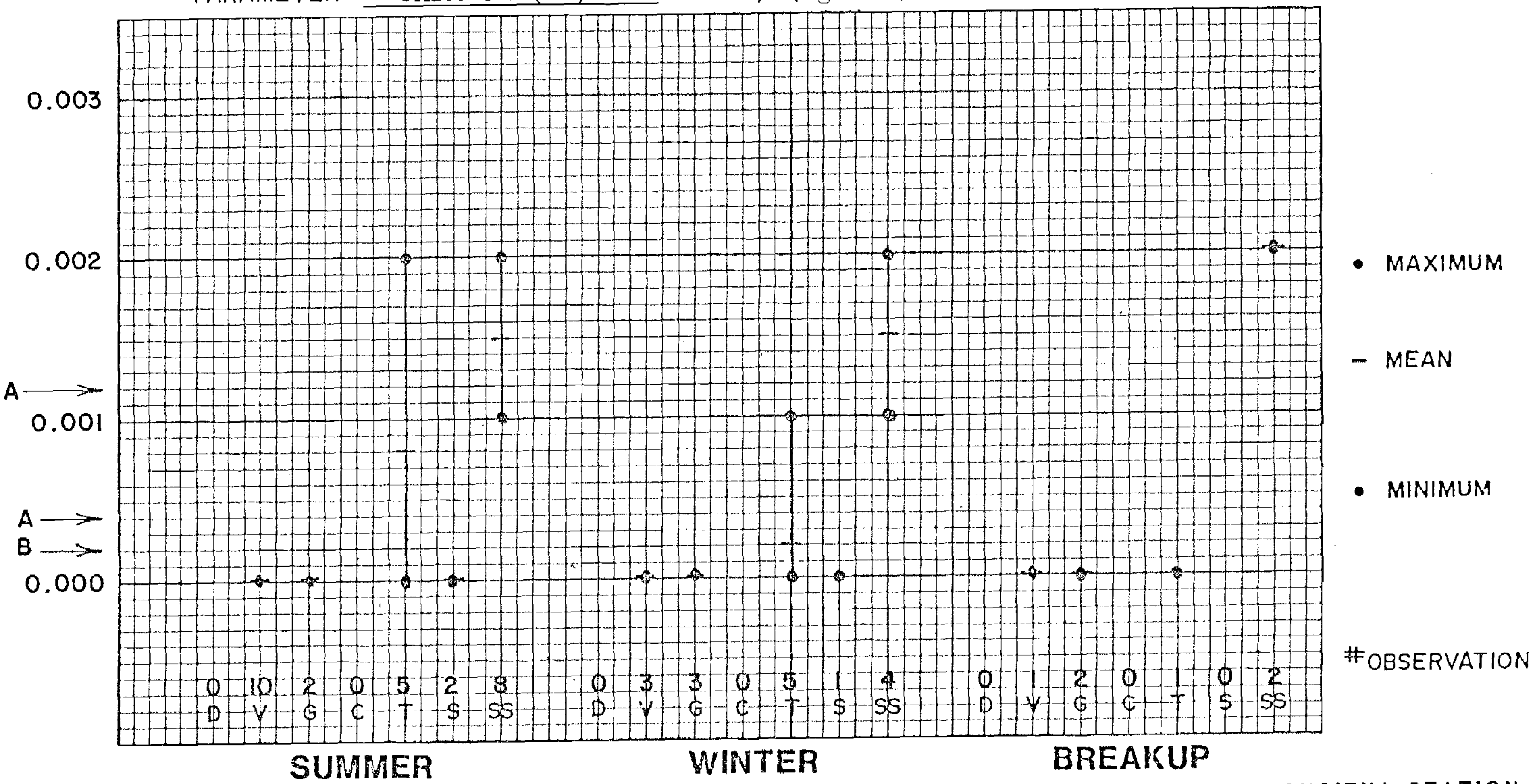
DATA SUMMARY - BISMUTH (d)

FIGURE 2.25

PARAMETER: CADMIUM (Cd) DISSOLVED, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. 0.0012 mg/l in hard water and 0.0004 in soft water. (EPA, 1976)

B. Less than 0.0002 mg/l. (McNeely, 1979)

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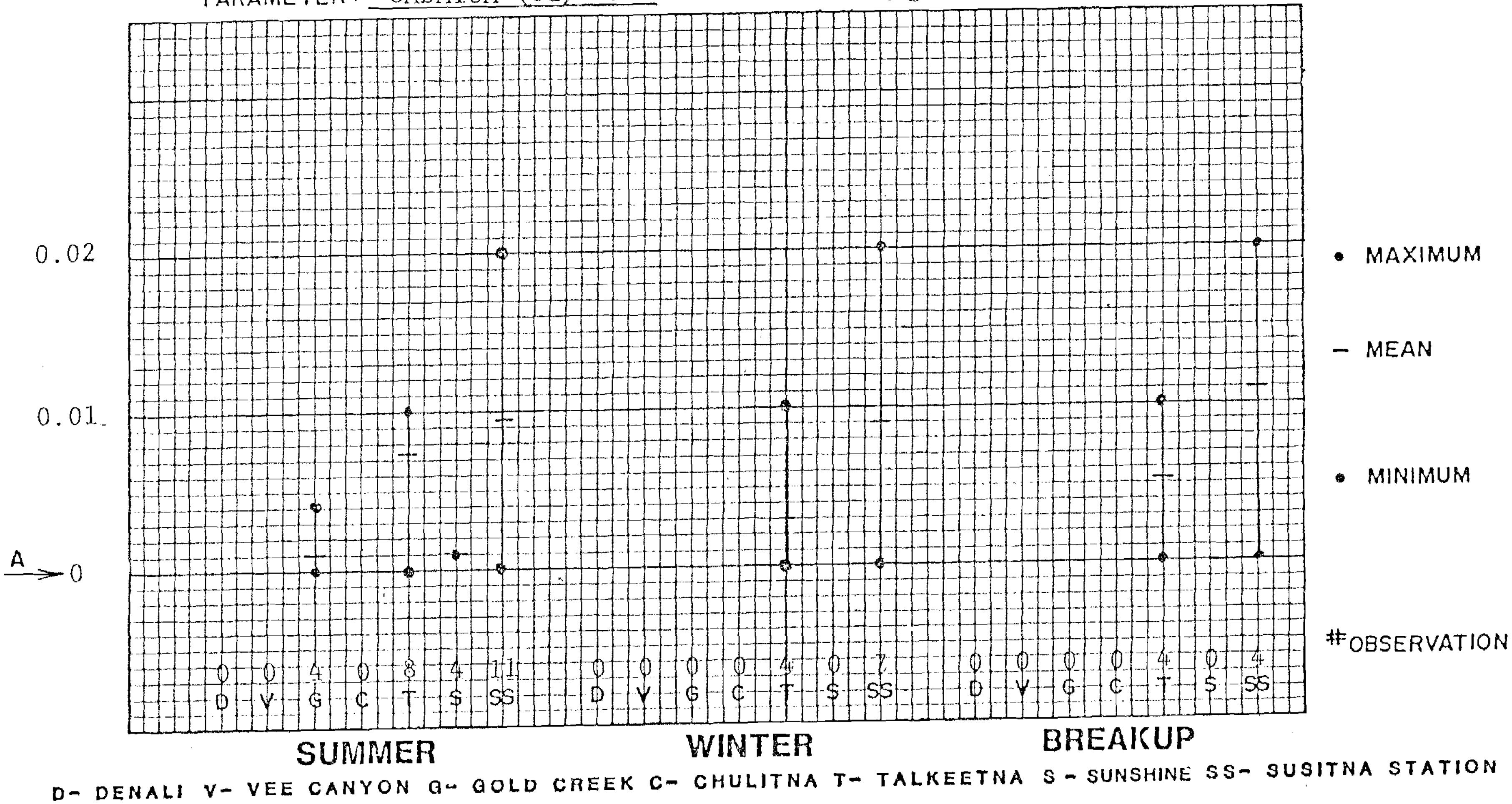
DATA SUMMARY - CADMIUM (d)

FIGURE 2.26

PARAMETER: CADMIUM (Cd) Total Recoverable (mg./l.)



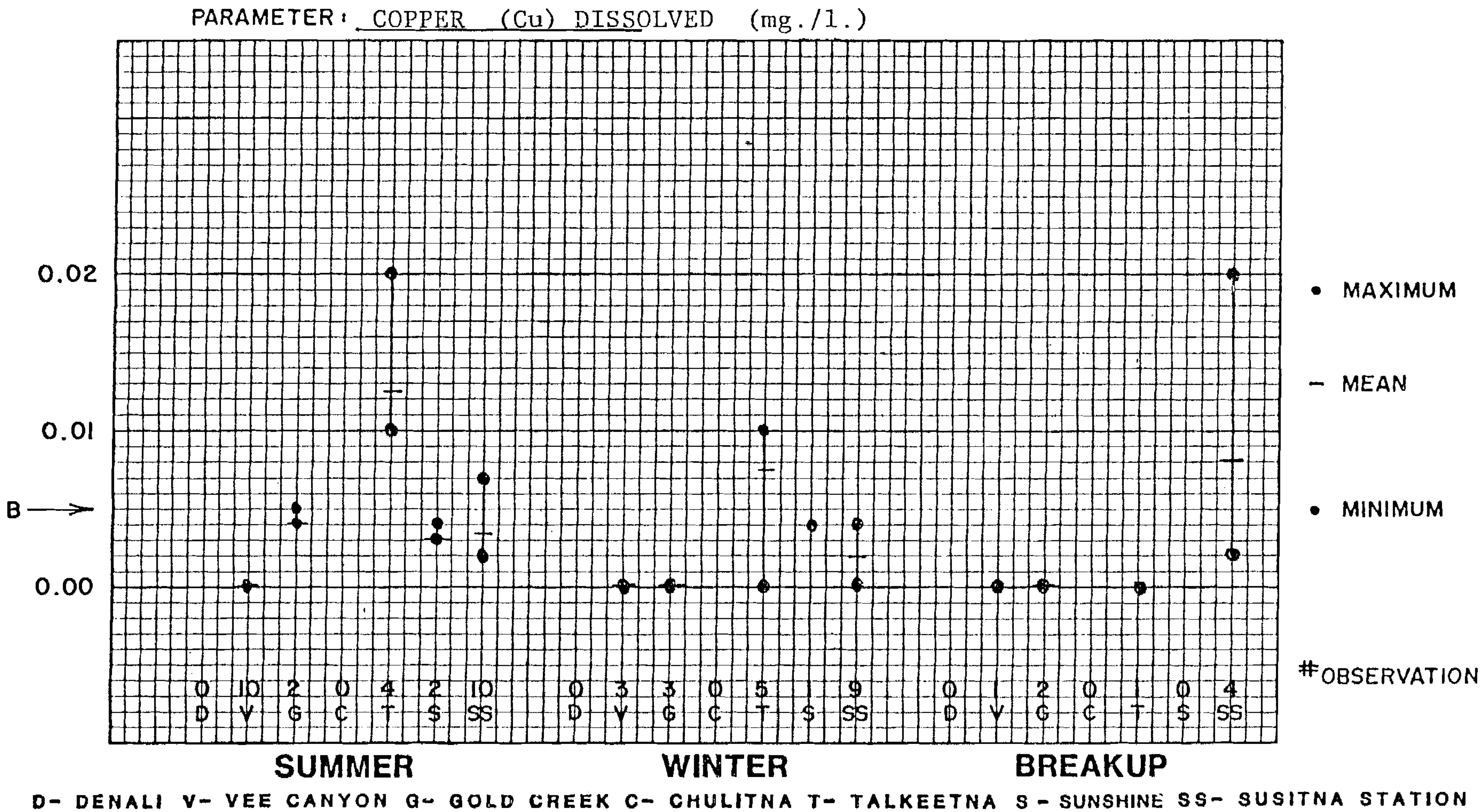
A. 0.0012 in hard water and 0.0004 mg/l in soft water (EPA, 1976).

B. Less than 0.0002 mg/l (McNeely et al, 1979).

R&M CONSULTANTS, INC. ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

DATA SUMMARY - CADMIUM (t)

FIGURE 2.27



A. 0.01 of the 96-hour LC_{50} determined through bioassay (EPA, 1976).

B. 0.005 mg/1, (McNeely et al, 1979)

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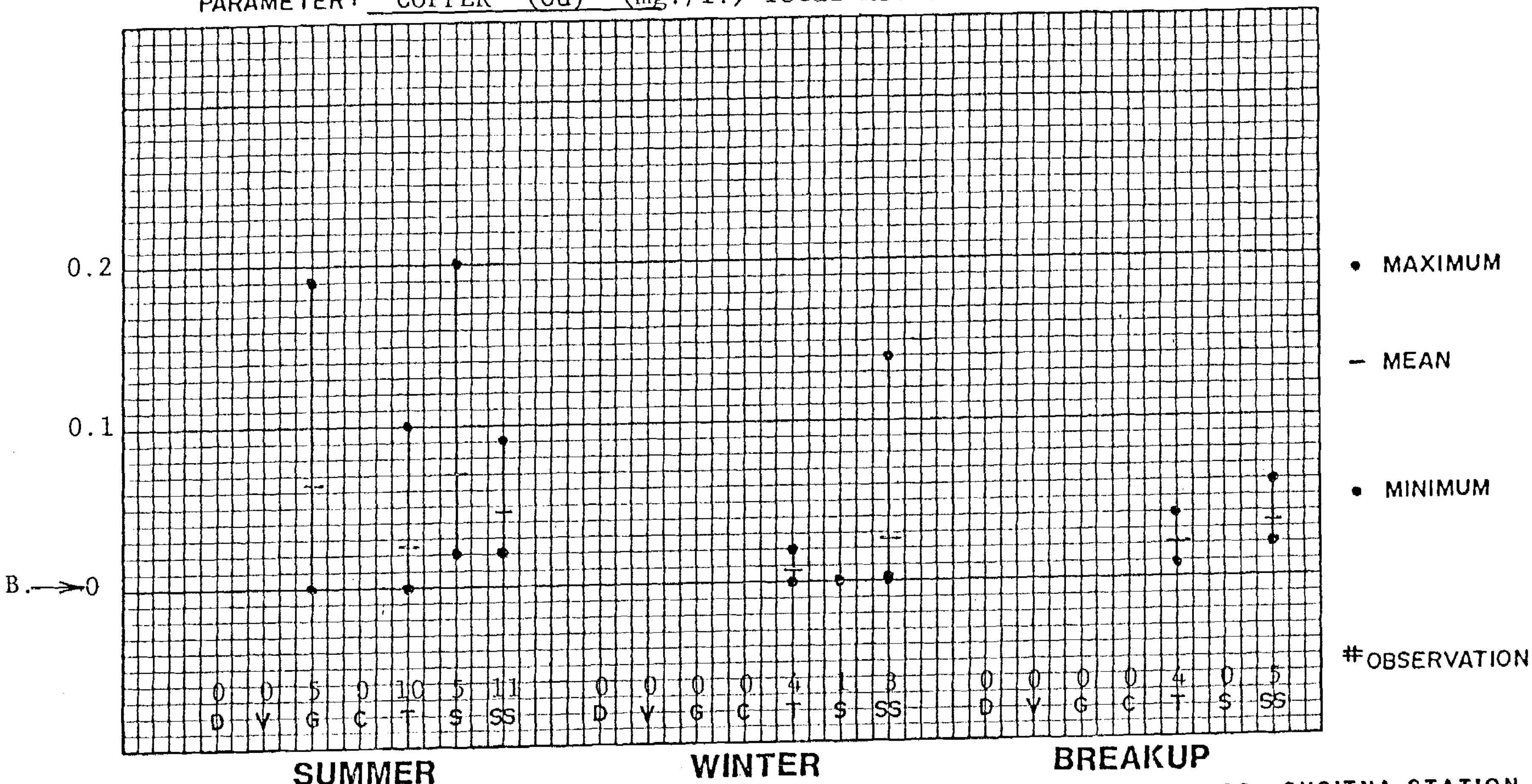
DATA SUMMARY - COPPER (d)

FIGURE 2.28

PARAMETER: COPPER (Cu) (mg./1.) Total Recoverable



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976).

B. 0.005 mg/l (McNeely et al, 1979).

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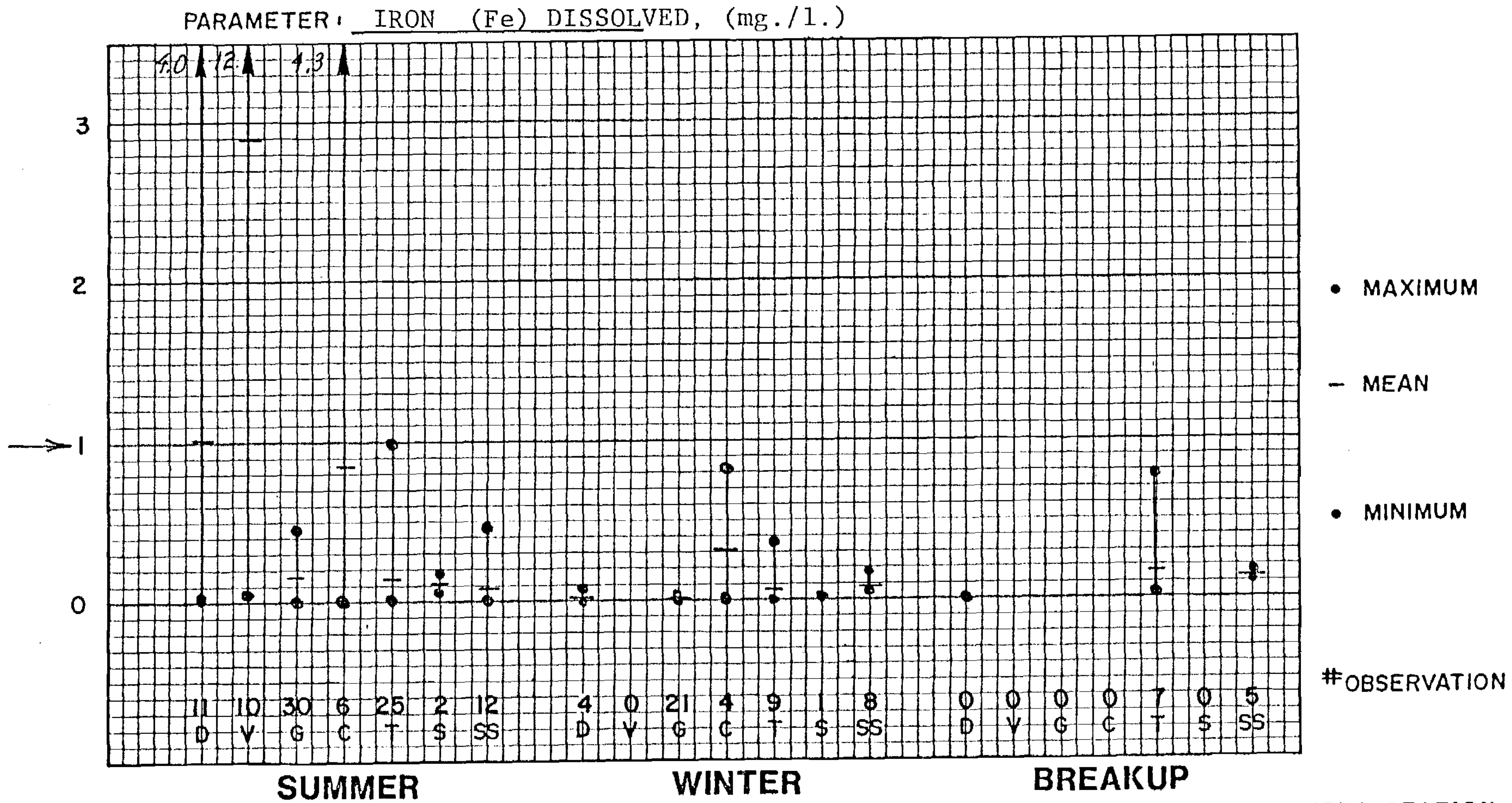
DATA SUMMARY - COPPER (t)

FIGURE 2.29



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 1.0 mg/l (EPA, 1976; Sittig, 1981).

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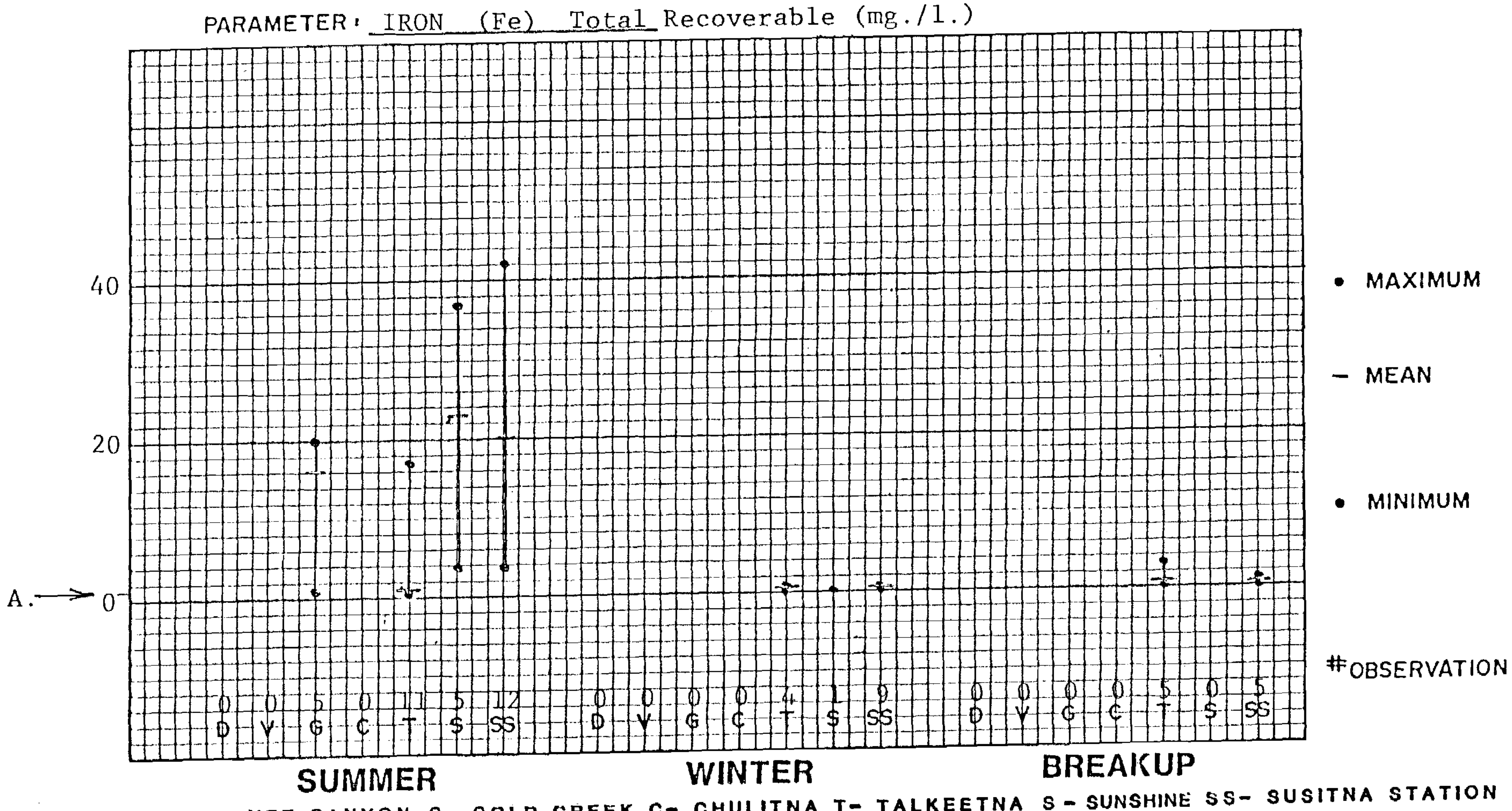
DATA SUMMARY - IRON (d)

FIGURE 2.30



A. Less than 1.0 mg/l (EPA, 1976; Sittig, 1981)

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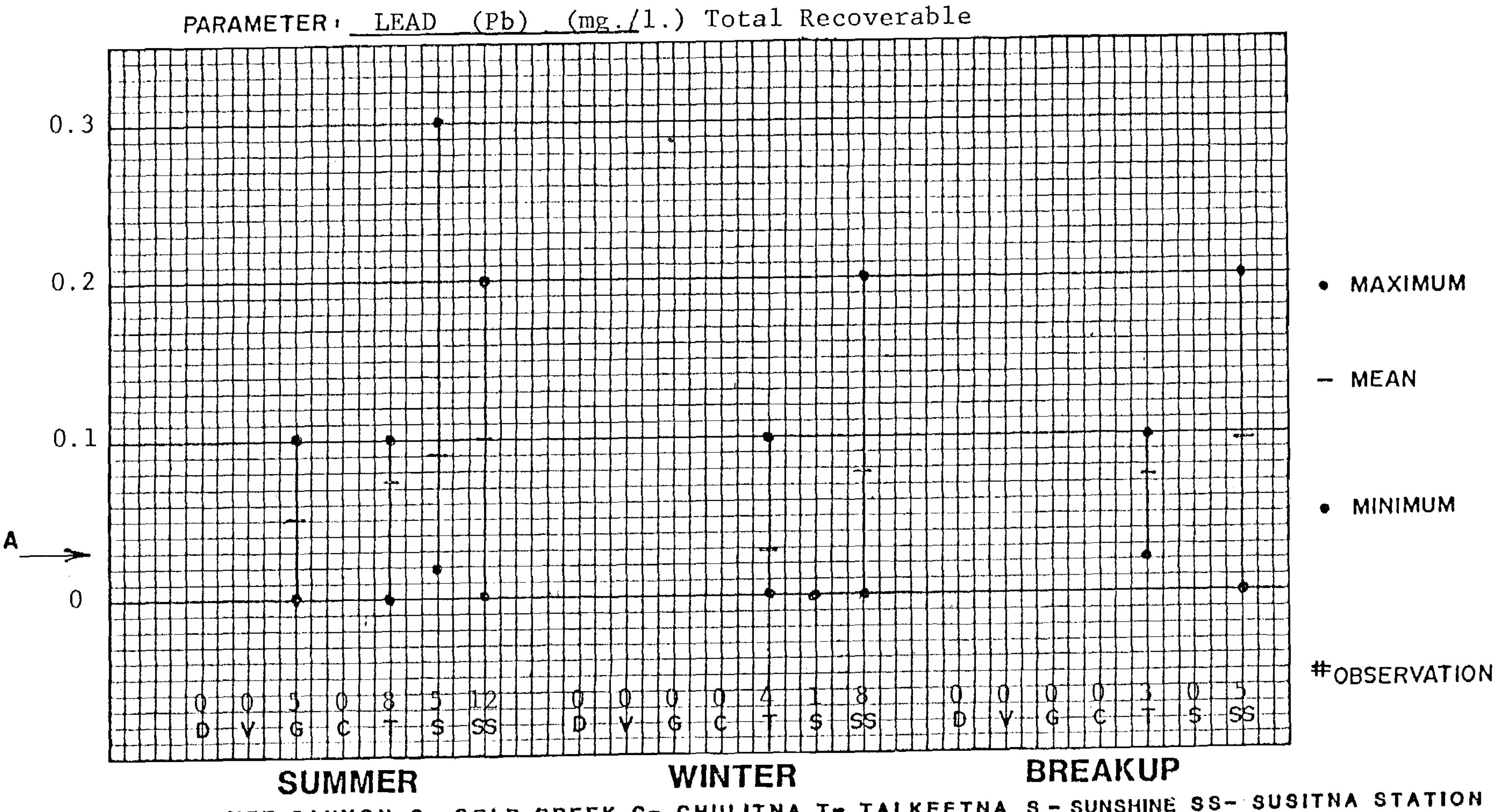
DATA SUMMARY - IRON (t)

FIGURE 2.31



A. Less than 0.03 mg/l (McNeely et al, 1979).

B. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976).

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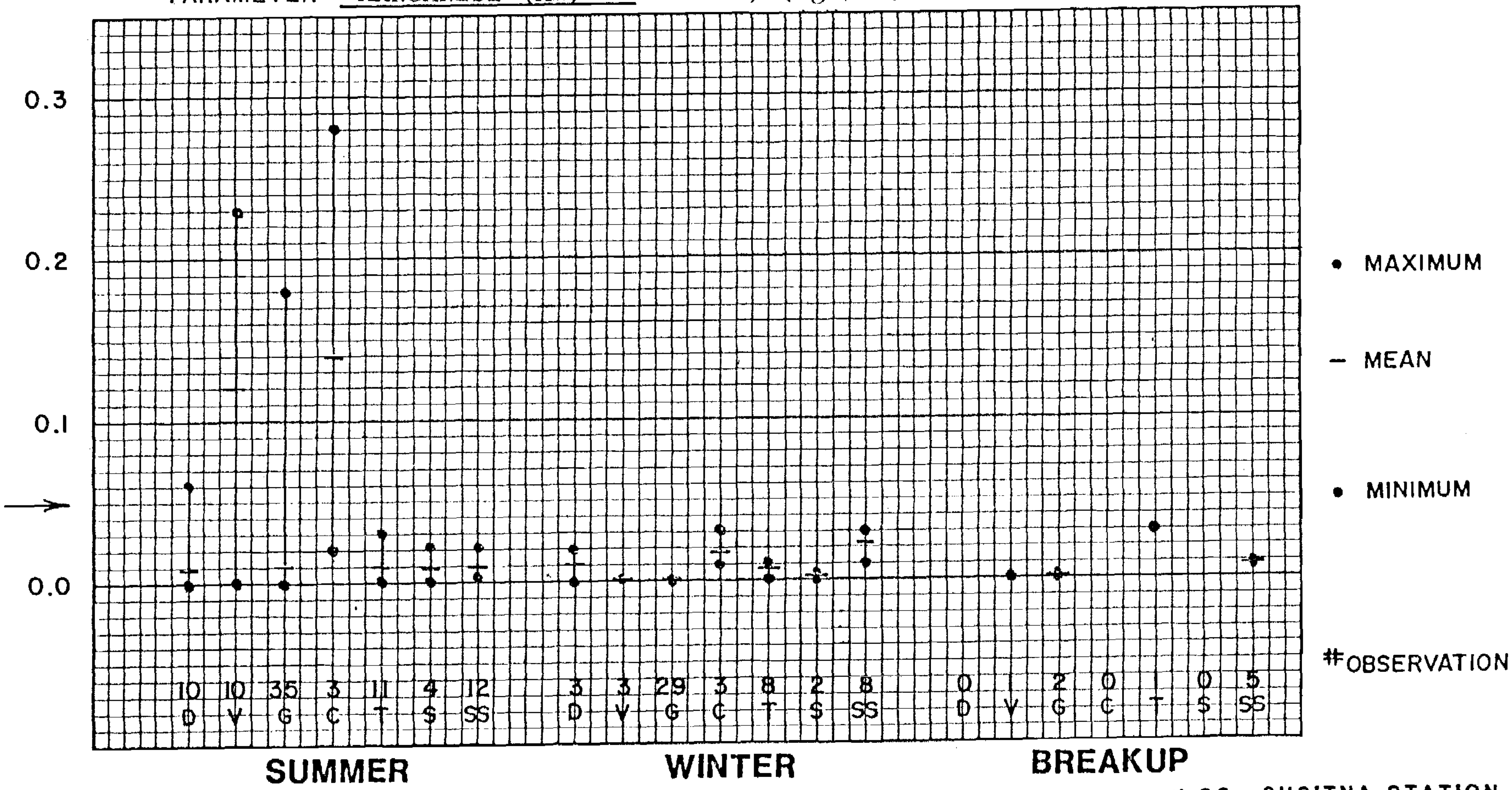
DATA SUMMARY - LEAD (t)

FIGURE 2.32

PARAMETER: MANGANESE (Mn) DISSOLVED, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.05 mg/1 for water supply.(EPA, 1976).

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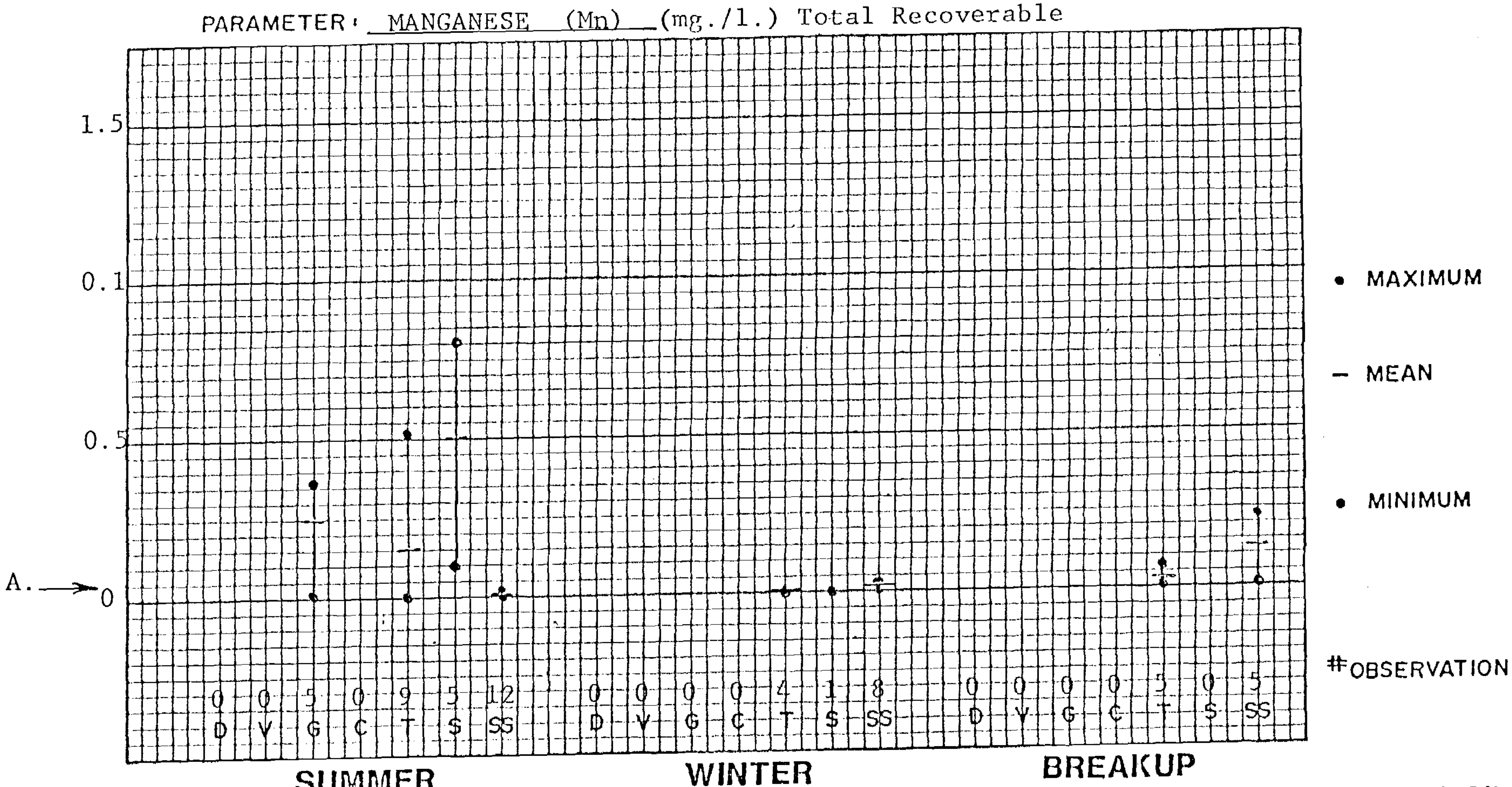
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

DATA SUMMARY - MANGANESE (d)

FIGURE 2.33



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.05 mg/l for water supply (EPA, 1976)

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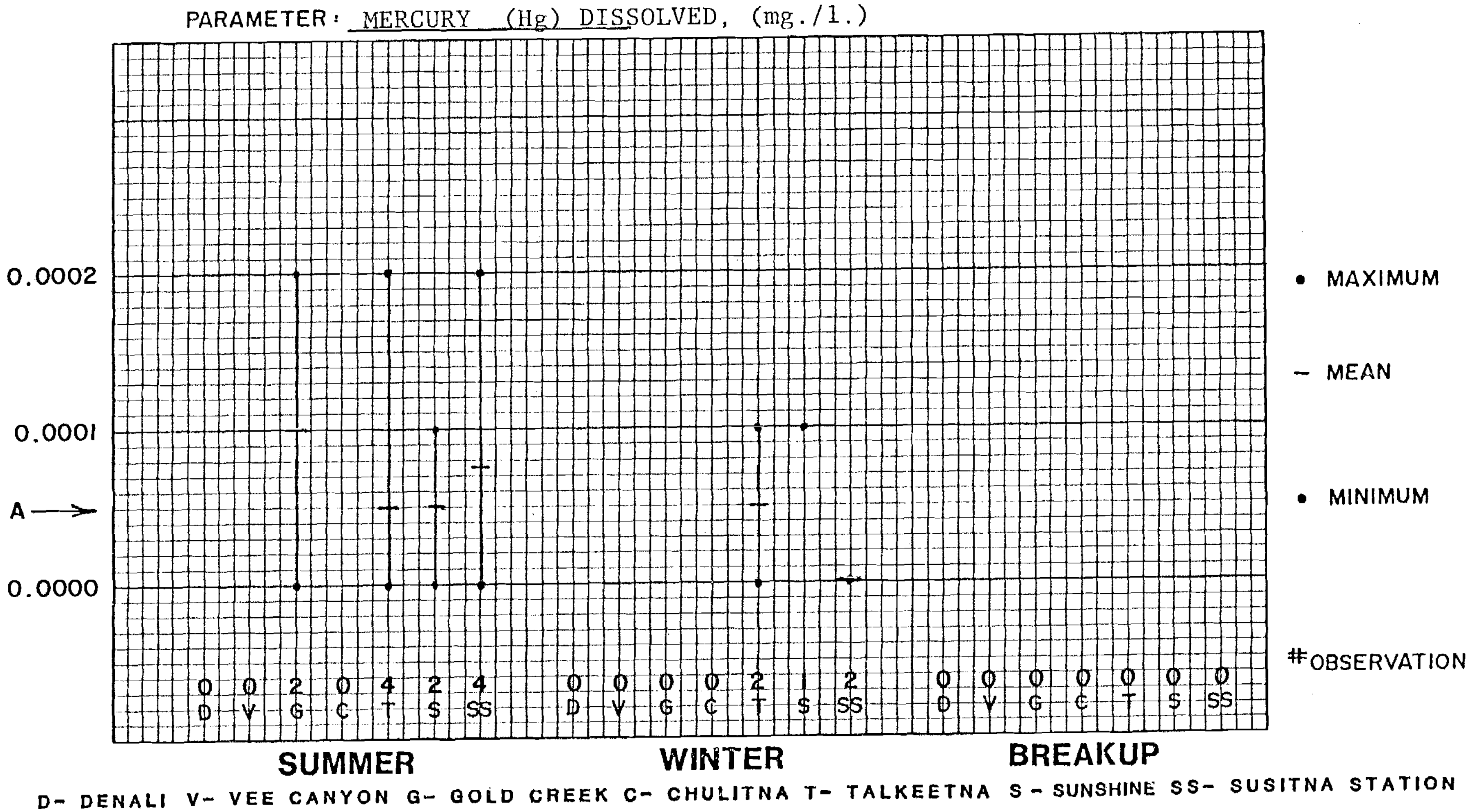
DATA SUMMARY - MANGANESE (t)

FIGURE 2.34



A. Less than 0.00005 mg/1. (EPA, 1976).

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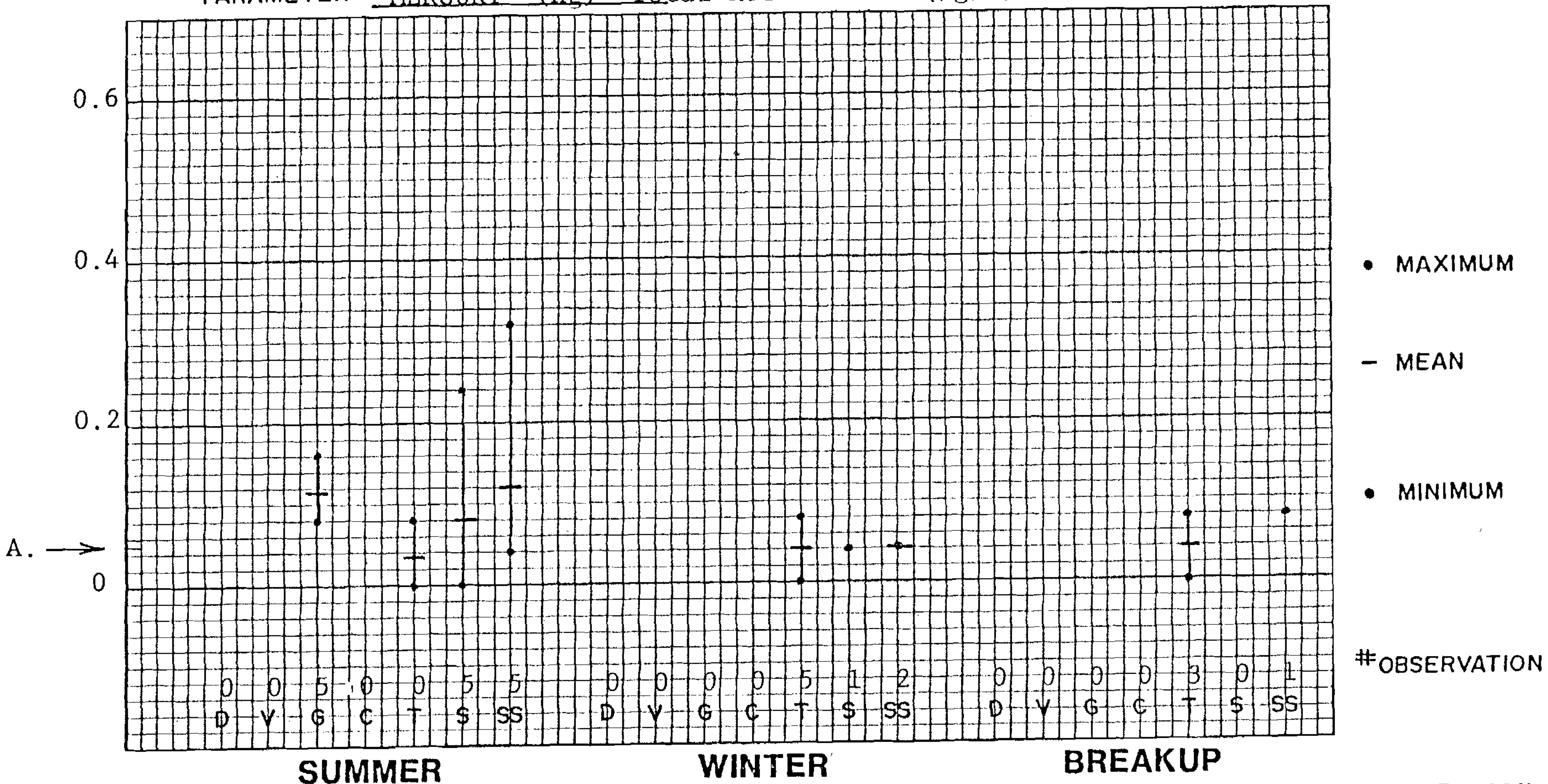
DATA SUMMARY - MERCURY (d)

FIGURE 2.35

PARAMETER: MERCURY (Hg) Total Recoverable (µg/l)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S- SUNSHINE SS- SUSITNA STATION

A. Less than 0.05 µg/l (EPA, 1976)

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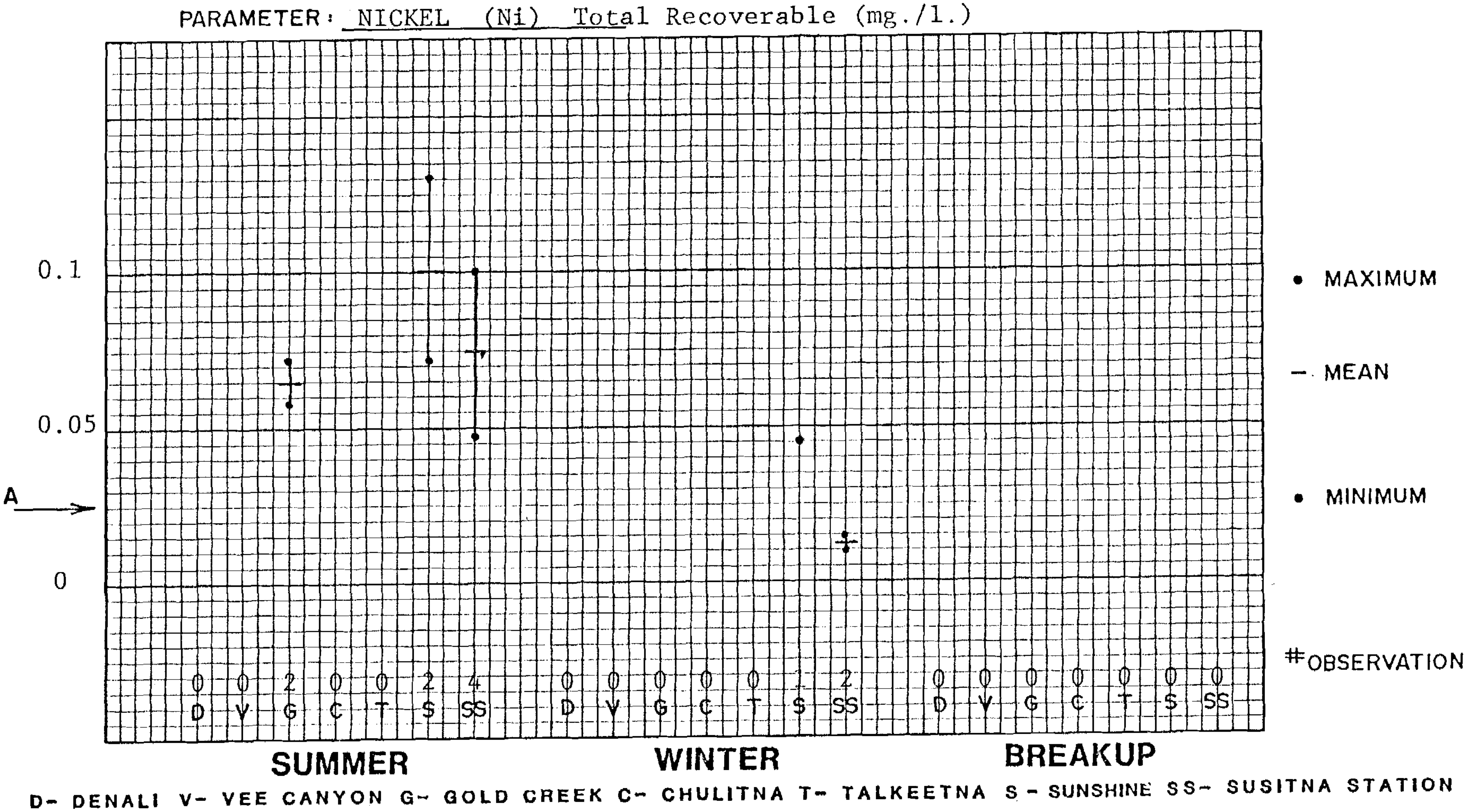
DATA SUMMARY - MERCURY (t)

FIGURE 2.36



A. Less than 0.025 mg/l (McNeely et al, 1979).

B. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976)

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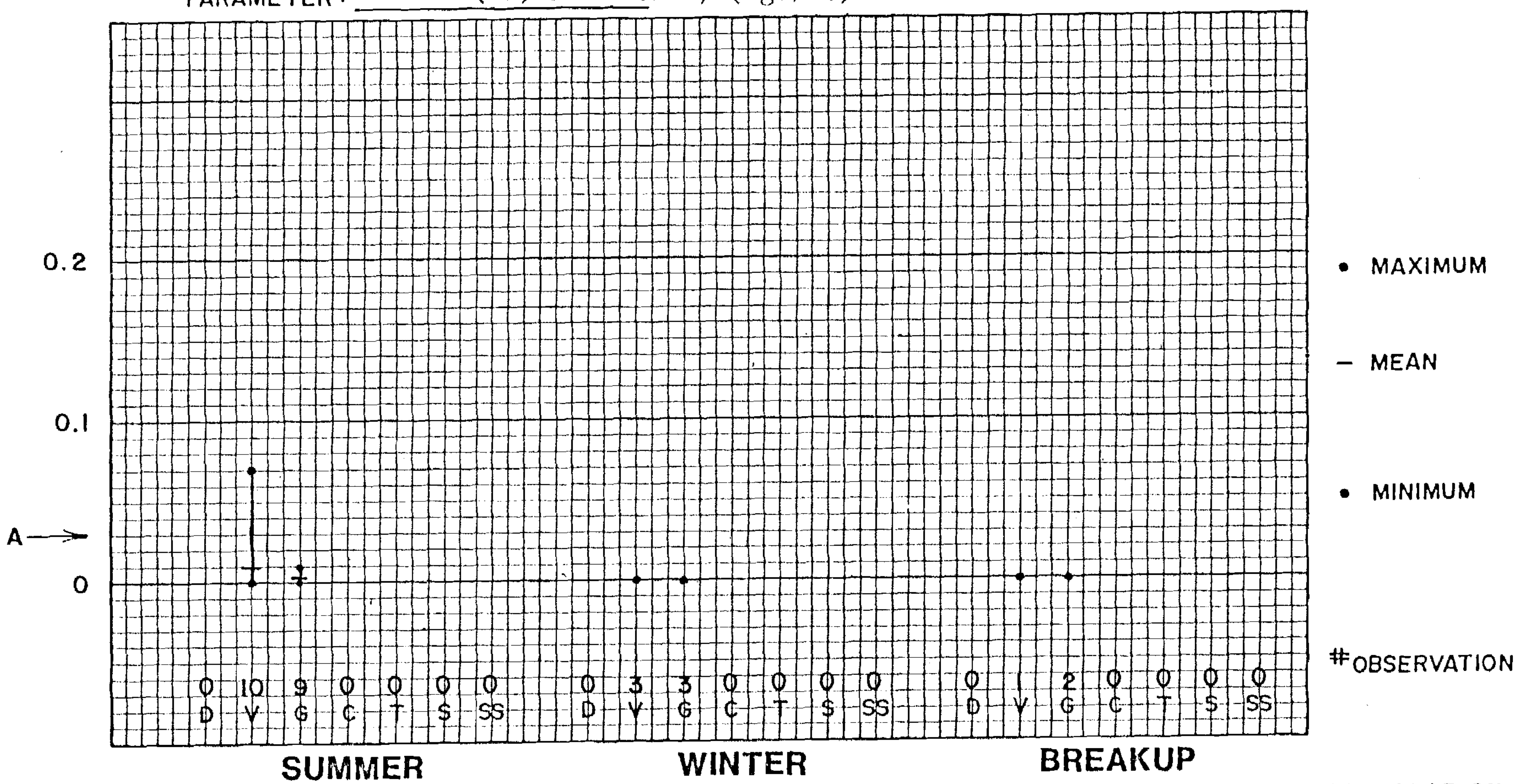
DATA SUMMARY - NICKEL (t)

FIGURE 2.37

PARAMETER: ZINC (Zn) DISSOLVED, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.03 mg/l (McNeely, 1979)

B. 0.01 of the 96-hour LC_{50} determined through bioassay (EPA, 1976).

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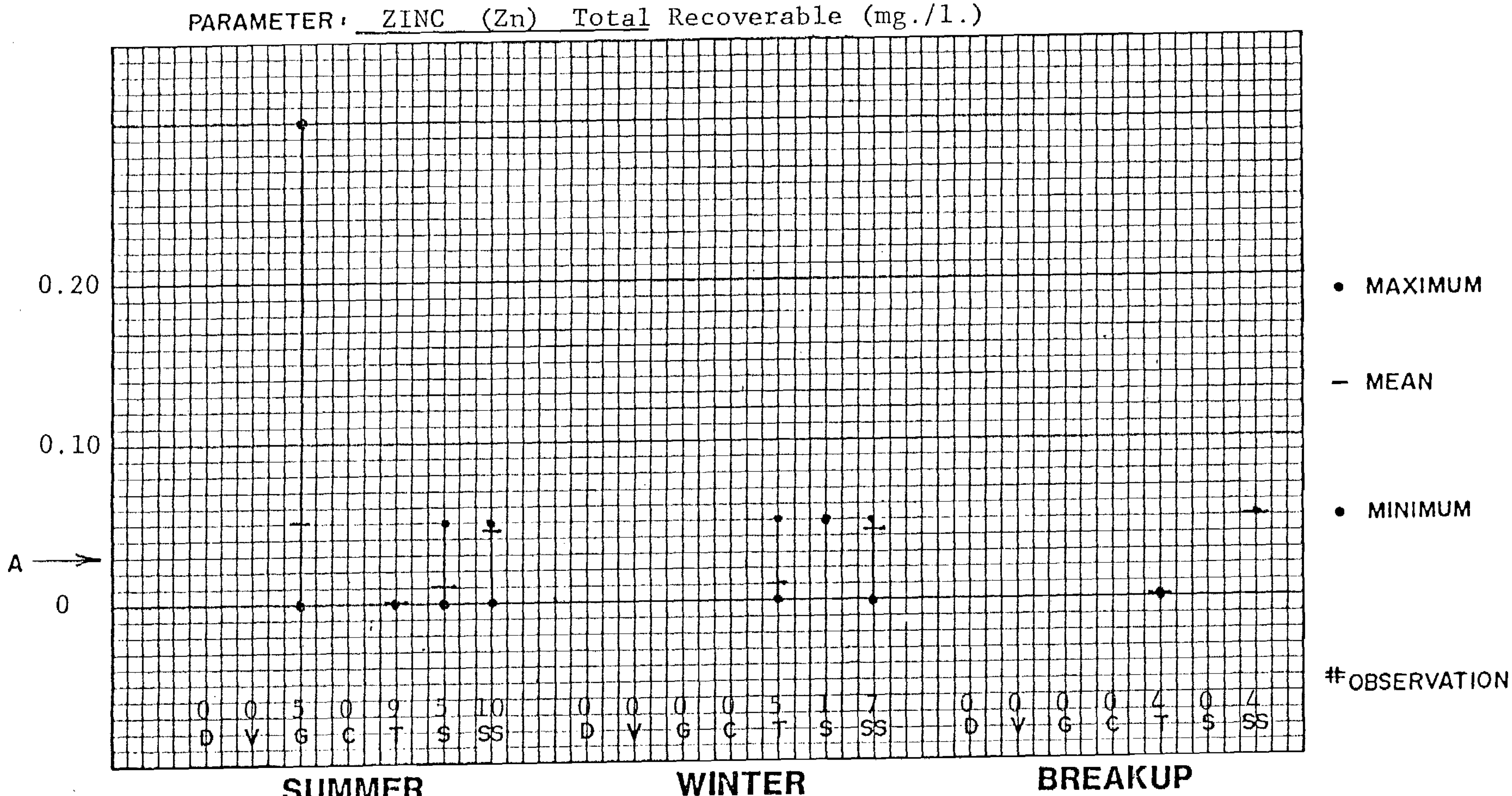
DATA SUMMARY - ZINC (d)

FIGURE 2.38



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.03 mg/l (McNeely, 1979).

B. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976).

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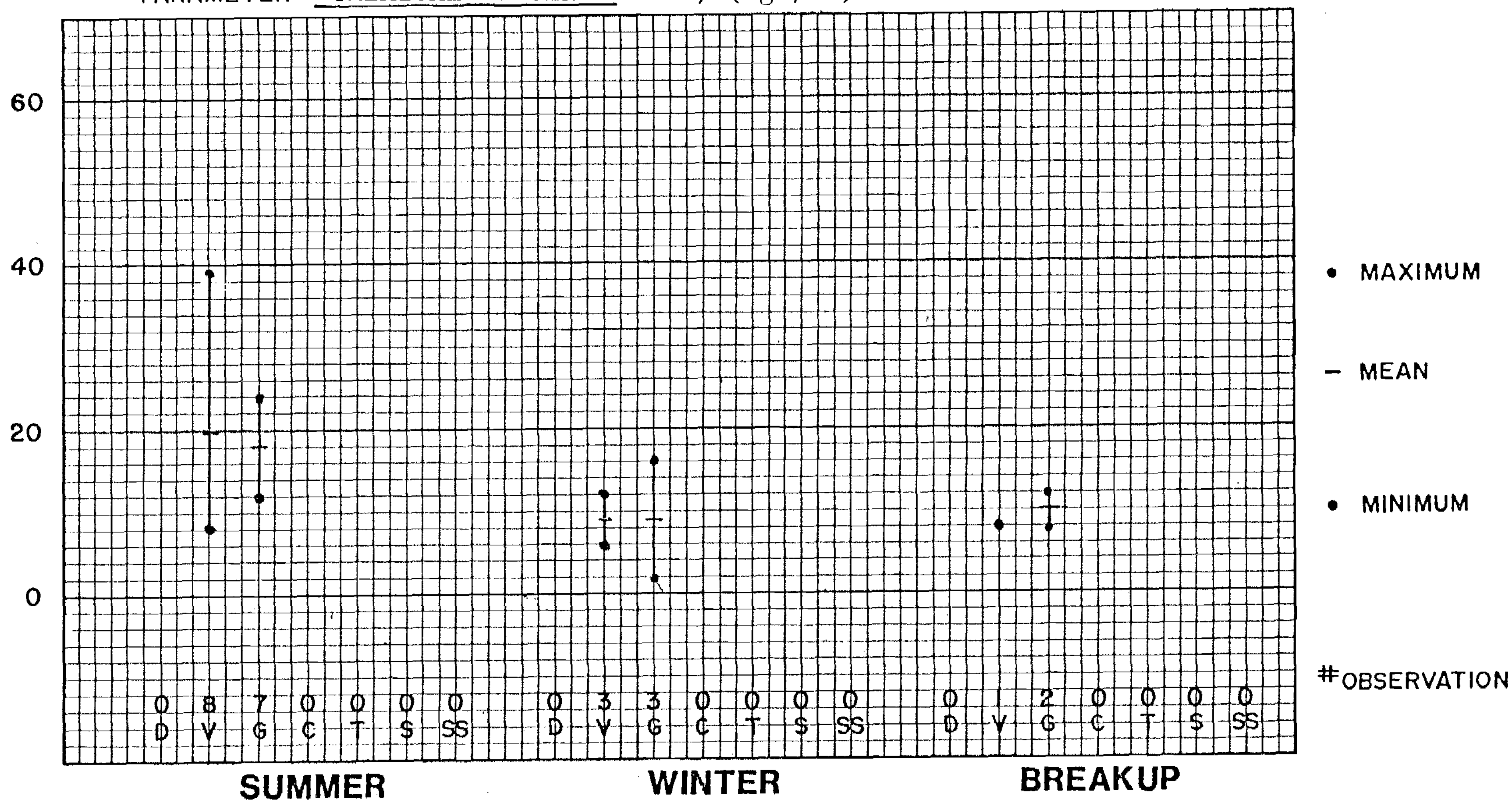
DATA SUMMARY - ZINC (t)

FIGURE 2.39

PARAMETER: CHEMICAL OXYGEN DEMAND, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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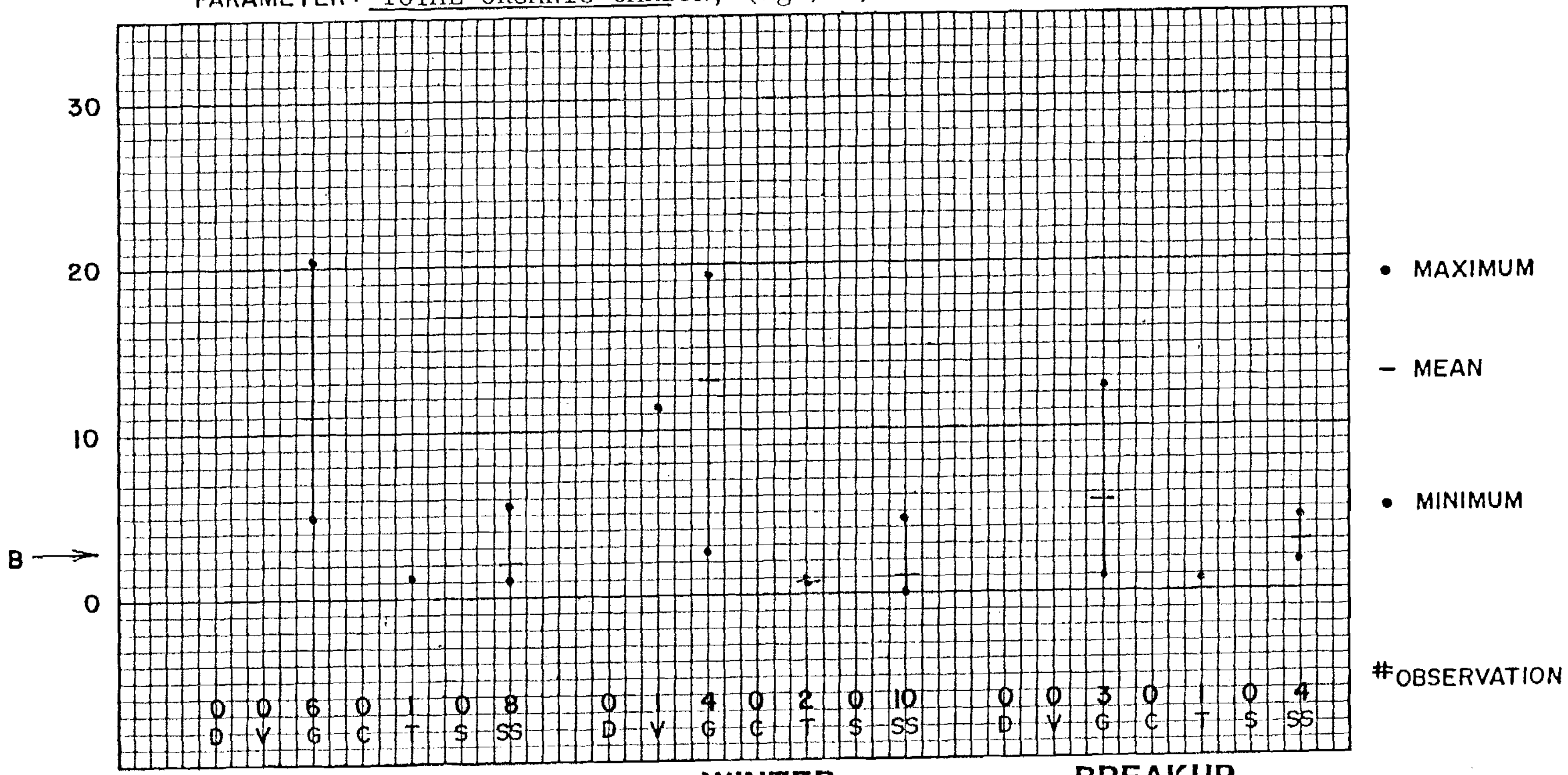
DATA SUMMARY - CHEMICAL OXYGEN DEMAND

FIGURE 2.40

PARAMETER: TOTAL ORGANIC CARBON, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. No criterion established

B. Waters containing less than 3.0 mg/l have been observed to be relatively clean, (McNeely et al, 1979).

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DATA SUMMARY TOTAL ORGANIC CARBON

FIGURE 2.41

3 - REPORT ON FISH, WILDLIFE, AND BOTANICAL RESOURCES

3.1 - Description of Botanical Resources

Descriptions of vegetation/habitat types in the upper basin and transmission corridors were based on aerial photograph interpretation and on air and ground reconnaissance. Ocular estimates of the cover of dominant species were used to classify the vegetation according to the system developed by Viereck and Dyrness (1980). High altitude (U-2) color infrared photographs and LANDSAT imagery were used to map the vegetation cover types. Vegetation of the entire upper Susitna River drainage (upstream of Gold Creek) was mapped at a scale of 1:250,000. Vegetation adjacent to and within 16 km of the upper Susitna River and within the transmission corridors was mapped at a scale of 1:63,360. The vegetation within the proposed impact areas (that is, impoundments, areas within 0.8 km of impoundments, floodplain from Devil Canyon to Talkeetna, and borrow sites) was mapped at a scale of 1:24,000. Delineation of wetlands was based on the classification of Cowardin et al. (1979).

Reconnaissance-level surveys were made of each major vegetation type. During these ground surveys, information was obtained on species composition, community structure, wildlife habitat, and physical characteristics of the site.

Descriptions of downstream floodplain plant communities were based on quantitative descriptions of 29 stands between the Deshka River and a location 11 km north of Talkeetna. Vegetation cover was estimated on four to eight randomly located 30-meter transects within each stand. Density, age, height, and diameter breast height (dbh) of trees and tall shrubs were measured along each transect; density, age, height, and width of low shrubs were also measured.

(a) Regional Botanical Setting

The upper Susitna River basin is located in the Pacific Mountain physiographic division in southcentral Alaska (Joint Federal-State Land Use Planning Commission for Alaska 1973). The Susitna basin occurs within an ecoregion classified by Bailey (1976, 1978) as the Alaska Range Province of the Subarctic Division.

The Susitna River system drains parts of the Alaska Range on the north and parts of the Talkeetna Mountains on the south (Figure 1.3). Many areas along the east-west portion of the river between the confluences of Portage Creek and the Oshetna River are steep and covered with conifer, deciduous, and mixed conifer and deciduous forests. Flat benches occur at the tops of these banks and usually contain low shrub or woodland conifer communities. Rising from these benches are low mountains covered by sedge-grass tundra and mat and cushion tundra.

The southeastern portion of the study area between the Susitna River and Lake Louise is characterized by extensive flat areas covered with low shrubland and woodland conifer communities, which, because of intergradations, are often intermixed and difficult to distinguish in the field or on aerial photographs. To the northeast, the area along the Susitna River between the Maclaren River and the Denali Highway is covered with woodland and open spruce stands. Farther east, the area has more low shrubland cover. The Clearwater Mountains north of the Denali Highway have extensive tundra vegetation. The floodplain of the Susitna River north of the Denali Highway has woodland spruce and willow stands, while the Alaska Range contains most of the permanent snowfields and glaciers in the study area.

The steep sections and some adjacent areas along the east-west portions of the river are considered in the closed spruce-hardwood forest type of Viereck and Little (1972), the moderately high mixed evergreen and deciduous forest map unit of Spetzman (1963), or the upland spruce hardwood forest of the Joint Federal-State Land Use Planning Commission of Alaska (1973). Whichever label one chooses, this type of vegetation is found mainly along rivers in the southcentral and interior regions of the state.

Both the benches bordering this same east-west portion of the river and the area around the Maclaren River are classified as moist tundra in all three of the previously mentioned references. This classification includes herbaceous meadows as well as shrub-dominated areas, both of which also occur around the Brooks Range, on the Seward Peninsula, and near the Killuck Mountains.

The extensive flats in the lower Oshetna River and Lake Louise areas, in the southeastern portion of the study area, are considered open, low growing spruce forests by Viereck and Little (1972), low mixed evergreen and deciduous forests by Spetzman (1963), and lowland spruce-hardwood forests by the Joint Federal-State Land Use Planning Commission of Alaska (1973). Viereck and Little's (1972) description appears most appropriate, since the area is covered primarily by spruce stands with treeless bogs.

The vegetation along the lower mountains, and the lower slopes of the higher mountains, was classified as alpine tundra by Viereck and Little (1972) and the Joint Federal-State Land Use Planning Commission (1973) and as barren and sparse dry tundra by Spetzman (1963). In the current study, some of these areas were mapped separately as rock, while other areas were mapped as sedge-grass tundra or mat and cushion tundra, whereas the previous maps included the rock in the alpine tundra. Some areas mapped as rock do have some important pioneering species growing in crevices, but the plants provided negligible ground cover. Alpine tundra grows on mountains throughout the state.

The downstream floodplain is a part of the Cook Inlet-Susitna Lowlands, a portion of the trough which forms a major bifurcation in the Pacific Mountain System (Joint Federal-State Land Use Planning Commission for Alaska 1973). This region is generally flat, occurs mostly below 150 m in elevation, and experiences a climate that is transitional between maritime and continental. The growing season is at least one month longer than that in the upper basin. The vegetation of this region is considered closed spruce-hardwood forest by Viereck and Little (1972), moderately mixed evergreen and deciduous forest or high evergreen spruce forested by Spetzman (1963), and the upland spruce-hardwood or bottomland spruce-poplar forest by the Joint Federal-State Land Use Planning

Commission (1973). White spruce, balsam poplar, paper birch, and alder (see Table 3.1 for scientific names of plants) are all important species in the floodplain vegetation. Additionally, willows and horsetails are dominant aspects of pioneer, non-forested communities.

(b) Vegetation/Habitat Types

The vegetation/habitat types described in this section include those in the upper basin (upstream of Gold Creek), the downstream floodplain (Devil Canyon to Delta Islands), and the transmission line corridors. Additional description information is presented in the Plant Ecology Studies - First Annual Report (APA 1980b). Vegetation cover maps for the entire upper basin and an area 16 km on either side of the river from Gold Creek to the mouth of the Maclaren River are presented in Figure 3.1 and in Figures 3.2 through 3.4, respectively.

The area covered by each vegetation/habitat cover type is presented in Tables 3.2 and 3.3. Vegetation/habitat cover maps for the transmission line corridors are presented in Figures 3.5 through 3.9; corresponding area measurements are provided in Tables 3.4 and 3.5.

(i) Upper Basin

- General Description of Forest Types

Forest vegetation/habitat types were located at the lower elevations of the upper basin (Figures 3.1 through 3.4). The average elevation of sampled areas was 523 m. These forest types were divided according to their dominant tree types (conifer, deciduous, or mixed) and then by tree crown cover percentage. Deciduous and conifer types had at least 75% of the tree cover provided by deciduous or conifer trees, respectively. The woodland type had between 10% and 25% tree cover and was only observed for conifer stands. Open stands contained 25-50% tree cover, while closed stands had over 50% tree cover. The boundary percentage between open and closed types was set at 50% rather than the 60% that Viereck and Dyrness (1980) used, since the former percentage was easier to estimate both on the aerial photographs and in the field.

Conifer, deciduous, and mixed stands with open canopies were observed in the field, while the only stands with closed canopies located in the field were deciduous and mixed. One closed conifer area that appeared on the aerial photographs near Lake Louise was not field checked. All forested stands had almost complete vegetation cover with 80-95% ground layer cover.

- Spruce Forests

Spruce stands were dominated either by white spruce (see Table 3.1 for list of scientific names) or black spruce and contained a well-developed ground layer, which itself accounted for most of the vegetation cover. The layer structure of open black and white spruce stands was similar, except that white spruce stands contained more overstory, a reflection of the generally larger size of white spruce trees. These units were mapped only at the 1:24,000 and 1:63,360 (Figures 3.2 through 3.4) scales. Another difference was that the overstory in open white spruce stands was less variable in height among stands than was the overstory in black spruce stands. Open spruce stands were usually found on slopes or flatlands along the rivers at elevations averaging 487 m. Overstory provided almost one-fourth cover in open stands which contained trees several meters tall.

While the white spruce cover was concentrated in the overstory layer, most of the black spruce tree cover was contained in the shrub layer. Black spruce stands contained low shrubs, such as crowberry, northern Labrador tea, bog blueberry, and mountain cranberry in the ground layer, while prickly rose and bluejoint were the most important ground layer species in open white spruce. Twin-flower was important in the white spruce stands but was not observed in the black spruce stands, possibly reflecting that ground species' preference for better-drained soils. In each of these mapping units, 30 to 35 identified species were encountered. In these open white and black spruce stands, feather mosses covered as much ground as trees did. Low shrubs, such as crowberry, northern Labrador tea, bog blueberry, and mountain cranberry accounted for much of the woody ground layer. Important herbaceous species included bluejoint and horsetails.

Northern Labrador tea, Labrador tea, bog blueberry, mountain cranberry, and sphagnum and feather mosses were found in black spruce forests in the upper Susitna River basin. Crowberry, nagoonberry, and woodland horsetail were also important in black spruce stands; however, these varieties were not reported along the Chenan River by Virecek (1970).

Meadow horsetail and feather mosses provided significant amounts of cover in white spruce stands along the Chena River (Viereck 1970) and in the upper Susitna River basin, but bluejoint, twinflower, and the moss Ptilium crista-castrensis were apparently more important along the Susitna River than along the Chena.

All woodland spruce stands visited were black spruce. Here, it was observed that, unlike open spruce stands, woodland stands were composed of scattered, stunted trees, and the overstory was almost negligible. One reason for this pattern is that this vegetation/habitat type was usually found on the relatively level benches where soils were poorly drained. Average elevation of sampled areas was 620 m. The resulting trees were usually too small to qualify for the overstory layer because trunks were <10 cm dbh. Maximum heights were less than two meters in some areas.

In these woodland stands, sphagnum mosses, not feather mosses, were the most important cover species; important ground layer species included sedges, woodland horsetail, and low shrubs similar to those found in the open spruce stands. Slightly over 30 identified species were encountered in the woodland spruce vegetation/habitat type.

Woodland spruce sites graded into boggy areas where tree cover might be less than 10% and where the vegetation resembled muskegs. Low birch shrub stands and woodland spruce were frequently difficult to distinguish in the field because birch stands sometimes had scattered trees which, on occasion, produced almost 10% cover. On aerial photographs, the overall pattern created by small trees produced similar textures for woodland spruce and for low birch shrub sites. This phenomenon, along with the fact that these areas took on a similar color when photographed (dark gray), made distinguishing between them difficult.

Among black spruce stands, those occupying significant slopes (8-10°) appeared to be more productive of browse species and, in fact, received noticeably greater use by moose than did other black spruce areas. Compared to other vegetation types, browse production was low, but since the browse had incurred heavy use, such stands appeared to provide important cover areas during severe weather. Open black spruce stands on the flats were generally very poor in terms of forage production, but some caribou sign was present. Skoog (1968) considered this forest type to represent a good supply of terrestrial forage lichens for caribou in winter.

- Deciduous Forests

Deciduous forest vegetation usually had a greater overstory cover than had spruce stands because individual trees had more foliage cover. These types were restricted mostly to the steep banks and floodplain along the river (Figures 3.2 through 3.4). Elevations averaged 582 m, with closed stands occurring at average elevations of 560 m and open stands at 625 m. They had almost complete vegetation cover, with an especially well-developed ground layer. While the overstory layer in closed stands covered almost three-fourths of the area, it only covered about three-eighths in open stands. Overstory was sometimes 15 m tall and, in the balsam poplar stands, even taller. Paper birch, trembling aspen or balsam poplar dominated the overstory. Neither the shrub layer nor the understory layer was of major importance. Important woody species in the ground layer in both types included crowberry, northern Labrador tea, bog blueberry, and mountain cranberry. Open stands appeared to have more woody cover in the ground layer than did the closed stands, while closed stands had more herbaceous components, such as bunchberry, bluejoint, and oak fern. Sixteen identified species were encountered in open deciduous forest types; in closed forest, 31 were found.

Closed deciduous stands were separated on the 1:63,360-scale map (Figures 3.2 through 3.4) according to the dominant species:

either balsam poplar or paper birch. Minor amounts of trembling aspen were also found but were barely large enough to sample and not large enough to map.

Closed balsam poplar generally occurred on islands in the river or on flat areas alongside the river. Balsam poplar was usually the first tree in the successional stage of vegetation development on alluvial deposits. The trees themselves provided about three-fourths cover. The ground layer was well developed and included bunchberry, crowberry, northern Labrador tea, bog blueberry, and mountain cranberry. About 14 species were encountered and identified in these areas.

Closed paper birch stands occurred on steep, usually south-facing slopes. The vertical layer structure is similar to the closed balsam poplar stands: three-fourths overstory, a well-developed ground layer, and relatively unimportant shrub and understory layers. The most important ground layer species were bunchberry, bog blueberry, bluejoint, and oak fern. Twenty five species were identified in the birch stands.

The minor, closed trembling aspen stands were usually found on the upper portions of dry, south-facing slopes. Their general structure was similar to other closed deciduous stands in that there were well-developed overstory and ground layers but insignificant shrub and understory layers.

- Mixed Conifer-Deciduous Forests

Mixed conifer-deciduous forests were usually dominated by white spruce and paper birch. Elevations for mixed conifer-deciduous forests averaged 466 m, with closed stands having a mean elevation near 425 m and open stands occurring around 482 m. Most of the larger stands occurred on slopes downstream from Tsusena Creek (Figures 3.2 through 3.4). These were probably successional stands, which developed as spruce replaced deciduous trees.

Cover in these vegetation/habitat types was almost complete with a well-developed ground layer containing important amounts of bluejoint, bunchberry, woodland horsetail, and Ptilium. The extent of overstory cover for the mixed conifer deciduous vegetation/habitat types fell between that for spruce stands and that for deciduous stands. Overstory cover in closed mixed stands was about 60%, while that in open mixed stands was 38%. The height of the overstory was sometimes up to 20 m. The shrub layer was more important in the open stands, mostly as a result of tall blueberry willow. Bog blueberry was an important ground species in the open mixed stands. Forty identified vascular plant species were encountered in open mixed stands; 29 were found in closed mixed stands.

- General Discussion of Forest Types

Forested communities in the upper Susitna River basin were similar to those described by Viereck (1975). Black spruce generally occurred in wetter sites than white spruce did, while deciduous or mixed forests as well as all closed forests occurred on warmer sites than those supporting spruce. The drier of these closed sites were usually deciduous, while the moister ones either were mixed or were dominated by spruce. Deciduous and mixed forest stands were considered earlier successional stages of the conifer stands (Viereck 1970, 1975 and Hettinger and Janz 1974).

In general, the deciduous and the mixed conifer-deciduous forests, particularly in the closed stands, appeared to represent a relatively poor forage resource for moose and caribou. Steep slopes often associated with these types might also be partially responsible for the low preference by ungulates. Natural records of browsing intensity, as indicated by the structure of paper birch suckers, suggested that these forest types may incur heavy use in severe winters. Skoog (1968) stated that these types were little used by caribou at any time of the year. The frequency of berry-filled bear scats in these types in spring suggested that these areas might be an important food resource for black bears as they come out of winter torpor. The open nature of the understory vegetation, however, made sighting of fecal piles easier in these forest types and, therefore, positively biased any comparison with other types.

- Tundra Types

Tundra communities usually occurring above the present limit of tree growth (Figure 3.1) exhibited approximately 70 identified vascular plant species. Most of the well-vegetated tundra communities occurred on flat to gently sloping areas, while sparser vegetation occurred on steep or rocky terrain. Although aspects of tundra vegetation/ habitat types were variable, four distinct subtypes occurred in areas large enough to map: wet sedge-grass tundra, mesic sedge-grass tundra, herbaceous alpine tundra, and closed mat and cushion communities.

Wet sedge-grass tundra communities occurred at an average elevation of 587 m in wet, depressed areas with poor drainage. They had almost total vegetation cover, with most of it occurring in the ground layer. Nineteen species were identified. The most important herbaceous species were sedges, especially water sedge; bluejoint; and sphagnum as well as several other unidentified mosses. The shrub layer, when it was present, contained scattered individual willows. Wet sedge-grass communities could potentially contain up to 10% cover of erect shrubs. There was usually a large amount of organic matter in these soils, and there was sometimes a thick organic layer on top of mineral soil.

Mesic sedge-grass tundra generally occurred at an average elevation of 1372 m on rolling uplands with well-drained soils. The soils were well-developed in some areas, but in others, the soil occurred as patches alternating with rocks. Nine identified species were identified, with total vegetation cover between half and three-fourths of the area. All vegetation was low in the ground layer, usually less than 30 cm tall. Bigelow sedge was the most common species and accounted for almost half of the total vegetation cover.

Two types of herbaceous alpine tundra occurred in the upper Susitna River basin, although only one herb-sedge occurred in areas large enough to map. Herb-sedge communities occurred at elevations of around 1295 m near the glaciers, particularly the West Fork Glacier, where there existed gentle slopes of fairly well-drained and relatively well-developed soils. These were basically mineral soils but contained about 5% organic matter. Some of the soil may also have developed from loess. Vegetation cover was almost complete, but cover was dispersed evenly among the many species present so that no group of species dominated the area. Because of both time constraints and the complexity of the vegetation, no estimates were made of cover. All vegetation occurred in the ground layer, and approximately 42 identified species were encountered in the one area of herb-sedge tundra visited.

The other type of herbaceous alpine community was found in small, isolated rocky areas that were too small to map or to sample. Small forbs and, sometimes, shrubs grew in the pockets of mineral soil imbedded between the rocks.

The fourth major type of tundra community was the mat and cushion tundra, which was found at high elevations (1013 m) on dry, windy ridges. Vegetation covered about three-fourths of the area and was usually less than 20 to 30 cm tall. Lichens and low mat-forming shrubs, such as dwarf arctic birch, crowberry, bearberry, and bog blueberry, dominated these areas, and soils were shallow and coarse.

Diverse wildlife occupied the high elevation tundra communities in summer. Most obvious were whimbrel, caribou, black and brown bears, ptarmigan, hoary marmots, and arctic ground squirrels. Whimbrels were frequently spotted here in early summer. Bear scat indicated over wintered berries were the major attraction for bears in June, although many squirrel dens were also found which had been excavated by bears. Caribou were more frequently sighted in the sedge-grass tundra than in any other type. In fact, Skoog (1968) considered sedge-grass tundra to be important year-round range for caribou in this region. On the other hand, he considered mat and cushion tundra to be a more important winter forage supply, since its wind-swept condition generally meant it was relatively snow-free.

Wet sedge-grass communities, more common below tree line, showed use by moose where browse was available. Otherwise, these types were more important to wading birds and, where topography allowed dam building, to beaver. In many cases, in fact, the wet sedge-grass vegetation was likely the result of beaver activity.

- General Description of Shrub Types

Shrubland vegetation/habitat types were the most prevalent types in the upper Susitna River basin (Figure 3.1 and Table 3.2). They generally occurred at higher elevations than forest communities but at lower elevations than tundra types. Most areas, particularly the low shrub, were found on extensive, fairly level benches at mid-elevations throughout the upper basin. Less extensive areas, usually tall shrub, were found on steep slopes above the river. While aspects of the shrubland vegetation/habitat types were variable, two main types, tall and low, were found, with each being further divided by the percentage shrub cover into closed and open types. Approximately 65 identified species were encountered in this overall type.

- Tall Shrub Types

Tall shrub communities were dominated by Sitka alder and were found mostly on steep slopes above the river or sometimes above the flat benches at an average elevation of 573 m. Many of these stands were two to four meters tall. Approximately 25 identified species were encountered in the alder stands, whether closed or open.

Along the slopes by the river, these stands frequently occurred as stringers through other vegetation/habitat types. Many areas also contained alder as a ring around a mountain at a certain elevation or in a strip along a river drainage, as at Portage Creek. The closed stands had almost complete vegetation cover, with the ground layer and understory accounting for most of the cover. Portions of some stands were like thickets. Again, alder provided the most cover, with bluejoint and woodland horsetail making up most of the ground layer cover.

Only one open alder stand was visited. It had less vegetation cover than the closed alder sites, and most of the vegetation was in the understory layer. Bluejoint was the most important ground layer species; white spruce was present in both the overstory and understory. This mixture of alder with white spruce indicated that this was probably a successional stand.

Hanson's (1953) description of alder types was similar to those found in the upper Susitna basin in that these thickets occurred on well-drained slopes and varied from one to four meters tall. In many cases, bluejoint was the dominant ground layer species. Hanson (1953) also mentioned Beauverd spiraea and bog blueberry as important species, which was consistent with the findings of the present study. Hanson (1953) also observed birch shrubs as an important species in alder stands, but the alder stands encountered in the upper Susitna River basin did not contain birch shrubs. In contrast, the Susitna stands contained important quantities of woodland horsetail. As in the Susitna study, Hettinger and Janz (1974) likewise observed that alder stands occurred on steeper slopes and older riparian sites.

One alder stand located on a slope of the Susitna canyon (R11E,T29N) was very heavily used by moose. Currant appeared to be highly preferred browse in this stand. Willow was important browse in all stands, and certain individuals of American green alder were heavily browsed.

- Low Shrub Types

As in earlier studies in northwestern (Hanson 1953) and northeastern Alaska (Hettinger and Janz 1974), low shrub vegetation/habitat types were common in the upper Susitna River basin. Low shrub communities were found on the extensive, relatively flat benches where soils were frequently wet and gleyed but, except for those supporting willow types, usually lacking standing water. Average elevation was about 781 m. Over 40 identified species were encountered in this vegetation/habitat type. Subtypes included birch, willow, and a mixture of the two. (Because of the gradations between them, descriptions of the subtypes are very general).

Birch shrub stands were usually dominated by resin birch about 1.0 m tall and contained several other species of low shrubs, especially northern Labrador tea. The most important associated species in these stands was bog blueberry, while mosses and lichens contributed an important amount of cover. In some stands, there was a buildup of soil and debris around the base of each birch shrub clump, creating a large amount of microrelief. Sometimes, the stands were dense, like a thicket, while others had large openings between individual birch shrubs. Scattered black spruce occurred in some stands contributing almost 10% cover. Hence, low shrub and woodland black spruce stands were difficult to distinguish on the ground and on the aerial photographs. The two species of birch shrub, resin and dwarf arctic birch, were sometimes difficult to distinguish based on leaf shape and plant height. Viereck (1966) also commented on this problem.

Willow stands were usually found in wetter areas, frequently with standing water. Diamond willow sometimes formed thickets along small streams at high elevations. Water sedge was the important herbaceous species in these stands. Because of the wetness, these communities were usually less diverse than birch shrub stands. Willows frequently also had soil and debris built up at their bases, with standing or running water in the troughs.

The birch and willow types were further divided into open and closed stands. Both open and closed stands had almost complete vegetation cover. The ground and shrub layers contributed similar amounts of cover in closed stands, while the ground layer alone provided most of the cover in the open communities.

Moreover, shrub layer cover estimates might be high because of problems in estimating cover from the ground, the same problem encountered in the forest types.

Associated species similar to those noted by Hanson (1953) and Hettinger and Janz (1974) were observed in the Susitna area and included northern Labrador tea and bog blueberry. Mountain cranberry, however, while not important in the northwestern part of the state, was important in both northeastern Alaska and in the Susitna region.

Birch shrub communities apparently received moderate use by moose most of the year. It was obvious, however, that stands with more willow were preferred. Indeed, willow stands received greater use than any other vegetation type. Feltleaf willow and diamond willow were heavily utilized in most areas.

Caribou sign, too, were frequent in birch communities. Skoog (1968) found that leaves of resin birch were important food for caribou in summer, and in winter, lichens were important. He found that caribou feed on willows in both spring and fall, and he considered willow stands important to the ecology of caribou. The present study's findings agree with this conclusion, with the exception that, in the Susitna area, apparently only those stands above the rim of the river canyon are important to caribou.

- Herbaceous Types

Two herbaceous types were found in the upper basin. Grasslands dominated by bluejoint were present on level to sloping areas at lower elevations along the river and along the Portage Creek drainage (Figure 3.2). Herbaceous pioneer communities were present on gravel and sand bars that had recently become vegetated. Soils here had little organic matter and often had a large number of cobbles. Pioneer species included horsetails, lupines, and alpine sweetvetch.

- Unvegetated Areas

Three classes of unvegetated areas are depicted on the maps: (Figures 3.1 to 3.4) water, rock, and snow and ice. Lakes and streams were included in the water category. Lakes were generally found along flat benches and ranged in size from small ponds to large lakes, such as Big Lake (approximately 450 ha). Rock incorporated those areas of bedrock or deposited geologic materials supporting little or no vascular vegetation. Rock occurred as outcroppings, either at high elevations or along steep cliffs along the river, or as unconsolidated gravel in newly deposited river bars. The category snow and ice includes permanent snowfields and glaciers. Glaciers and permanent snowfields were most common at the northern end of the study area in the Alaska Range, although some did occur near the southern boundary in the Talkeetna Mountains.

(ii) Downstream Floodplain

An intensive study of the vegetation on the downstream floodplain (Devil Canyon to Delta Islands) was conducted during summer 1981. Tabular presentation of summarized data is not practical; consequently, a general description of each vegetation type encountered is provided below.

- Early Successional Stages

Early successional communities commonly found on the floodplain were dominated by horsetail, horsetail-willow, horsetail-balsam poplar, balsam poplar, or dryas vegetation. Horsetail was generally the first to invade silty or sandy sites. Established horsetail communities had approximately 40% cover by horsetail, 2% by balsam poplar seedlings, and 4% by willow. Bare ground was 47%. Willow and balsam poplar sometimes occurred on newly formed bars but usually did not become established until after the horsetail. The mean density of willow was 22,333 stems/ha, while balsam poplar density was 13,000 stems/ha. Rockier or more gravelly sites tended to have less horsetail cover.

In most cases, alder (thinleaf and Sitka) did not appear until two or three years after the willows and balsam poplar. Its rapid growth, however, made it the highest shrub after two to four years of growth. The average ages of willow, balsam poplar, and alder in early successional stands was 4.5, 6.5, and 3.2 years, respectively.

Dryas was visually dominant on gravelly sites having little silt. Living dryas, however, accounted for only 4% cover. Balsam poplar and dead dryas covered 6% and 7.5% respectively. Dryas is a nitrogen-fixing plant and benefits other species by adding nitrogen to the soil. Even so, vegetation on these sites is of poor form and is slow-growing until sufficient soil is deposited by wind and water, at which point dryas is important for stabilizing these soil deposits. Bare ground equaled 76% of cover; of that percentage, one-third was cobbles.

- Mid-Successional Stages

Deposition of sands and silts, elevating sites above the level of frequent flooding and freeing them from disturbance by ice and fast water, appeared to be necessary for transition of early successional vegetation to mid-successional stages. Mid-successional vegetation was characterized by immature balsam poplar or by thinleaf alder which had developed into tall shrubs or trees.

Total vegetation cover in alder stands averaged 87%. Trees and tall shrubs provided 29% and 46% cover, respectively. Bluejoint grass gave 44% cover; wormwood, 5%. Thinleaf alder dominated the overstory cover (59%), with balsam poplar providing 13%. Age and dimension data indicated that, initially, balsam poplar either lagged behind or was suppressed by alder until late in the mid-successional stage. Alder canopies were typically seven meters high, with protruding balsam poplar averaging eight meters. When balsam poplar did emerge through the alder canopy, it quickly doubled its height to approximately 17 m. Thinleaf alder and balsam poplar averaged 20 and 19 years, respectively. Density of alder >4 m high was 3,557 stems/ha, whereas there were only 414 stems/ha of balsam poplar. Density of browsable willow (>0.4 m high) was 3,333 stems/ha. Highbush cranberry (>0.4 m high) averaged 466 stems/ha. Browsable balsam poplar (>0.4 m, <4 cm dbh) had a density of 1,332 stems/ha.

Balsam poplar dominated the overstory of immature balsam poplar stands, giving 62% cover; thinleaf alder provided 40% cover. Bluejoint provided 23% of the ground cover; perennial forbs gave 9% cover. Total vegetation cover was 91%.

Balsam poplar tree (>4 m height) density was 620 stems/ha. Thinleaf alder density (all sizes) was 5,049 stems/ha. Browsable balsam poplar, willow, and highbush cranberry densities were 433, 400, and 633 stems/ha, respectively.

The average height of immature balsam poplar trees was 17.7 m with an average age of 44 years. Thinleaf alder averaged 6.6 m and 22.3 years. Compared with the ages of trees and tall shrubs in alder stands, immature balsam poplar stands appeared to represent a later phase of the mid-successional stage.

- Late (Mature) Successional Stages

As the balsam poplar stands mature, white spruce may appear in the canopy (a few may become evident as early as the alder stage). Eventually, the balsam poplar becomes decadent, leaving space for development of more balsam poplar or of spruce and birch. The factors responsible for development of the birch-spruce stands versus continuation of the balsam poplar are still unclear. Geographic locations and continuity of stands suggest, however, that birch-spruce forests occur on more stable sites than do mature or decadent balsam poplar forests.

Mature and decadent balsam poplar stands, collectively, averaged 90% total vegetal cover. Trees provided 50% cover, tall shrubs 43%, low shrubs 36%, perennial forbs 23%, and perennial grasses 12%. The average height of balsam poplar trees was 26.4 m, with an average age of 98 years. White spruce growing in these stands averaged 12.6 m and 100 years; thinleaf alder was 7.3 m and 28 years.

The density of balsam poplar trees was 293/ha. White spruce density was less than seven per hectare. Density of thinleaf alder (all sizes) was 4,801 stems/ha. Browsable highbush cranberry density was 21,831 stems/ha. No browsable balsam poplar or willow were present in the understory of mature or decadent balsam poplar stands. Prickly rose, wild currant, and American red raspberry, however, occurred at densities of 12,365; 6,566; and 6,133 stems/ha, respectively.

Birch-spruce communities were characterized in the overstory by 42% cover by paper birch and 12% cover by white spruce. Tall shrubs, predominantly thinleaf alder, accounted for 14% cover. Low shrubs, forbs, and grasses provided 40%, 44%, and 18% cover, respectively. Horsetail, highbush cranberry, prickly rose, and bluejoint were the dominant understory species, providing 30%, 19%, 20%, and 18% cover, respectively.

The average height and apparent age of paper birch trees was 15.3 m and 70 years; 70 years is a low estimate, since unrotted tree trunks were difficult to find. White spruce average 16.2 m and 90 years. Thinleaf alder (>4 m) averaged 5.6 m and 28 years.

The density of paper birch trees was 227/ha. There were 147 white spruce/ha and 1,525 alder (all sizes)/ha. Browsable willow, paper birch, highbush cranberry, and prickly rose had densities of 200; 39; 17,065; and 16,932 stems/ha, respectively. Birch-spruce stands were the most diverse of vegetation types found on the floodplain. There was some evidence that these stands are self-perpetuating. That is, upon overmaturity, the birch overstory falls, making the spruce more susceptible to wind throw and, thereby, allowing a paper birch shrub-alder/highbush cranberry-prickly rose community to become established. The shrub community then advances again to the birch-spruce forest condition. The woody species composition and density of the seral brush phase makes it ideal moose habitat, especially as it is interspersed with the more mature forest.

(iii) Healy to Fairbanks Transmission Corridor

The mapping units presented on Figures 3.5 through 3.7 and in Table 3.4 are based on vegetation characteristics and are named according to Viereck and Dyrness (1980). Since the same classification system was used, transmission corridor mapping units are similar to those used in the upper basin. Deciduous mapping units consist of aspen and/or birch and contain broadleaf vegetation. Complexes of types were used where individual types existed in the field but were too small to separate on the map. Some cover classes may be under estimated, since trees had started losing their leaves when the corridors were flown for field-checking.

The northern transmission corridor consists of three basic sections: Healy to Nenana River, Nenana River to Tanana River, and Tanana River to Fairbanks. The Healy to Nenana River section contains a dissected plateau on the west side, a relatively flat area in the middle, and the Parks Highway and Nenana River to the east. Vegetation along the ridges leading from the plateau is predominantly open spruce, open mixed spruce/deciduous, and open deciduous forest. The flat area is predominantly low shrub with sedge-grass and open and closed spruce types. Except along the streams, most of the spruce trees were relatively short.

The Tanana Flats area extends from just beyond the Nenana River crossing to the Tanana River. This section is characterized by a mosaic of wet vegetation types, including open spruce (usually with larch), low shrub, and wet sedge-grass. Locations of many types appear to be controlled by old stream meanders and drainage patterns. Some patches of deciduous forests also occur. Some portions of the mosaic could be delimited on the map, while others were too intermingled to separate. Similarly, dry streambeds have stringers of other vegetation, such as low shrub, through them, and frequently these could not be delimited on the map.

The section from the Tanana River to Fairbanks passes through rolling hills covered predominantly by open deciduous forest with small areas of spruce, usually in drainages. Some low areas of spruce contained larch (tamarack) but not as much as in the previous section. The woodland mixed patches in this section are generally cutover areas. Many of the closed spruce areas have very short, scrub-like individuals and appear more like a low shrub type.

Species of spruce were not checked on the ground, but stands in low, poorly drained areas were assumed to be black spruce. Individuals in better drained locations may be either species. These species could not be separated confidently without ground-checking many stands. Therefore, this vegetation was mapped spruce.

Most spruce areas between the Tanana River and Fairbanks contain only spruce and little larch, while about half the areas in the Tanana Flats section contain larch as well. Larch was not observed between Healy and the Nenana River. The spruce-larch mixture was easily visible from the air but could not be distinguished on the aerial imagery. The black spruce-larch type, which is confined in Alaska to the interior, is generally found only on wet lowland sites with shallow permafrost (Viereck and Dyrness 1980).

(iv) Willow-Cook Inlet Transmission Corridor

The Willow-Cook Inlet transmission corridor passes through an area dominated, first, by closed birch and mixed conifer-deciduous forests, next, by large wet sedge-grass marshes, and, finally, by open and closed spruce stands (Figures 3.8 and 3.9 and Table 3.5). Forested stands in this particular area of the Susitna valley are characterized by generally good stocking of relatively good quality birch, white spruce, aspen, and balsam poplar. Many of the stands, however, have poor regeneration and have developed a woodland/shrubland or woodland/grassland aspect. Birch is the predominant deciduous species. Localized stands of balsam poplar and aspen are associated with active river floodplain (Willow vicinity) and drier south slopes, respectively.

Wet sedge-grass is the second most dominant vegetation type in this area. Most stands are quite extensive and associated with diverse networks of ponds, lakes, and meandering streams. These areas are generally thought to be unsupportive of other types of vegetation except for scattered islands of black spruce and low shrub along drier margins.

White spruce is dominant in stand composition for most of interior Alaska but occupies a minority position in this part of the Susitna valley. The vegetation map of this corridor is not specific as to spruce species. Most of those areas identified, however, as closed and open spruce and occurring in areas dominated by mixed conifer-deciduous forest are likely white spruce. Spruce stands skirting wet sedge-grass or low shrub areas may be either white or black spruce, while most woodland spruce stands are black spruce.

(c) Floristics

In the upper Susitna River basin and downstream floodplain combined, 254 vascular plant species, occurring in 130 genera in 55 families, were identified. Some collected specimens have yet to be identified, and others need to be verified by experts in the field. This situation is particularly true for the *Carex* and *Salix* genera. The families containing the most species were Asteraceae (Compositae), Salicaceae, Rosaceae, Poaceae (Gramineae), Cyperaceae, and Ericaceae. The Salicaceae family was important from the standpoint of canopy cover, wildlife usage, and pioneering on gravel bars, whereas the Asteraceae contributed relatively minor cover. The genus *Salix* contained 17 species, tentatively, while *Carex* had 10 species and *Saxifraga* had nine species.

Seven genera of lichen, which included at least 11 species, were identified, while five taxa of mosses were identified. More extensive work on lichens and mosses would undoubtedly reveal many more species.

The major floristic and botanical feature observed in the study of the upper Susitna River basin was a tendency for lowland and alpine species of the Cook Inlet and coastal region to extend into the Susitna River drainage farther than botanical records indicate. Actually, this finding is to be expected because of the paucity of collections in the upper Susitna River basin previous to this study. A list of those species discovered in the upper basin which are outside of the range reported by Hulten (1968) are listed in Table 3.6.

(d) Wetlands and Aquatic Vegetation

Apparent wetlands within the direct impact areas were classified and mapped according to that system (Cowardin *et al*. 1979)recently adopted by the U.S. Fish and Wildlife Service (USDI 1980a). Lakes, ponds, rivers, and streams were not specifically classified. This study's estimates of total palustrine wetland acreages (Table 3.7) were extremely liberal, since the wetlands were highly integrated with non-wetlands and because no supporting soil data were available for each of the types. Also, although the mapping was performed using the U.S. Fish and Wildlife Service system, which is acceptable to the U.S. Army Corps of Engineers for permit applications, there are several wetlands mapped under this system which are outside of the Corps' jurisdiction. Isolated wetlands, for example, with an outflow of less than five cubic feet per second are included in Table 3.7 but are not within the Corps' jurisdiction.

Most of the water bodies in the upper basin occur on the upland plateau between the edge of the river canyon and the surrounding mountains.

There are virtually countless numbers of lakes in the large flats of the upper Susitna basin, such as those in the Lake Louise area. Most of the lakes and ponds immediately adjacent to the proposed impoundment area are classified according to Cowardin et al. (1979) as: Lacustrine-Limnetic-Unconsolidated Bottom or Aquatic Bed; or Lacustrine-Littoral-Aquatic Bed or Unconsolidated Bottom.

The dominant "true" aquatic vascular species of the water bodies were: horsetail, bur reed, water sedge, yellow pond lily, mare's tail, and bladderwort. Dominant "bank" or edge species included: horsetail, bluejoint, cotton grass, water sedge, marsh fivefinger, and buckbean. The Susitna River and its fast-flowing tributaries are essentially devoid of aquatic vegetation.

3.2 - Description of Wildlife Resources

(a) Big Game

A variety of methods were employed to study the big game species associated with the Susitna project. Dall sheep was the only species which was studied without the use of radio-telemetry; sheep numbers were determined through the use of aerial surveys. Radio collars were placed on moose (upstream and downstream), caribou, wolf, wolverine, brown bear, and black bear. The resulting telemetry data were utilized to determine movement patterns, home range size, den locations, calving grounds, habitat utilization, and territory size and location.

Aerial census procedures were also employed in the case of moose (upstream and downstream) and caribou. Several different estimating techniques were applied to the census and survey data to determine the distribution and abundance of moose as well as the size of the Nelchina caribou herd.

A variety of physiological and morphometric data were collected on animals during the radio-collaring procedure. This included the analysis of blood and hair samples, teeth (for aging), and the measurement of important morphometric features.

Both bear and wolf dens were visited on the ground and their characteristics recorded. Two wolf dens were intensively monitored to determine daily activity patterns and the reaction of denning wolves to various types of human disturbance. Wolf scats were also collected from den and rendezvous sites and analyzed for food habits information. The Jay Creek mineral lick, used by Dall sheep, was visited to determine the extent of usage and to collect soil samples for mineral analysis.

A detailed survey of browse availability and utilization was conducted along the lower Susitna River from Devil Canyon to the Delta Islands. This entailed determining the relative amount of five key browse species that were available along numerous sampling transects in addition to the percentage of each species that had been utilized by moose.

The common and scientific names of the big game species are presented on Table 3.8.

(i) Moose - Downstream

Because the ADF&G Phase I report on downstream moose studies was not yet available, the following description of downstream moose is based on a compilation of information taken from previous ADF&G Susitna reports. As a result, the conclusions should be viewed as preliminary, and in some cases obvious voids exist in the data. The information that was available, however, is sufficient to develop at least a preliminary understanding of the moose resource associated with the lower Susitna River.

Prior to 1930, few moose were found in the Susitna Valley (Spencer and Chatelain 1953). At that time, moose likely utilized riparian habitats and what few browse species were available in the mature spruce-hardwood forest. It wasn't until man-caused fires and clearing of land during and after railroad construction created prime moose habitat that the moose population rapidly increased. In the early 1950's the Susitna Valley was termed "probably the most productive moose habitat in the [Alaska] Territory" (Chatelain 1951). Rausch (1958) stated that the period of peak moose abundance along the railroad between Houston and Talkeetna was February and that movement from the foothills to the railroad tracks was basically seasonal and influenced, but not necessarily caused, by deep snow. The moose population presently remains at relatively high levels.

For the Susitna studies, a total of 39 moose over a two-year period were radio-collared in an attempt to determine the movement patterns of and timing of riverine use by moose that frequent the lower Susitna River. Of these 39 moose, 10 were collared in 1980 and 29 in 1981. Some moose slipped their collars, and one was killed by a hunter, which left a total of 35 moose with functional collars during the spring of 1981. These 35 moose had been captured in the following general locations: Devil Canyon to Gold Creek - 4, Gold Creek to Talkeetna - 6, Talkeetna to Sunshine Bridge - 6, Montana Creek to Sheep Creek Slough - 9, and Kashwitna River to Delta Islands - 10. Of these 35 moose, eight were males ranging in age from 2 to 11 years, and 27 were females ranging in age from 3 to 21 years.

- Distribution and Movement Patterns

Due to differences in the number of radio-collared moose that were monitored in 1980 (6) versus 1981 (35) and the absence of a summarizing report from ADF&G, the following discussion of moose movements and distribution is broken down into the two study periods for which data are presently available: 1980 and the first 7 months of 1981.

o 1980 Study Period

During 1980, a total of 131 radio relocations were made; of these 89 (68%) were visual observations of the moose. All three types of migratory patterns [as presented by LeResche (1974)] were found in the study area: Type A, resident; Type B, migratory between two ranges; and Type C, migratory among three ranges. The bulls were either Type A or Type C. Each of the three collared cows exhibited a different type of migratory behavior.

Home range size and migration distances of moose in the area studied were likely intermediate to those found for moose in other parts of Alaska or North America. This characteristic is a function of physiography, since the availability of all life requisites between an area just west of the Susitna River eastward to the Talkeetna Mountain benches makes longer moose movements unnecessary.

From observations of the moose that winter on the river below Talkeetna, it was learned that some calve, summer, rut, and possibly winter in the flats west of the Susitna; some calve, summer, rut, and possibly winter in the forest between the river and the mountains; others spend spring, summer, fall, and possibly winter in the western benches and drainages of the Talkeetna Mountains.

Several rutting areas were documented. These were found deep into the creek and river drainages of the Talkeetna Mountains and on the benchland near timberline at the mouths of these canyons. Rutting bulls in the lowlands aggregated less and were frequently alone or in small groups of 2 to 5 moose.

No specific calving areas were recorded, but cows appeared to calve frequently on river islands. On boat trips up and down river in late May and in June, it was obvious that a fair although unknown number of cows had done so. Four cows with newborn calves were observed along the river, and the tracks of several others were seen on mud banks of islands.

The movement of moose on the river floodplain in late summer and early fall was less certain. In fall it appeared (from overflights but no quantitative data collection) that moose did not remain on the river floodplain. ADF&G biologists, however, observed them crossing the river, and hunter success along the river in September also indicated that moose were near the river in fall.

In general the home and seasonal range sizes were quite varied. Because there were some Type A moose in the study group, home ranges were as small as approximately 65 km^2 (25 mi^2). Seasonal ranges were often smaller. Type C moose had home ranges at least as large as 233 km^2 (90 mi^2). The timing and distances of migration were equally as varied. (For example, one cow moved from her summering to rutting area in early August, while another did so in late September). The longest distance traveled between summering and rutting areas was 64 km (40 mi).

o <u>1981 Study Period (January through July)</u>

Not long after the moose were captured and radio-collared, they began to emigrate from the river basin. By the end of April 1981, only four of the 35 radio-collared moose were still within the confines of the river banks.

On 28 April, 1981, of the 25 moose radio-collared within the river basin south of Talkeetna, 20 had moved to the west of the Susitna River, two were still in the river basin and only three were to the east of the river.

Of the 19 moose captured and radio-collared on the Susitna between Talkeetna and the Delta Islands, several in the Delta Island area itself remained within the confines of the river. Three of these spent a considerable amount of time on riverine islands; one of these three, which had been within the confines of the river since it was collared, moved off the river to the west only during the last week of July. Most others between Talkeetna and the Delta Islands left the river and did not return to it during calving. Only one of the 19 was east of the Susitna River at the end of July, and it was only during the last week of July that this moose moved to that location.

Moose captured on the Susitna River north of Talkeetna also left the river shortly after being radio-collared, but unlike those captured below Talkeetna, these appeared to return to the river between late May and early June, a time when calving normally occurs. Two cow moose who are residents in an area north of Talkeetna made relatively long forays [24-40 km (15-25 mi)] into apparently new range. Within a week or so, they were back in their usual range.

Several of the moose that have been monitored for more than one year have visited locations where they were found the last year. Though some distances traversed were great [25-40 km (15-25 mi)], relocations within the same hectare or so were not uncommon.

These data suggest that, for the 1980-1981 winter of relatively little snowfall, most of the moose using the riparian habitat came from the generally flat land to the west and that, because great quantities of snow did not accumulate in the Talkeetna Mountains, moose from the mountain area did not migrate to the river basin. It is also possible that migrant moose from the Talkeetna Mountains did winter in the river basin but simply spent spring and summer to the west of the Susitna before returning to the mountainous habitat in the fall.

For moose south of Talkeetna, movements of 16-24 km (10-15 mi) to the west of the river basin were not uncommon. These patterns of movement may be related to the depth of snow and the patterns of its disappearance in early spring. Areas to the west of the Susitna appeared to become snowfree before those to the east. This was particularly evident on the small knobs that rise to the elevations slightly above the general terrain and muskeg in the area. These higher sites are slightly drier and support birch in amounts equal to that of spruce. It is assumed that the disappearance of snow accelerated plant phenology on the west side of the river; it may have, in turn, attracted moose from the riparian habitats to the east.

For moose north of Talkeetna, movements to areas more than 5 km (3 mi) from the river have not occurred. Even in a year of relatively little snowfall, areas to the north of Talkeetna along the Susitna had an accumulation of 0.6 m (2 ft) or more. Because such snow depths presumably discourage lengthy movements by moose and also because forage species in that area are more confined to the riparian habitats, resident moose were relatively sedentary compared to those south of Talkeetna.

- Habitat Use

A preliminary consideration of the data revealed that during 1980, climax mixed birch/spruce (of high or medium density) was the habitat in which moose were observed in 46% of the observations. The remaining observations were made in a variety of habitats including black spruce, muskeg bogs, alder/willow, willow, alder, cottonwood/spruce and bluejoint fields.

It was surprising to find moose making so much use of mature conifer/hardwood vegetation, but an obvious bias in technique may account for the data. Most flights, and therefore most observations, were made from mid-morning to mid-afternoon. This was a time when most moose were bedded down. They may have eaten in a different habitat type earlier in the day or after the observation, but for ruminating they sought more protective cover.

On the other hand, on two separate radio-locating flights (18 June and 22 July) an unusual number of moose were observed in open muskeg/meadow habitats. It could be that particular type(s) of aquatic/semi-aquatic vegetation became available at those times and attracted moose into the relatively open habitats. Circumstantial evidence provides another possible explanation for moose using the open habitats. Several moose were observed running and shaking their necks and heads. One moose, up to its shoulders in water, was observed behaving in a similar manner. These behaviors appeared to be the result of insect harassment, and it is possible that moose were seeking relief in the open habitats where wind currents move more rapidly because of the lack of interfering vegetation.

In late May, several small groupings of moose were observed in areas on riverine islands where beavers had cut down mature cottonwood trees. It appeared that the moose had gathered to feed on the leaves and buds in the crown portions of the downed trees. Similar situations of temporary food availability probably arise when spring flood waters erode river and island banks and undermine the root systems of mature trees so they become top heavy, fall, and become available to moose.

- Food Habits

Only one study has been conducted in the vicinity of the study area to determine what moose eat. Rumen samples from railroad killed moose were collected by Rausch in 1957 and analyzed by Shepherd (1958). From 122 samples, 17 different food items were identified. Willow, birch and aspen comprised 97% of the identifiable material. These moose probably had been feeding in mixed birch/spruce habitats in several successional stages near the railroad tracks where they were killed. Along the river, few birch and no aspen were found and, therefore, moose using the river would have a different diet than that indicated by the above study.

- Browse Availability and Utilization

In 1980, in the overall study area, dense-climax cottonwood/spruce (13.1%) and sparse-low cottonwood/willow/alder (12.3%) were the most frequently encountered habitats. In the Sheep Creek Study Site, dense-medium and dense-tall cottonwood/willow/alder (18.4% and 15.9%, respectively) were the most abundant habitat types.

A mean of 1.4 browse plants/m^2 was recorded for all habitat types in the overall study area, and many habitats had browse densities close to that value. Browse species were most utilized in equisetum/willow (49.2%) and medium-tall cottonwood/willow/alder (36.4%) habitats and least utilized in medium-dense climax cottonwood/spruce (6.9%) and sparse-climax birch/spruce (4.0%).

Willow and cottonwood occurred most frequently in habitats that were in early successional stages of cottonwood/willow/alder. The percentages of utilization of these two species were: willow - 36.5%; cottonwood - 16.2%. The utilization of each was greatest, however, in habitats in which it less frequently occurred. Birch was seldom found on floodplain habitats, but, where it did occur near the river, it was well utilized (26.9%). Highbush cranberry and rose were found most in tall or climax habitats. Mean densities for highbush cranberry (1.1/m^2) and rose (0.9/m^2) were higher than those for willow (0.7/m^2) and cottonwood (0.6/m^2). The mean utilization of highbush cranberry (15.9%) was similar to that of cottonwood (16.2%) but both highbush cranberry and rose had lower percentages of utilizaion than did willow (36.5%).

On the Sheep Creek Study Site, as in the overall study area, about 20% of available browse plants were utilized. Dense-medium cottonwood/willow/alder contained the greatest density (2.6/m^2) of browse plants, but medium-tall cottonwood/willow/alder had the highest percentage of utilization (35.2%) of its available browse.

Approximately one-third of the available willow on the Sheep Creek Study Site was utilized by moose. Willow was most dense (2.4 plants/m^2) in dense-medium cottonwood/alder/willow but utilized most (70.3%) in medium-climax cottonwood/willow/alder. Cottonwood was less dense than willow (1.2/m^2 vs 1.6/m^2) and utilized much less (only 8.5%). No birch was found on the Sheep Creek Study Site. As in the overall study area, highbush cranberry and rose were most abundant in climax type habitats. There were mean densities of 1.5 and 1.0 plants/m^2 for the two species, respectively. Highbush cranberry was utilized twice as much as rose (16.3% vs 8.3%).

General observations indicated that alder was seldom browsed by moose, but in some localities a small alder clump could be heavily browsed. Some islands with good moose browse apparently are not used by moose over winter: moose sign indicated heavy use of some islands in the past but no use at the time of observation.

(ii) Moose - Upstream

The history of the Game Management Unit (GMU) 13 moose population has been described by Rausch (1969), Bishop and Rausch (1974), McIlroy (1974), and Ballard and Taylor (1980). Briefly, the GMU 13 moose population increased during the 1950's and peaked about 1960. After the severe winter of 1961-62, the population began declining and continued to decline with the severe winters occurring in 1965-66, 1971-72, and 1978-79. Fall calf-cow ratios, in addition to nearly all other population ratios, declined sharply and reached a record low for the basin in 1975. Although the decline was attributed to a variety of factors, predation by wolves was suspected of preventing the moose population from recovering during mild winters.

From 11 through 23 April 1980, 40 adult moose (37 females and three males) were captured and radio-collared in the Susitna moose study area (Figure 3.10). Three of these moose represented animals that had been radio-collared during previous studies. During March and May 1981, in an effort to provide additional movement information on portions of the Susitna study area not adequately sampled in 1980, an additional 34 moose (18 adults and 16 calves) were captured and radio-collared.

- Population Biology

o Age Structure

The average age of the 37 cow moose captured in spring 1980 was 9.4 years (s.d.=3.8), while the three bulls averaged 4.3 years (s.d.=0.6). The 12 adult cows captured in 1981 averaged 7.6 years (s.d.=2.9). Mean ages of cow moose tagged in the upper Susitna River basin in 1976 and 1977 (Ballard and Taylor 1980) were compared with those captured in 1980 and were found to be significantly younger ($P<0.05$).

o Pregnancy Rates

Of the 37 cow moose captured and examined in April 1980, 23 (62%) were determined to be pregnant, while in 1981, 11 of 14 (79%) were pregnant. Observations of the radio-collared cows following capture in 1980, however, revealed that four cows which had been diagnosed as not pregnant subsequently had calves. Therefore, the actual pregnancy rate for 1980 was at least 73% and may have been higher. The 1980 and 1981 pregnancy rates may, in actuality, have been comparable to the 88% observed in 1977, which was similar to rates determined elsewhere in Alaska (Ballard and Taylor 1980).

o Calf Production and Survival

Calf moose comprised 13% of the moose observed during the distribution survey in March 1980. This low calf percentage reflects poor calf survival during 1979-80, probably a result of predation (both bear and wolf) and perhaps some winter starvation. Farther upstream, above the Denali Highway, where both bear and wolf densities had been experimentally lowered (Ballard et al. 1980), calf moose comprised 33% of the moose counted in late May 1980, reflecting increased calf survival because of the lower predator densities. During 1980, of 32 cow moose radio-collared during the Susitna studies, 19 were subsequently observed with 30 calves for an observed calving rate of 0.94 calves/cow. Fifty-eight percent of the cows producing calves had twins. These rates of calf production were quite comparable with those observed in 1977 and 1978 (Ballard and Tobey 1981).

Mortality of newborn moose calves in 1980 was high. By 1 August 1980, 23 (77%) of the calves known to be associated with radio-collared cows were missing. Rates of 1980 calf loss were compared with those observed in 1977 and 1978. Although causes of moose calf mortality were not determined in 1980, the pattern of loss was quite similar to that observed in 1977 and 1978 when predation by brown bears was responsible for 79% of the calf deaths (Ballard et al. 1981a). Calf mortality appeared to continue at a high level in 1981 as well.

During the 1981 calving season, radio-collared moose were not monitored intensively enough to document parturition dates and rates of calf loss. Of the 46 sexually mature cow moose which could have produced calves, however, only 20 (43.5%) were observed with calves. Four (20%) produced twins. The calving rate for known producers was 1.2 calves/cow. Of the 24 known calves, 14 (58.3%) were missing by 28 July. This pattern of calf loss is quite similar to that in 1977, 1978, and 1980, when predation by bears accounted for most of the losses. Overall calf survival, however, may have improved in 1981.

o Condition Assessment and Carrying Capacity

Criteria developed by Franzmann and LeResche (1978) were utilized to assess the physical status of Susitna study area moose. Analyses performed on moose tagged in 1975 and 1977 had suggested that Susitna moose were in good physical condition relative to other Alaskan moose populations (Ballard and Taylor 1980). Adult moose examined in spring 1979, however, had the lowest blood parameters of any moose examined in GMU 13 and were judged to be nutritionally stressed because of the severity of the winter of 1978-79 (op. cit.).

Blood values were determined for 34 individual moose sampled in April 1980 and 13 adults sampled in 1981. The blood data collected in 1980 and 1981 suggested that over the previous few years, the physical condition of moose had deteriorated to some degree. One reason for their condition may have been poor quality habitat. It is generally accepted that good moose habitat is closely linked with the frequency of wildfire. Since there have not been any sizeable wildlfires in GMU 13 for at least 30 to 35 years (Ballard and Taylor 1980), a gradual deterioration in habitat quality may be occurring. Even though the quality or condition of moose habitat may be gradually deteriorating, however, available evidence suggests that the population is not yet at carrying capacity.

Although no formal browsing studies have been conducted in GMU 13, casual observations along the Susitna River and elsewhere in the unit suggest that the browsing intensity may be similar to that in Mount McKinley National Park (Denali National Park and Preserve) as reported by Wolf and Cowling (1981). Even at a heavy level of browsing intensity, however, the McKinley moose herd does not appear to be limited by range conditions but, instead, by predation (op. cit.). Wolf and Cowling (1981) speculated that the McKinley herd could increase an additional 10-15% before reaching carrying capacity. It is possible that moose in GMU 13 are also below range carrying capacity, as evidenced by moose population increases following reductions in predator densities.

Studies of moose calf mortality in the upper Susitna River basin north of the Denali Highway suggested that predation by bears was responsible for 79% of the early calf losses (Ballard et al. 1981a). A bear reduction program reduced early neonatal losses from an estimated 55% to an estimated 9% (Ballard et al. 1981b).

On the other hand, if the available moose range were at carrying capacity, a significant number of calves would have been expected to have died from starvation during the first winter following the bear reduction program. Such was not the case; the first and second year winter mortality was only 6% and 4%, respectively (op. cit.). It can be inferred from that increase in the moose population that the population is not limited, at least on a short-term basis, by range conditions. Further, it is possible that a 15% increase in the moose population to reach carrying capacity is actually minimal for that area because the bear reduction program alone may have allowed the population to increase by as much as 19%. In summary, it appears that although blood data suggested that range quality in the Susitna study area has deteriorated to an undetermined degree, other evidence suggests that the range could support a larger number of moose.

o Population Estimates

Three previously established moose census areas are located within the Susitna study area. These are count areas 6, 7, and 14. Surveys of these count areas were used to generate an estimate of the number of moose present in the Susitna study area during fall 1980.

Count areas 7 and 14 (Fig. 3.11) were intensively censused from 5 through 8 November 1980. A total of 743 moose were censused within 26 sample areas, which amounted to 948 km^2 or 39% of the total of 2,448 km^2 for count areas 7 and 14. Based on the 26 sample areas, 35% of the 2,448 km^2 census area was classified as low moose density; 38%, as medium moose density and 27%, as high moose density. Also, based upon census data, each stratification was estimated to contain the following number of moose/km^2: low--0.434, medium--0.713 and high--1.439. Thus, the estimated fall population for count areas 7 and 14 was 1,986 ± 371 (90% CI).

Next, in an effort to generate a sightability correction factor, portions of 10 sample areas within count areas 7 and 14 were randomly chosen and were resurveyed at a greater sampling intensity. With the additional surveying effort, it was estimated that during the census, approximately 98% of the moose were being observed yielding a correction factor of 1.03. Therefore, the adjusted population estimate for count areas 7 and 14 was 2,046 ± 382 (90 % CI).

On 29 November, in an attempt to provide a gross fall population estimate for the entire study area, those portions of the Susitna study area which had not been censused were stratified. A total of 179 moose was observed during 3.6 hours of surveying time. The area stratified amounted to 2,150 km^2 of which 1,456 km^2 were classified as low moose density; 663 km^2, as medium moose density; and only 31 km^2, as high moose density. The area covered by each stratum was then multiplied by the individual density estimates derived for count areas 7 and 14 to derive a crude population estimate of 1,151 moose. This figure, added to the population estimate for count areas 7 and 14, resulted in an estimated population in early November 1980 for the study area west of the Susitna and Oshetna rivers of approximately 3,197 moose.

Using methods similar to those described in the preceding paragraph, relative moose densities in count area 6 (Figure 3.11) were also stratified. This procedure was undertaken because count area 6 has a migratory population of moose which overwinter in the vicinity of the mouth of the Oshetna River. Of the 1,217 km^2 stratified, 528 km^2 (43%) were classified as low moose density, 536 km^2 (44%) were classified as medium moose density and 153 km^2 (13%) were classified as high moose density. Extrapolating the average moose densities per stratum derived for count areas 7 and 14 to the area of each stratum in count area 6, it was grossly estimated that the fall moose population for count area 6 was 830 animals.

- Movement Pattern

Between October 1976 and mid-August 1981, over 2,700 locations were obtained on approximately 207 moose of both sex and all age classes in the Susitna and Nelchina River basins of south-central Alaska (Ballard and Taylor 1980; Ballard et al. 1981a, 1981b). Radio-collared moose exhibited all of the types of movements described by LeResche (1974) for moose in North America. For purposes of this report, however, they could basically be divided into two groups, sedentary and migratory. A sedentary moose is defined as one which confines its movements to a relatively small area and where portions of the summer and winter range overlap. A migratory moose, on the other hand, is defined as one with a relatively large home range with non-overlapping summer and winter home ranges. The latter type of moose often moves from 16 to 93 km between seasonal home ranges.

In earlier moose movement studies (Ballard and Taylor 1980, Ballard et al. 1981a), it was suggested that most of the migratory moose were located from Jay Creek and eastward. Additional information collected in 1981 suggested that a large number of migratory moose also occur in the Watana Creek area.

Movement patterns of most moose examined from 1976 through 1981 appeared to approximate the drainage patterns of the tributaries of the mainstem rivers in the area. Consequently, most movements in the upper Susitna River basin involve a north-south pattern.

From October 1976 through December 1981, 33 radio-collared moose crossed the Susitna River a minimum of 73 occasions. Of the 75 moose captured in 1980 and 1981, 15 crossed the river in the area of the proposed impoundments a minimum of 40 times. Of the 40 river crossings, all occurred during May through November. Distribution of the crossings was as follows: May - 20%, June - 7.5%, July - 12.5%, August - 12.5%, September - 25%, October - 12.5%, and November - 10%.

On 24 March 1981, the Susitna River was censused for moose crossings from the mouth of Portage Creek to the mouth of the Tyone River. A total of 73 sets of moose tracks was observed crossing the river on this date. Based upon locations of radio-collared moose and upon track sightings, crossings of the Susitna River appear to occur throughout the proposed impoundment area but appear to be relatively concentrated in the following areas: from the mouth of Fog Creek to the area opposite Stephan Lake, from the mouth of Deadman Creek upstream for approximately eight kilometers, from Watana Creek to Jay Creek, and from Goose Creek upstream to Clearwater Creek.

o Home Range

Home ranges of radio-collared moose were relatively large, averaging 224.2 km^2 and ranging from 3.8 km^2 to 2,011 km^2. LeResche (1974) reported that, regardless of how far a moose moved between seasons, seasonal home ranges of moose were consistently small. A preliminary analysis of seasonal home range data where migration points were excluded suggested that moose in GMU 13 have significantly larger home ranges than those reported in the literature (Ballard and Taylor 1980). It is suspected that a more thorough analysis of these data will demonstrate that seasonal home ranges are substantially larger than reported earlier (op. cit.). Ballard et. al. (1980) and Ballard and Taylor (1980) compared the summer home ranges of cow moose accompanied by calves with those reported elsewhere in North America and found that ranges of GMU 13 moose were substantially larger. They also determined that predator densities influenced the movements and, subsequently, the home-range sizes of the cow-calf pairs. The large seasonal and the total home-range sizes reported in the present study probably reflect an adaptation by moose to exploit habitats which are only available on a seasonal basis.

- Distribution

o Fall

The general distribution of moose in November 1980 was reflected in stratification surveys conducted as part of a census. Both count areas 7 and 14 were stratified from fixed-wing aircraft from 2 through 4 November 1980. The Devil Canyon area was stratified on 29 November and count area 6 on 9 November 1980.

Based upon relative differences in moose tracks, numbers of moose observed, and homogeneity of habitat types, moose densities were stratified as high, medium, and low. Distribution patterns exhibited by radio-collared moose (Figure 3.11) were similar to those derived from the survey; generally moose densities were greater in upland regions located away from the proposed impoundment areas west of Jay Creek but were greater closer to the Watana impoundment east of Jay and Kosina creeks because of the proximity of upland areas.

o Winter

A moose winter distribution survey was conducted from 4 through 25 March 1980 in portions of the Susitna River basin containing subpopulations of moose which could be influenced by the proposed project. In 26.1 hours of survey effort, 1,086 moose were counted. Undoubtedly, not all moose in the area were observed during this cursory survey. General distribution of observed moose is depicted in Figure 3.12.

Approximately 60 moose (6%) were observed at elevations which would be inundated at normal pool level. Only two moose were observed in the Devil Canyon impoundment area; the remainder were in the Watana impoundment, with 38 of these 58 moose (66%) concentrated at Watana Creek.

Although relatively few moose were observed along the Susitna River bottomlands, large concentrations of tracks indicated that moose had utilized these areas earlier in the winter. It is likely that heavy cover in these low areas decreased the likelihood of observing moose which were present. Among these bottomland areas, large track concentrations were observed at the mouths of Watana Lake, Watana Creek, Jay Creek, and the Oshetna River. Tracks and subjective observations suggested that most moose had moved from the lowland areas which were covered by relatively deep snow to higher windswept elevations, where snow cover was nearly absent.

On 26 and 28 March 1981, the Devil Canyon and Watana impoundment areas were intensively censused in an attempt to assess the number of moose that might be displaced during winter by the reservoirs. In the Devil Canyon impoundment (144 km^2), 28 moose (0.19 moose/km^2) were observed. It was estimated that 94% of the moose had been counted, yielding a correction factor of 1.06. Thus, the adjusted population estimate for the Devil Canyon impoundment was 30 moose (0.21 moose/km^2).

In the Watana impoundment (188 km^2), 42 moose (0.22 moose/km^2) were counted. The estimate of 42 moose within the Watana impoundment area was not adjusted. The low numbers of moose occupying the two impoundments was not surprising since radio-locations suggested that during this relatively mild winter, most moose were located away from the impoundment.

o Calving Areas

To determine if calving concentration areas occurred in or adjacent to the proposed impoundment areas, all observations of radio-collared moose between 15 May and 15 June 1977 through 1981 were plotted. Although moose parturition apparently occurs in scattered areas throughout GMU 13, several areas of concentration were evident. They included the region around Coal Creek and its tributaries, along and near the Susitna

River from the mouth of Tyone River downstream to a point several miles downstream from Clarence Lake Creek, from Jay Creek to Watana Creek, at the mouths of Deadman and Tsusena creeks, from Fog Creek to Stephan Lake, and across the Susitna at Fog Creek to Devil Creek.

- Habitat Utilization

  o Elevation

Average monthly elevations at which radio-collared moose were located from October 1976 through mid-August 1981 are summarized in Table 3.9. Generally, moose occupied relatively low elevations during late spring and early summer ($\bar{x}$=785 m for April and 805 m for May). As summer progressed, moose generally moved to higher elevations, with the highest average elevation occurring in December ($\bar{x}$=901 m). Statistical comparisons suggest that many of the average monthly values were quite similar but there were significant differences between winter and summer elevations.

In earlier studies of moose movements in GMU 13, both VanBallenberghe (1978) and Ballard and Taylor (1980) described the altitudinal movements of moose: "During summer these moose occupied areas at about 2500-3000 ft [762-914 m] elevation, and during winter habitat types at the 1800-2200 ft [548-761 m] elevation were utilized." The analyses provided in Table 3.9 do not fit this pattern. Summer elevational use appears to be quite similar, but winter elevational use during this study was different. Mean monthly elevations from December through March ranged from 818 m to 900 m, which were considerably higher than the 549 m-671 m elevations reported in earlier studies. Moreover, although portions of the data used for this analysis were derived from the earlier movements studies reported by Ballard and Taylor (1980), over half of the locations were obtained during 1980 and 1981. From October 1976 through mid-August 1981, with the exception of 1978-79, winters were relatively mild in terms of total snow depth. Since during the winter of 1978-79, only a few radio-locations were obtained, the combined data primarily represents the altitudinal movements of moose during relatively mild winters.

The altitudinal movements depicted in this study suggest that moose occupied relatively high elevations during winter. These results conflict somewhat with the commonly accepted theory that moose use lowland elevations during winter. It is generally assumed that deep snow drives moose from the highlands, forcing them to concentrate on low elevation winter range. This type of movement pattern was not prevalent during this study. It is possible that during this study, snow depths at higher elevations were reduced because of high winds and temperature inversions. This circumstance would have resulted in a greater availability of browse at the higher elevations than at lower elevations, where snow depths were likely to be greater. Consequently, moose were not forced to concentrate on low elevation winter range, which would only be used when upland snow depths become excessive. Therefore, moose winter movement and concentration patterns exhibited during this study may only reflect those of mild winters.

o Vegetation Types

Vegetation types dominated by spruce comprised the most frequently used habitats, with sparse and medium density-medium height black spruce accounting for 35% of the total observations. This finding was not particularly surprising since the classification system was based on overstory vegetation and the "spruce-moose" association is well recognized. In the upper Susitna drainage basin, spruce and shrub types combined comprise 59% of the total area but during the study received over 90% year-round use by moose.

Use of upland shrub-willow habitat types corresponded with observed elevational movements of moose. Use of this habitat type was at its lowest during the month of April, when moose were at relatively low elevations just prior to calving. Use gradually increased through summer, reaching a plateau of 43% in October and remaining at a relatively high use percentage through February. As mentioned earlier, it was suspected that the use of relatively high elevations from late fall through winter may have been the result of mild winters.

During calving in May, sparse and medium dense-medium height spruce habitats were utilized by moose. We suspect these lower elevational types are selected by cow moose because of their value as escape cover and because new foliage emerges earlier than that of other vegetation types. Based on aerial observations, several habitat types, such as birch, alder, and several spruce types did not appear to be selected by moose.

(iii) Caribou

The Nelchina caribou herd, one of 22 herds in Alaska (Davis 1978), is important to sport and subsistence hunters because of its size and proximity to population centers in southcentral Alaska. Currently, the Nelchina herd contains about 6% of the total statewide caribou population (325,000). As a measure of the interest in caribou, between 1954 and 1981, over 100,000 Nelchina caribou were killed by hunters (Skoog 1968; unpublished data Alaska Department of Fish and Game). Another indication of hunter interest is that in 1981, 6,662 people applied for 1,600 permits to hunt for Nelchina caribou.

- Distribution and Movement Patterns

The herd occupies an area of approximately 51,800 km^2 (20,000 mi^2) bounded by four mountain ranges: the Alaska Range to the north, the Wrangell Mountains on the east, the Chugach Mountains to the south, and the Talkeetna Mountains to the west (Hemming 1971). The Nelchina range contains a variety of habitats, from spruce-covered lowlands to steep, barren mountains. Human development is largely limited to the peripheries of the Nelchina range and consists primarily of the Alaska Railroad, Parks Highway, Denali Highway, Richardson Highway, trans-Alaskan Pipeline, and Glenn Highway.

Use of the Nelchina range during this study by radio-collared caribou from the main herd is portrayed by Figure 3.13. Two major areas that were used extensively at times in the past received minimal use during the study period. These areas were the northwestern portion of the range, including drainages of the Chulitna, Nenana, and upper Susitna rivers and the far eastern portion of the range, including the Mentasta and Wrangell Mountains.

During the past 30 years, Nelchina caribou have used numerous winter ranges from the Nenana-Yanert Fork drainages to the Talkeetna River and east to the Mentasta and Wrangell Mountains (Skoog 1968, Hemming 1971). During the winter of 1980-81, the Nelchina herd wintered on the Lake Louise Flat and the middle portion of the Gakona and Chistochina River drainages. Considerable use of the western foothills of the Alphabet Hills was also noted.

The primary migratory route from winter range on the Lake Louise Flat to the calving grounds in the eastern Talkeetna Mountains was westward across the flat from Crosswind Lake and Lake Louise into the Talkeetna Mountains on a front from Lone Butte to Kosina Creek.

It appeared that many animals used the frozen Susitna River between the Oshetna River and Kosina Creek as a travel route in the spring of 1981. In the spring of 1980, one radio-collared animal moved south and crossed the Susitna River near the mouth of Deadman Creek. Many animals historically used this route to the calving grounds after wintering in upper Susitna-Nenana drainages (Skoog 1968).

Since 1949, the first year for which records are available, Nelchina caribou have utilized an area of about 2,590 km^2 (1,000 mi^2) in the northern Talkeetna Mountains for calving (Skoog 1968, Hemming 1971, Bos 1974). While the precise areas utilized have varied, calving has taken place between Fog Lakes and the Little Nelchina River at about 900 m and 1400 m elevation.

Observations during the calving period (15 May - 10 June of 1980 and 1981) indicated the calving activities occurred in drainages of Kosina Creek, Goose Creek, Black River and Oshetna River (Figure 3.14). Observations of females outside this area during the calving period were of nonbreeders which reached the calving grounds later in the calving period. During the calving period, radio-collared Nelchina bulls were found in a wide variety of locations mostly in transit to summer ranges.

Historically, the female-calf segment of the Nelchina herd has primarily summered in two areas: the eastern Talkeetna Mountains and across the Susitna River in the Brushkana, Butte, Deadman, Watana, Jay, and Coal creeks complex (Skoog 1968, Hemming 1971). In most years between 1950 and 1973, varying proportions of the female-calf segment (ranging from 0-100%) crossed the Susitna River from the calving grounds to the summer range on the north side of the river. The female-calf segment of the Nelchina herd spent the summer period (11 June through 31 July) of both 1980 and 1981 in the northern and eastern slopes of the Talkeetna Mountains. Summering radio-collared males were found in many locations in the high country of the Nelchina basin.

In both 1980 and 1981, autumn (1 August through 31 September) was a time of considerable movement and dispersal by both cows and bulls. It appeared that, compared to the obvious segregation in June and July, considerable mingling of the sexes occurred. In mid- to late August 1980 a portion of the main summering concentrations moved out of the Talkeetna Mountains onto the western portion of the Lake Louise Flat, and in some cases, into the Alphabet Hills. Through September, the distribution remained relatively stable, with the main herd divided between the northeastern Talkeetna Mountains, the Lake Louise Flat, and the Alphabet Hills.

Historically, Nelchina caribou have rutted in a number of locations; however, Lake Louise Flat and the eastern Talkeetna Mountains have been the most widely used. The Deadman Lake area was also used extensively during the rut in many of the years when major segments of the herd summered in the area. During both 1980 and 1981, considerable movement from west to east occurred during the rut. In both years, a portion of the herd was in the eastern foothills of the Talkeetna Mountains in early October, but by mid-October, most animals were in the northern Lake Louise Flat. In 1980, a small group remained in the Slide Mountain area. In 1981, on the other hand, a third to a half of the herd had crossed the Richardson Highway and trans-Alaskan pipeline by 10 October.

- <u>Subherds</u>

Radio-collars were placed on animals in three suspected subherds, one in the area of the Talkeetna River, the second in the Chunilna Hills region, and the third from the upper Susitna-

Nenana drainages. Because of the changeable nature of caribou movements and the brevity of the study period, the results are tentative.

Small groups of caribou, including cows and calves, have been seen in most of the side drainages of the upper Talkeetna River. This appears to be a legitimate, resident subherd, probably composed of <400 animals. Some spatial overlap with the main Nelchina herd does occur, however.

Three caribou in this upper Talkeetna River subherd (two adult females and one adult male) were collared on 18 April 1980. These animals were relocated 50 times and were always found in drainages of the upper Talkeetna River or in the upper reaches of the nearby Chickaloon River (Figure 3.15). One female raised a calf in 1980, and both raised calves in 1981. The male spent the summer of 1980 in the mountains west of the Talkeetna River.

During late April 1980, one adult bull and one adult cow were collared in the Chunilna Hills. The cow died within a month of capture. The bull remained in the Chunilna Hills through November, when it shed its collar. Two additional females were collared in the spring of 1981, both of which subsequently gave birth to calves in the area. Relocations of Chunilna Hills caribou are shown in Figure 3.15. No overlap with radio-collared animals from the main herd or other subherds was noted, although one female did move across the Talkeetna River. The Chunilna Hills group appears to be a resident subherd numbering <350 animals.

During early May 1980, four adult females and one adult male were radio-collared from the upper Susitna-Nenana subherd (Figure 3.15). One of the females migrated to the main Nelchina calving area, summered in the Talkeetna Mountains, migrated back through the upper Susitna-Nenana area in the fall, and rejoined the main Nelchina herd on the Lake Louise flat during the rut and early winter. The other three females remained in the upper Susitna-Nenana area throughout the study period, two producing calves in 1980 and two having young in 1981. The bull summered in the Clearwater Mountains, then joined the main Nelchina herd during the rut in the Lake Louise Flat. It seems likely that a resident subherd of <1,000 caribou exists in this area; however, the situation is confounded by movements of animals from the main Nelchina herd through the area and by use of the area by summering bulls from the main Nelchina herd.

- Habitat Use

Habitat use by caribou was examined in the main Nelchina herd and the three identified subherds by recording vegetation type and elevation on each relocation of radio-collared caribou. The vegetation classifications were simplifications of Viereck and Dyrness's (1980) level I categories. Categories used included spruce forest (virtually no use of deciduous or mixed forest types was seen), tundra and herbaceous, shrubland, and bare substrate. For seasonal analyses, the following categories were used: calving, 20 May to 10 June; summer, 11 June to 31 July; autumn, 1 August to 30 September; rut, 1 to 20 October; winter, 21 October to 31 March; spring migration, 1 April to 19 May.

With the exception of their use of shrublands and bare substrate, habitat used by bulls and cows was significantly different ($P<0.01$). In the main Nelchina herd, bulls were found more often in spruce forest and cows in tundra and herbaceous vegetative types. Male and female radio-collared caribou from the main herd, likewise, showed significant ($P<0.001$) differences in seasonal habitat use. The main differences were heavy use of spruce forests during the rut, winter, and spring and increased use of the tundra-herbaceous type during calving and summer. Both sexes occurred with nearly equal frequency in shrublands; however, seasonal use patterns were different. Female use of shrublands occurred nearly equally in spring, calving, and summer, while male use peaked in summer and autumn.

Radio-collared caribou from the upper Susitna-Nenana, Talkeetna River, and Chunilna Hills subherds were primarily found in tundra-herbaceous vegetative type. Shrublands were also used frequently by animals from the upper Susitna-Nenana and Chunilna Hills area.

Male and female radio-collared caribou from the main Nelchina herd were located at similar elevations during autumn, the rut, and winter. During spring migration, calving, and summer, however, females were found at significantly higher elevations than males. During spring and calving, males lagged far behind the females, remaining longer on winter range and then often spending the summer period in the lower shrublands.

Mean elevations for relocations of radio-collared animals during all seasons was greater ($P<0.05$) for the Talkeetna River (1,440 m) and upper Susitna-Nenana (1,171 m) subherds than for the main Nelchina herd (1,050 m). Chunilna Hills caribou were found at slightly lower but not significantly different elevations (996 m) from the main Nelchina herd.

- Population Size and Composition

Census activities during 1980 were conducted from 2 to 5 July. A total of 17,061 caribou were counted in the primary post-calving aggregation. An additional 244 (including cows and calves) were found in peripheral areas. Therefore, the post-calving aggregation totaled 17,305 caribou with an estimated composition of 2,808 males $\geq$ 1 year; 9,285 females $\geq$ 1 year; and 5,212 calves.

Fall composition data were collected on 14 October 1980, when the main Nelchina herd was distributed on the Lake Louise Flat. The estimated 1980 fall population was 18,713 caribou. The ratio of males $\geq$ 1 year to 100 females $\geq$ 1 year was 61.9, the highest ever recorded for the Nelchina herd. An increase in the proportion of males would be expected for a herd which is increasing and previously had a relatively low proportion of males. Bergerud (1980) pointed out that a herd with good recruitment and a young age structure will have large numbers of young bulls.

The 1981 census was conducted from 23 to 25 June. The estimate of the post-calving aggregation was 19,264 caribou with 10,416 females $\geq$ 1 year, 3,035 males $\geq$ 1 year; and 5,813 calves.

Fall composition sampling was conducted on 19 October 1981 between Ewan Lake and the Chistochina River. The ratios of males $\geq$ 1 year (60.4) and calves (42.9) per 100 cows $\geq$ 1 year were nearly identical to those estimated in October 1980. Because of poor weather, the composition count was conducted about one week later than normal. It appeared that some bulls had separated from the cow-calf segment, and males may thus have been slightly underrepresented in the sampling. The estimated 1981 fall population was 20,730 caribou. The presence of all radio-collared females from the main Nelchina herd in the census area in 1981 and all but one in 1980 lent confidence in the accuracy of the population estimates.

In recent years the herd had experienced a growth phase, 1950-60; a peak, 1962-1967; a decline, 1967-1973; and then another growth phase, 1974-1981 (Table 3.10). The technique currently used to estimate herd size (aerial photo-direct count extrapolation caribou census technique) has not always produced precise estimates; however, a trend of herd growth since about 1974 is apparent when the complete series of estimates is examined.

Alaska Department of Fish and Game management objectives for the Nelchina herd include: (1) restricting the harvest until a population level of 20,000 animals older than calves is reached, (2) maintaining a minimum sex ratio of 25 males/100 females, (3) providing for the greatest opportunity to participate in hunting caribou, and (4) providing for an optimum harvest of caribou. To allow for continued herd growth, harvest of the herd is currently restricted by a permit system.

- Mortality

Three radio-collared caribou died of natural causes. Estimates of annual natural mortality rates were 0.067 $\pm$ for females $\geq$ 1 year, and 0.138 $\pm$ for males $\geq$ 1 year based on the number of observed mortalities of radio-collared caribou and the number of animal years monitored (Trent and Rongstad 1974).

These estimates were probably somewhat low as only one winter-spring period, when most mortality of caribou older than calves normally occurs (Skoog 1968), was included, while two summer periods, when natural mortality is minimal, were considered.

Calf survival from birth to 11 months of age (May 1980 to April 1981) was estimated from a theoretical birth rate of 0.66 calves per cow $\geq$ 1 year (Skoog 1968, Bergerud 1978) and an observed ratio in April of 0.30 calves per cow $\geq$ 1 year. This ratio was corrected to account for those females (0.95) who survived between May 1980 and April 1981 (Fuller and Keith 1981). Estimated calf survival was, therefore, 0.43.

Reported hunter harvest for the Nelchina caribou herd has averaged about 670 animals annually over the past 10 years (Table 3.11). Females have composed about 25% of the reported harvest. Hunter numbers have been controlled by permit since 1977.

(iv) Wolf

From 20 February 1980 through May 1981, 36 gray wolves from six individual packs were captured and radio-collared for this study. Seven wolves were recaptured on one or more occasions for re-collaring. Twenty-one (57%) of the captured wolves were males (six pups and 15 adults) and 15 (43%) were females (seven pups and eight adults). Six of the 23 were recaptured from earlier studies. From January 1980 through October 1981, individual radio locations were obtained for the 36 radio-collared wolves, yielding an average of approximately 33 locations per animal. A total of 2,255 wolf sightings were made while locating the radio-collared packs, which represented 437 pack days. (A pack day is defined as any day on which a pack was located one or more times.) Radio contact with at least four and perhaps as many as six wolf packs occupying habitats along the Susitna River near the proposed impoundments was not established during this study.

- Territories and Population Numbers

For the purposes of this report, Etkin's (1964) definition of territoriality was used, that is, "any behavior on the part of an animal which tends to confine . . . its movements to a particular location." Most definitions of territoriality assume that the territory is defended against intruders. Although wolves in the Nelchina basin apparently do, at times, defend their territories against other wolves, intrusions into a neighboring territory often occur when the home pack is not using that portion of the area.

Table 3.12 summarizes territory sizes for the six wolf packs which have been intensively investigated for the Susitna hydroelectric studies. Territory sizes for the six packs averaged 1,414 km^2, which was almost identical with sizes determined for other wolf packs in Game Management Unit (GMU)13 (Ballard et al. 1981c).

Figure 3.16 depicts the spatial arrangement of known and suspected wolf territory boundaries in the project area during 1980 and 1981. Based upon track counts, public sightings, and radio locations of radio-collared packs and previous studies, at least six and perhaps seven wolf packs occupy portions of the Susitna River which would be directly affected by the Devil Canyon or Watana impoundments.

Wolf territories were essentially non-overlapping during the course of any particular year (Ballard et al. 1981c). What overlap appeared to occur was either seasonal in nature or was the result of the manner in which territories were plotted.

Numbers of wolves estimated to occur in at least 13 wolf packs known to occur in the study area are presented in Table 3.13. Spring 1980 and 1981 estimates represent the post-hunting population while those in fall represent gains due to reproduction and dispersal prior to hunting and trapping losses.

- Den and Rendezvous Sites

General locations of both den and rendezvous sites located from 1975 through 1981 in GMU 13 are depicted in Figure 3.17. Use of these sites by wolves in GMU 13 was fairly traditional. Of the 23 sites examined, at least six have been used a minimum of three seasons. Several have been used during two seasons since 1975. The average elevation of the 23 sites was 775 m (s.d.=108 m) ranging from 610 m to 1,097 m. Most den sites were old red fox den sites which had been dug out by wolves. Most sites consisted of three to four large holes and were characterized by several small holes, which are commonly referred to as pup holes and which are rarely, if ever, used. Most sites were located on slightly elevated areas, with sandy soil providing good drainage. Although we found that holes were oriented in all directions, most were found on south to northeast exposures. Thirteen of the sites examined contained what were termed "whelping chambers" which were usually located back from the main entrance.

Table 3.14 summarizes the distances of discovered den and rendezvous sites from both the Devil Canyon and Watana impoundments. Four den sites and one rendezvous site occurred within 8 km of the reservoirs. It should be noted that the figures contained on Table 3.14 must be considered absolute minimums because they pertain primarily to the area lying east of Deadman and Kosina Creeks.

- Elevation and Seasonal Usage of Habitat Types by the Watana Pack

Because the Watana pack was intensively monitored, sufficient data were gathered with which to characterize the elevational and habitat usage of a pack. Radio location data for the Watana pack were plotted on 1:63,000-scale vegetation maps. Data points which did not specifically fall within one habitat were tallied as in an ecotone between the two types.

According to this analysis eight of 24 habitat types were not used, either singly or in combination as an ecotone by the Watana wolf pack during the study period (April 1980 through October 1981). The unused types included snow and ice, wet sedge grass, closed balsam poplar, open balsam poplar, willow shrub, grassland, disturbed, and lakes. The non-use of lakes is misleading and is a result of the sampling period's having occurred during warm months. Wolf packs frequently make kills on or at the edge of lakes and streams during winter.

Of the 18 habitat or ecotone types used by the Watana wolf pack, ten were monotypes. Assuming the radio-location data and the boundaries of the habitat types were accurate, wolves were located in the monotypes on 58% of the occasions they were located. Of the 10 monotypes, low shrub, woodland black spruce, closed tall shrub, open black spruce, and birch shrub accounted for 86% of the use. Thirty-six (43%) of 86 locations occurred in ecotone areas. Seventeen (81%) of the 21 classified ecotone areas were used only once. Twenty (56%) of 36 uses, however, involved one of the shrub habitat types. Overall, shrub habitat types accounted for 50% of all use.

The average monthly elevation occupied by the Watana pack members ranged from 673 m in April to 1,021 m in November. Sample sizes were too low to compare seasonal changes in elevational use.

- Food Habits

During 1980 and 1981, six radio-collared wolf packs were observed on 83 kills. Moose comprised 57% of the kills, while caribou comprised 33%. Other prey, such as snowshoe hare, beaver, muskrat, and other small mammals made up the remaining percentage of kills. Moose calves accounted for 51% of the moose kills, while for caribou, calves comprised 7% of the kills.

Table 3.15 summarizes wolf summer food habits as determined from analyses of scats collected at den and rendezvous sites during 1980 and 1981. Moose of all ages were the most important summer food items during both years of study. However, it is suspected that the importance of calf moose is probably over-emphasized by these data.

Studies of wolf food habits in GMU 13 since 1975 have suggested that moose are the single most important food item (Ballard et al. 1981c). This trend appears to have continued in 1980 and 1981 as well, except that caribou appear to have increased in importance as a prey item.

Based on data collected during this study and data collected in GMU 13 from 1970 to 1972 and from 1975 through 1979, it was concluded that wolves were preying upon relatively healthy calf and short yearling moose. During severe winters, wolves also preyed upon relatively healthy adult moose, and this predation was in proportion to the occurrence of that age class of moose in the total population. During average or mild winters however, wolves preyed more heavily on older adult moose.

The annual percentage of observed caribou kills has varied from 4% to 30%. Excluding 1978, when the main body of the Nelchina caribou herd wintered in the Wrangell Mountains and thus were largely unavailable to GMU 13 wolves during winter, the importance of caribou in the diet of wolves appears to have increased. (Wolf diet averaged 18% caribou for 1975 through 1977 in comparison to 26% caribou for 1979 through 1981). Some of the annual difference in percentage of occurrence of caribou could be attributed to the difference in the locations of wolf packs studied during these time periods. Caribou distribution, however, is probably, at least in part, a function of their density. The Nelchina herd reached a record low of approximately 7,500 in 1972. Since that time the population has increased so that by 1981 the herd numbered over 20,000. It is suspected that the increase in the caribou population generally has made caribou more available to wolves throughout GMU 13. If true, this pattern would suggest that as the herd grows even larger, caribou will also become more important as wolf prey. Assuming wolf populations in GMU 13 increase slightly or remain stable, a larger caribou population may have some positive benefits for moose, in that a larger percentage of the kills may be comprised of caribou, relieving the moose population from some predation mortality.

- Predation Rates

Winter predation rates were estimated for three packs, through the use of intensive radio monitoring and by back tracking. A detailed discussion of these rates follows.

From 23 January through 27 March 1980, members of the Susitna pack were observed on nine kills. These data were divided into two periods because of changes in pack numbers. The first period extended from 23 January through 12 February 1980, during which time the pack numbered seven (three adults, two yearlings, and two pups). During this interval, they preyed upon four caribou and one adult moose for a kill rate of 1/4.2 days. Caribou comprised 80% of the kills in 1980, while in 1979, all of the observed prey were moose. Differences appeared to be related to the availability of prey. In 1979 few, if any, caribou had been available to this pack, while in 1980 relatively large numbers of caribou were present.

During the second sampling period, from 12 March through 27 March 1980, this pack numbered four wolves, providing an opportunity to compare kill rates for the pack when its numbers were lower. Kills were comprised of one adult moose, one calf moose, and two adult caribou. The kill rate was 1/4.0 days, which was fairly close to the rate of kill observed when the pack included seven members.

During early 1980, the Tyone Creek pack of two adults and six pups was monitored during a 54-day period (23 January through 16 March 1980). The pack was observed on 11 kills: three adult moose, seven calf moose, and one adult caribou. The prey species used by this pack were similar to those observed in 1979. In 1979, however, when the pack was comprised of two adults, calf moose comprised only 29% of the kills, while in 1980, when the pack numbered eight wolves, calves comprised 64% of the kills. This difference could indicate a change in prey selectivity based on pack composition. This pack was observed on a fresh kill at the rate of 1/4.9 days.

From 9 January through 26 January 1981, an attempt was made to determine the predation rate of the Tolsona Pack on caribou by attempting to locate the pack every other day. During this period, the pack numbered 14 to 15 wolves and appeared to be feeding quite heavily on caribou. A total of four kills were observed--two adult caribou, one adult moose and one calf moose. Based upon these data, this pack of 15 wolves preyed upon a moose or caribou at the rate of 1/4.5 days. Comparison of this rate with other predation data (this study and Ballard et al. 1981c) reveals that the rate was well below the rate believed necessary for the pack to maintain its size and productivity. Therefore, it is believed that several kills were not detected during the study period.

Data concerning predation rates during summer were collected on the Watana Pack. At the initiation of the study, three members split off from the pack, leaving the main pack with eight members. From 10 May through 23 June 1981, the eight remaining members of the main Watana Pack were observed on only six kills. The kills were comprised of two adult caribou (one was unclassified and assumed to be an adult), two calf moose, one adult moose, and one unknown species. In addition to the kills, pack members were known to have twice visited an adult caribou which had been killed by a black bear, revisited one old moose once, and visited the unknown species kill on three separate occasions. The observed kill rate of 1/7.5 days is well below the winter rate of 1/4 to 5 days.

Peterson (1980) believed that summer wolf predation rates were lower than those of winter. Studies of two wolf packs elsewhere in GMU 13, however, suggested that predation rates in summer were equal to or greater than those occurring in winter. It is believed that the low summer rate for the Watana Pack was the result of poor visibility and of a lack of radio-contact with the alpha male.

From 10 May through 28 May 1981, the three wolves, mentioned above, that had separated from the main Watana Pack functioned as a distinct pack themselves. These three adults were observed on a total of four kills over a 19-day period, with a kill rate of 1/4.8 days. The kills consisted of two adult moose, one yearling moose, and one calf moose. This particular set of data then, does not support the hypothesis of smaller packs having lower predation rates.

Although there appear to be some inconsistencies in the data as well as variation among seasonal and pack predation rates, there is sufficient evidence to estimate a kill rate for wolves in this area. Therefore, for purposes of this report a year-round predation rate for a pack of wolves was assumed to be 1 kill/5.0 days.

An effort was made to integrate these data collected in wolf predation rates with data regarding populations of prey species in the same area. Based upon an intensive census of the study area in fall 1980, it was estimated that a portion of the wolf study area contained 1,985 moose (see Figure 3.11). The area censused roughly corresponds to an area which would be occupied by five wolf packs.

Using the census and the stratified moose data along with the estimate of five wolf packs, an attempt was made to assess the importance of wolf predation to the study area moose population. It was assumed that each pack made an ungulate kill once every five days and that from 60-70% of the kills were comprised of moose, 32% of which were calves. Based upon these assumptions, it was estimated that wolves were annually preying upon 11% to 13% of the study area's fall moose population. Percent mortality of calves present in fall ranged from 16% to 18%, while mortality on adults of both sexes ranged from 10% to 11%. It should be pointed out that these calculations are based on a prey base present in November, and thus, the mortality figures are slightly inflated. Based upon calf and yearling mortality studies conducted in and adjacent to the Susitna study area, it was estimated that between 9% and 24% of the fall calves were succumbing to wolf predation. The new estimate obviously falls within the latter range.

Determining the level of wolf predation on caribou for the study area required a slightly different approach because of the seasonal nature of caribou distribution. The impact of wolf predation on caribou was estimated by assuming that 25 wolf packs occur within the range of the main Nelchina herd and its subherds in 1981. A mortality rate was estimated for 1972, when the Nelchina herd numbered a record low of approximately 7,500 animals and approximately 45 wolf packs occurred in the range of this herd. Further, a year-round predation rate of 1 kill/5.0 days was assumed. The assumption was also that caribou comprised 20% to 30% of the annual wolf diet. No separation was made between calf and adult caribou because existing wolf data do not suggest selection of the calf age class. Based upon these assumptions, it was estimated that in 1972, wolf predation accounted for an annual mortality rate of from 9% to 13%. In 1981, with the herd at approximately 22,000 animals and with 25 wolf packs present in its range, it was estimated that current caribou annual mortality from wolf predation ranged from 2% to 3%.

- Hunting - Trapping Mortality

Wolf harvests in the study area and in GMU 13 from 1971 through 1981 ranged from a high of 128 wolves in 1977-78 to a low of 45 wolves in 1980-81. The low harvest in 1980-81 was attributed to poor weather and relatively low wolf densities.

From 1971-72 through 1975-76, ground trapping was the most common method of harvesting wolves in GMU 13, accounting for 59% of the total harvest. From 1976-77 through 1978-79 ground shooting (primarily hunting using access via aircraft) was the most common method of harvest. In 1980-81 trapping again was the most prevalent method both because poor snow conditions did not allow wolves to be tracked from airplane and because the density of wolf populations was reduced.

(v) Wolverine

Historically, very few studies have been conducted dealing with wolverine ecology or the impact of human development on this species. There is indirect evidence, however, that in Canada, wolverine populations have declined as human influence increased (Van Zyll de Jong 1975). No historical information exists regarding wolverine populations in the upper Susitna basin.

- Distribution and Movement Patterns

Relocation data for five radio-collared wolverine, sightings of unmarked wolverine or wolverine tracks, and ADF&G harvest data yielded a total of 144 point locations scattered throughout the proposed impoundment vicinity. Distribution seems to be complete throughout the study area; however, the data indicate that concentrations are generally centered in hilly topography above treeline. There are inherent biases within the data, though since most of the track sightings and the commercial harvest occurred during the spring (March-May), when wolverine generally inhabit higher elevations (Hornocker and Hash 1981).

Radio-tracking data suggest that changes in wolverine distribution occur throughout the year. Van Zyll de Jong (1975), in Canada, suggested that food availability influences changes in wolverine distribution. Three different movements by wolverine in this study seemed to be induced by food supply.

- Home Range

Radio-collared wolverine were located on 104 occasions during these studies. Home ranges were determined for five wolverine; however, only the home range of wolverine No. 040 (627 km^2) represents an annual home range. The range of a lactating female (No. 042) was 86 km^2.

Direct comparison of home range sizes of Susitna wolverine with findings for other radio-telemetry studies is difficult due to this study's sample size and the differences in sampling periods. Comparing home range sizes for males from study areas in northwestern Alaska (Magoun 1979), the Susitna River basin, and northwestern Montana (Hornocker and Hash 1981), it appears that male wolverine in Alaska have a larger home range. Home range requirements for lactating females, however, were similar for the Susitna basin, northwestern Alaska and northwestern Montana. The generally larger home ranges of wolverine in Alaska are probably related to both fewer choices and lower density of prey.

- Population Estimates

An accurate estimation of wolverine density within the impoundment area is difficult to obtain with the available data. Within the 2,727 km^2 core portion of the study area (Figure 3.18), including the two proposed impoundments, where intensive radio-telemetry studies were conducted, a minimum of nine adult wolverine occurred, providing a minimum density estimate of one adult wolverine/303 km^2. By using several different kinds of estimates, the study area can be projected to support 11 to 21 adult wolverine, giving an estimated density range of from 1/248 km^2 to 1/130 km^2. Using this range of adults, the estimated number of kits added annually to the study area's population ranges from eight to 26. These figures yield a total population estimate, of between 19 and 47 wolverine.

- Habitat Utilization

As a result of the small number of animals radio-collared, information concerning habitat use by this species was rather limited. Wolverine No. 040 was the only animal which provided sufficient data to indicate seasonal changes.

Wolverine No. 040 utilized six of the 11 different habitat types within its home range. By frequency of observation, low shrub (37.5%), sedges and grass tundra (22.5%), open spruce (20%), and mixed open spruce (10%) habitats were preferred. It should be noted that 040 utilized low shrub habitat in a lower proportion to the amount of that habitat available (37.5% vs. 55.5%), while it utilized sedge grass and open spruce habitats in greater proportion than that habitat's availability (22.5% vs. 18.5% and 20% vs. 9%, respectively). Seasonal habitat preferences were also apparent. Seventy-five percent (six of eight observations) of open spruce usage occurred between mid-December and 1 April, and 67% (six of nine) usage of sedge grass tundra habitats occurred between May and 1 September.

Wolverines 043 and 044 displayed preference for ecotone habitats, since 34.6% (9 of 26) and 61.5% (8 of 13) of their relocations were present in these transition zones. Preference for or avoidance of homogenous habitat types was impossible to separate because of these animals' preference for ecotonal areas.

All of the radio-collared wolverine displayed an increased use of lower elevation areas during winter and early spring (December through March). The mean seasonal elevation values are 760 m (summer) and 948 m (fall). Hornocker and Hash (1981) also reported an elevational decline during winter for wolverines in northwestern Montana.

- Food Habits

It is well known that wolverines are not only well adapted for carrion feeding but also that carrion is important in the wolverine diet (Hornocker and Hash 1981, Rausch and Pearson 1972, Pulliainen 1968, Haglund 1966, Krott 1959). Some authors indicate, however, that wolverine additionally use smaller prey, such as marmot, snowshoe hare, Arctic ground squirrels, microtine rodents, and birds and that this use is extensive, especially in the spring and summer (Hornocker and Hash 1981, Magoun 1979, and Krott 1959).

Data collected during the course of the Susitna studies agrees with this information on food habits. Winter food habits data of Susitna wolverines indicate the increased importance of lower elevations and forested areas. The upper reaches of the proposed Watana impoundment area support a high density of moose during the winter. From mid-December to 1 April, 75% of wolverine No. 040's locations were within that area. During March 1981, at least two wolverine were using that area and were observed using three different moose carcasses. Ground tracking during December 1980 indicated that wolverine were also preying on small mammals. The numerous locations of wolverines 043 and 044 within ecotones is probably related to an abundant food source. It is well known that ecotones are usually high in plant diversity and, likewise, support a diverse microtine population.

As previously mentioned, there is a pronounced trend of wolverines using higher elevations in spring, summer, and fall. During these times, there are large numbers of ground squirrels, pikas, and marmots throughout the high country (APA 1981). Also present in the tundra habitats are 13 species of ground-nesting birds (Cooper, pers. comm.). An excellent example of this shift from lower elevation forests during winter to alpine tundra areas during spring was demonstrated by wolverine No. 040. Similarly, wolverine 044 moved a straight line distance of 70 km from an open spruce habitat (427 m elevation) to a tundra habitat (991 m elevation) coinciding with small mammal emergence, caribou use, and bird nesting season. This wolverine remained above treeline until 26 September 1980.

- Harvest

Trappers and hunters harvested 27 wolverine from the study area during Phase I studies, 20 during 1979-80 and seven during 1980-81. The low take during 1980-81 was probably a result of poor snow and weather conditions. During the 1979-80 trapping season, an estimated 23% to 31% of the population was harvested. It is possible that the level of that harvest may have been excessive, thereby lowering the wolverine population.

(vi) Brown Bear

Brown bears are widely distributed and abundant in Alaska. Brown bears seem well adapted to open areas of tundra or grasslands, although they do inhabit a variety of different habitats in Alaska. In contrast to Alaskan populations, brown bear distribution and abundance in the contiguous United States has greatly declined over the years. One reason is that bears using relatively open habitat are considerably more vulnerable to hunters, with the result that more animals are killed. In addition, because brown bears frequently represent a danger to man, they are eliminated or confined. Brown bear abundance is usually incompatible with increasing human presence except in a few parks where bears are given a legal priority over human developmental activities. As a result, except in Alaska and parts of Canada, this species is currently classified as endangered.

In the last 20 years, brown bear populations in Alaska have increased, and the current populations appear to be abundant, young, and productive. Fall harvests in the period 1973-1980 averaged 64 bears/year (30-84 bears/year) in Alaska's Game Management Unit (GMU) 13, which includes the upper Susitna basin. This level of harvest is suspected to be less than the maximum sustainable yield of this population. Even with the recent addition of spring seasons, most of the harvest still occurs during the fall, when bears are taken incidental to moose or caribou hunts.

Recorded brown bear harvests in the Susitna hydroelectric project study area, 1973-1980, have averaged 15/year (9-24/year). Hunting in the study area largely depends upon access by air, including some hunting by guided hunters, although many bears are taken from the Denali Highway. Indeed, the largest proportion of study area brown bears are taken from subregions that include the Denali Highway.

- Population Biology

The number of brown bear captures in connection with the Susitna hydroelectric studies in 1980 and 1981 totaled 53. This total includes 11 recaptures of bears in order to replace radio-collars. Six bears, primarily males with large necks, shed their radio-collars, and four bears were known to have been shot by hunters. Four bears died during capture or recapture efforts.

Five or more radio-locations were obtained for five male and 14 female brown bears. Primarily because of large males' shedding radio-collars, the numbers of radio-locations for males (109) have been fewer than for females (422). Part of this disparity also resulted because seven females were intensively monitored in spring 1981 (114 locations), while only one male (14 locations) was so closely followed.

The age structure of bears captured for the Susitna studies is essentially equivalent to that of intensive 1979 studies in the upper Susitna, to ten years of GMU 13 harvest data, and to the subsample of radio-collared individuals (Table 3.16). As mentioned, however, the subsample of radio-collared individuals is biased in favor of females. Thus, these data indicate that the sample of study animals is reasonably representative in terms of age structure but biased in terms of sex ratios.

Brown bears in the study area appear to be healthy and highly productive. Based on nine litters with newborn cubs observed with marked adults since 1978, the mean litter size was 2.3 (range=1-3). An unmarked bear with four cubs was also observed. The mean litter size of newborn cubs is equivalent to highly productive bear populations on Kodiak island (Hensel et al. 1969) and on the Alaska Peninsula, (Glenn et al. 1976) and is higher than has been found in a relatively unproductive population in the Brooks Range (Reynolds 1976).

Of ten cubs in five litters produced in 1981, three (in three litters) were lost during the summer of 1981. Two cubs in a litter of three were lost in 1979 studies, as were two yearlings or cubs in a litter of three in the same year. No other losses from yearling or two-year-old litters were observed, suggesting that offspring mortality is concentrated on cub classes. Causes of cub losses have not been determined, although predation by male brown bears is considered most probable.

Brown bear females in the study area typically accompany their offspring through their yearling year and wean them as two-year-olds in May or June of the following year. Many of the females breed again soon after their offspring are weaned; in all three cases in which the subsequent year's data are available, this breeding was successful, with newborn cubs as evidence. For these three bears, the reproductive interval was three years, doubtless additional data will reveal a mean reproductive interval for adult females of between three and four years.

Typically, female brown bears in the study area first breed at three or four years of age and produce their first litter when they are four or five years old. The data suggest that about 44% of the four-year-old females produce litters, 33% of the remaining barren five-year-olds, and 50% of the remaining barren six-year-olds. Obviously, some of the five- and six-year-old barren females could have previously produced, but lost, litters. All seven or eight-year-old females that have been caught were either with litters or showed evidence of having had a litter previously. Based on these data, it appears that for every 100 females ($\geq$ 4 years), about 44 will produce their first litter at age four, 20 at age five, 19 at age six, and 18 at age seven [these estimates are slightly more conservative, (that is, less productive), than indicated by available data]. Based on these calculations, the mean age at which these 100 females produce their first litter is 5.2 years.

Bear population estimates are exceptionally difficult to obtain and an accurate estimate was not achieved during the Phase I bear studies. Two reasons for the difficulty are the apparent abundance of brown bears in the Susitna study area and the large home-range sizes of Nelchina brown bears [average=570 km^2, range=192-1,380 km^2 (Ballard et al. in press)].

An imprecise estimate of brown bear density was obtained, however, from intensive trapping and mark-recapture techniques conducted in the Susitna River headwaters in 1979 (Miller and Ballard 1980). Based on this density estimate of one bear/41-62 km^2, the Susitna study area of 8,473 km^2 would have a population of 100-206 brown bears. It is our subjective evaluation that brown bear density in the Susitna study area is more likely to be higher rather than lower than that estimated in our earlier study. This estimate is compared with other North American estimates in Table 3.17.

The 1980-81 den sites for 13 radio-collared brown bears were located and measured; an additional three dens were located for unmarked individuals. Brown bear den sites ranged in elevation from 710 m to 1,570 m (2,330 to 5,150 ft); the average elevation of 29 dens was 1,274 m (s.d.=231 m). Brown bears in the study area typically denned on moderately sloping southerly exposures. Their dens were dug in gravelly soil, and no evidence of reuse of the previously used den was observed.

- Home Range and Movement Patterns

Home-range sizes for brown bears radio-collared during this study are presented and compared with results of 1978 studies on nearby ranges (Ballard et al. in press) in Table 3.18. Significant differences among 1978, 1980, and 1981 data sets were obtained only for females, which had smaller home ranges in 1980 than in either 1978 ($P<0.05$) or 1981 ($P<0.10$).

In comparison with studies in other portions of Alaska, Canada, and Montana, brown bears in the study area have relatively large home ranges (Table 3.19). Only in northwestern Alaska, where a relatively unproductive population resides, have larger home ranges been reported. Canadian, Montanan, and other Alaskan populations, except the northwest group also have a greater density than that of the study population (Table 3.17). Although a clear relationship has not been established, home-range size and bear density appear to be inversely related, and both seem a function of the distribution and abundance of food resources. The relatively large home ranges and low densities of study-area brown bears may reflect, therefore, relatively low primary productivity of food items important to brown bears in the study area. In addition to or instead of low primary productivity, these data may also reflect a patchy and wide-spaced distribution of important food items. Supporting this relationship are observations indicating that in areas of Alaska where salmon represent a primary source of food, such as on Kodiak Island or on the Alaskan Peninsula, home ranges tend to be smaller and densities higher (Table 3.19). Confounding this apparent relationship, however, is the ostensibly high productivity of study-area brown bear populations. If food were limiting this population, a relatively lower reproductive potential, such as has been found in northwestern Alaska, would be expected.

Prairie Creek, which flows from Stephan Lake to the Talkeetna River is well known as an area where brown bears concentrate in July and August to feed on salmon. Local residents have reported seeing 20 bears at one time on Prairie Creek. Here, on 10 August 1980, past the king salmon peak, 13 brown bears were observed at one time, and it is estimated that 30 to 40 individual brown bears fished in this area in the summer of 1980.

During the study, in both 1980 and 1981, radio-collared brown bears moved to Prairie Creek to fish for salmon. Unfortunately, poor weather conditions in 1981 made flights to relocate animals impossible and prevented complete documentation of how many bears made this movement. A minimum of four bears (of 11 with active radio-collars) moved to Prairie Creek in 1980 and two (of 18) in 1981. The longest distance moved by a bear to Prairie Creek was 58 km (G293 in 1981). Four of these six bears were documented to have crossed the proposed impoundment areas. All of the radio-collared bears seen at Prairie Creek had portions of their home ranges north of the Susitna River and, therefore, had to cross the river en route to or from Prairie Creek. The maximum number of times an individual brown bear was known to have crossed the Susitna River was ten.

The importance of the Prairie Creek salmon run to study-area brown bears will be difficult to evaluate. Without access to salmon, moderately dense brown bear populations currently exist in the Nelchina Basin. It is possible, however, that the availability of this interior run of salmon might provide nutritional benefits that result in local bear populations that are either more dense or less nutritionally stressed than adjacent populations without access to a salmon run. In the latter case, less nutritional stress may produce larger individuals in the species.

Seasonal movements of brown bears to areas where moose or caribou congregate, such as calving grounds, are difficult to document. For one thing, moose calving areas are poorly defined. In addition, movements of bears in the spring to prey on calves cannot readily be distinguished from their movements to these same areas which may be motivated by the presence of relatively more abundant early spring forage. For four bears, however, apparent directional movements to or from caribou calving grounds were observed.

ADF&G biologists conducting caribou surveys (S. Eide, R. Tobey, and K. Pitcher, pers. comm.) regularly report seeing many brown bears associated with the Nelchina herd. For example, in early July 1980, during caribou surveys on the upper Oshetna River, these biologists made incidental observations of 22 brown bears in approximately 673 km^2 of survey area. This number represents a minimum bear density of one bear/31 km^2. Since only a fraction (perhaps a third) of the bears present were likely to have been seen by biologists concentrating on caribou, the actual local bear density in this area was doubtless much higher. In 1981, these biologists, conducting the same survey in about the same area, saw no bears, even though some radio-collared individuals were known to be present.

The available data strongly support the theory that early spring is the period when many brown bears are most intensively utilizing the proposed impoundment area (conservatively defined for this analysis as within 1.6 km of the high-water mark of the proposed impoundments). Of 12 bears radio-collared in spring 1980, six were located in the proposed impoundment area at least once (Table 3.20). The mean elevation of these observations was 605 m for the Watana area and 601 m for the Devil Canyon area (Table 3.20). The mean elevation of observation was below proposed high water lines for Watana but not for Devil Canyon.

Even without prevalent over wintering berries, the same pattern was evident in spring 1981. Excluding females with newborn cubs, which tend to remain at high elevations throughout the year, eight (62%) of the radio-collared bears were located in proposed impoundment areas in spring 1981 (47% if those females with newborn cubs are included) (Table 3.20). Of these eight bears, seven utilized the Watana impoundment area and one the Devil Canyon area. The mean elevation of the spring observations within the Watana area was 640 m, or below the high water line of the proposed Watana impoundment (Table 3.20).

These data represent minimal values for early spring use of proposed impoundment areas by brown bears in the study area.

Other bears, particularly those relocated relatively infrequently in the spring, could also have utilized these areas without having been found there during weekly monitoring flights.

- Habitat Relationships

The habitat in which a bear was found when located from the air was recorded. To facilitate interpretation, these data were lumped into five gross habitat categories. These data, by month of observation, are given in Table 3.21, which also includes 85 habitat observations for uncaptured bears observed during radio-tracking flights.

Brown bear use of spruce habitats, which are concentrated in and around the proposed impoundments, were highest in May and June. Later in the summer, bears tended to move to shrublands at higher elevations. In winter (October-April), when bears were in dens, 71% of the observations were in the "other" category of habitat (Table 3.21). These were mostly snow or rock.

These observations were lumped to contrast habitat use in the "spring" (1 May to 30 June) with that during the rest of the year. This specific observation permitted subsequent examination of the general hypothesis that brown bears use the spruce habitats near the impoundments relatively more at this time than during the rest of the year. The relatively higher use of spruce habitats in the spring was significant (Chi square=10.3, 1 d.f., $P < 0.005$). This pattern would have been even more significant if females with newborn cubs had been excluded from the analysis. As mentioned before, females with newborn cubs tend to remain at high elevations away from the impoundments throughout the year following birth of their litter; of 68 habitat points for such bears, only two were in spruce (49% were in shrublands, 35% in other, 10% in tundra, and 4% in riparian).

- Predation Rates

In a 1978-1979 study conducted in the headwaters of the Susitna River and in nearby study areas (Ballard et al. 1981a), brown bears were shown to be significant predators of moose calves. In related studies of 23 radio-collared brown bears intensively monitored twice a day in spring 1978, 14 (61%) were observed on at least 1 calf moose kill (maximum=nine calf moose kills) (Spraker et al. 1981).

The results of this 1978 study were compared with the results of intensive (daily) spring monitoring of eight brown bears in the Susitna study area. During this period totaling 102 visual observation days, one monitored, subadult, female brown bear killed three moose calves, and another subadult female killed two adult moose. In addition, three animals of unknown species were observed to have been killed by brown bears, and in three other cases, brown bears were strongly suspected to have been involved in kills. Even incorporating these suspected kills, the observed predation rate (1/10.2 days) was lower than in the 1978 study. Of the total number of brown bear observations, radio-collared bears were seen on four calf moose, four adult moose, one adult caribou, and three unknown species, and were observed in five additional cases where a kill was suspected but not observed. Because of relatively infrequent monitoring and the limited visibility of kills in the relatively thicker vegetation in the Susitna study area, these data doubtless underrepresent actual predation rates.

(vii) Black Bear

Black bears, which have a very wide range in North America and are still abundant throughout most of their original range, are similarly widely distributed and abundant in Alaska. Black bear distribution in Alaska coincides closely with the distribution of forests, with the most abundant populations occurring in open forests rather than heavy timber; extensive open areas are usually avoided, however.

The abundance of black bears combined with relatively light hunting pressure in the upper Susitna basin permits a year-long open hunting season and an annual bag limit of three bears. An annual average of 66 black bears have been taken in Game Management Unit (GMU) 13 from 1973 to 1980 (58-85 bears/year). Most of the harvest, 74%, occurs in the fall season when bears are taken incidental to moose or caribou hunts. An average of only 23% of the GMU 13 black bear harvest has been taken by non-residents.

Recorded black bear harvests in the Susitna study area, 1973 to 1980, have averaged eight per year (1-15). In the study area, as in GMU 13 as a whole, black bear harvests have been increasing in recent years, with the largest recorded annual take occurring in 1980. In the study area, the largest harvests have occurred in the region farthest downstream on the Susitna River between the Talkeetna and Indian Rivers, the only portion of the study area currently accessible by river boat or highway vehicle.

- Population Biology

The number of black bear captures in connection with the Susitna Hydroelectric Project studies in 1980 and 1981 totaled 53. This total included five recaptures of bears to replace radio-collars and one recapture of a bear that had previously shed its collar. Two bears shed their radio-collars; hunters killed six bears; four bears died of unknown causes; one died during capture efforts; and the collar was not replaced on another bear recaptured because its neck was infected.

Five or more radio-locations were obtained for 14 male and 11 female black bears. The age structure of the sample of radio-collared individuals was comparable to that of captured bears in the study area in general but was somewhat older than the subsample of black bears taken by sport hunters in GMU 13 (Table 3.22). This discrepancy probably resulted from the tendency of hunters to take younger, less experienced bears as opposed to the effort of the study's techniques to capture a random selection of study-area animals. It is also possible that black bear hunters along the road system, where much of the harvest occurs, are sampling a more heavily harvested and, therefore, younger population than exists near the proposed impoundments. Males represented a smaller proportion in the study than they did in hunter kills in GMU 13, probably because by ranging greater distances, the males become more vulnerable to hunters. These data suggest that black bears marked for Susitna studies are reasonably representative of the existing black bear population.

Black bear populations in the study area appeared to be productive and healthy. This finding was somewhat surprising because the study area is situated on the northern limit of black bear distribution south of the Alaska Range. Apparently, the habitat is adequate even though limited in extent.

Eight litters with a total of 16 cubs were observed with radio-collared females in 1980 and 1981. Five of these litters were not observed until between June and August, so they may have experienced some losses between early spring and the date of their first observation. This possibility aside, the observed litter size was 2.0 (1-3) cubs/litter. The observed litter size for seven litters of yearling black bears was 1.9. In comparison, on the Kenai Peninsula, seven radio-collared females had a mean litter size of 1.9 upon emergence from natal dens (compiled from Schwartz and Franzmann 1980, 1981).

In the Susitna study area between May and August 1981, one cub in a litter of two was lost, one was lost from a litter of three, and both were lost from another litter of two. Counting only the four litters initially observed by June, four of nine cubs (44%) were lost, all in 1981. On the Kenai Peninsula on the other hand, no cub losses have been observed (Schwartz and Franzmann 1980 and 1981).

Three black bears with apparent yearling offspring were captured in 1980 (offspring were not captured). One of these weaned its offspring in 1980 and produced new cubs in 1981, a reproductive interval of two years. The third bear relocated its den in April 1980; perhaps its original den had collapsed, killing its litter. No den relocations were observed for other bears. A two-year reproductive interval is, therefore, probably the minimum; additional data will undoubtedly indicate a mean interval of between two and three years. The mean reproductive interval for an unproductive Montana population was over three years, and the percentage of adult females accompanied by cubs was low (15.6%) (Jonkel and Cowan 1971).

Three bears produced litters at five years of age and one bear at six years of age. Assuming no previous litters and correct aging, these bears became reproductively mature and successfully bred at four and five years, respectively. On the Kenai Peninsula, seven females (aged four years) had cub litters (Schwartz and Franzmann 1980, 1981), suggesting that reproductive maturity may be reached a year earlier on the Kenai. For an unproductive population in Montana, no females were observed in estrus prior to 4.5 years of age and no bears successfully produced litters at less than between six and seven years (Jonkel and Cowan 1971).

Available data are inadequate to calculate productivity of the Susitna-area black bear population, but available data on productivity parameters suggest it does not have quite the reproductive potential of the Kenai population. The basis for this assertion is primarily the older age for reproductive maturity. The Susitna population may also have a lower recruitment rate (based primarily on higher rates of cub losses). The recruitment rate is the rate at which the adult population is increased after cub and yearling losses and other reductions in subadult population are taken into account. Relative to the unproductive Montana population, however, the Susitna population appears highly productive, equivalent to productive populations in the midwest. It should be noted, however, that these comparisons are highly speculative at this point.

No reliable black bear density estimates are available from the study area or adjacent areas. Compared to other Alaskan habitats, however, portions of the study area appeared to be very densely populated by black bears. The only available data that permit even a crude density estimate come from sightings of marked and unmarked black bears during the August 1980 tagging operation. In 1 1/2 days of spotting effort (18, 19 August 1981), 35 bears, four of which were marked, were seen in approximately 259 km^2 of search area. A radio-tracking effort on August 14 verified the presence of seven radio-collared black bears in the search area. A straightforward Lincoln Index on these observations yields an approximation of 61 bears in this area or one bear/4.1 km^2. An "adjusted" index (Ricker 1975) yields an estimate of 58 bears (s.d.=19). A highly speculative estimate of the number of black bears in the study area is possible from this density estimation. Assuming that roughly one-third (1,400 km^2) of the study area is acceptable black bear habitat, this density figure would yield a population estimate of 341 black bears in the study area. These estimates should be viewed cautiously, however, as there are many possible sources of bias in the technique of estimating densities and it covers only a small portion of the study area at a season when bears might have concentrated in search of a locally abundant food source.

Regardless, the density estimate of one bear/4.1 km^2 falls roughly at the mid-point of reported black bears densities in North America and is only slightly lower than the most intensively studied nearby population (Kenai Peninsula, Schwartz and Franzmann 1981) (Table 3.23). In fact, the above density approximation is probably too low rather than too high, at least in the habitats where black bear density is highest.

Den sites for 1980 were located and measured for 14 radio-collared black bears; two additional approximate den locations were recorded but the actual dens were not found. The distribution of known black bear den sites indicated that study-area black bears tend to den in steep terrain along the main Susitna River or its feeder streams. As one proceeds upstream through the study area, the band of acceptable denning habitat apparently becomes progressively narrower and more confined to the immediate vicinity of the Susitna River, in much the same pattern as that for overall black bear distribution.

Black bear den sites ranged in elevation from 396 m to 1,323 m; only one bear, however, denned at an elevation above 914 m. Typically, black bears in the study area denned at elevations between 457 m and 762 m elevation. Of 16 den sites found in the vicinity of the proposed Devil Canyon impoundment, the average elevation was 664 m (range =454-1,323 m; S.D.= 86 m). Two black bear dens were observed downstream of the Devil Canyon site in 1981.

Of the 14 dens used in 1980/81 that have been located on the ground, eight were in natural cavities or caves, and six were excavated. Based on evidence found at the den site, all of the natural cavity dens examined and one of the dug dens examined had apparently been utilized previously. A determination of previous use could not be made for four dens. Four of the dens examined in 1981 were apparently reused by radio-collared black bears in the winter of 1981/82, three dens by the same individual that had utilized the den the preceding year.

These data on reuse of den sites may indicate either a scarcity of acceptable denning sites in the study area or simply habituation. Of 18 den sites examined on the Kenai Peninsula, eight had been previously used and ten were newly constructed. Only one bear reused the same den in successive years (Schwartz and Franzmann 1981). In relation to this Kenai study, reuse of den sites appears higher in the Susitna area. All of the dens in the Kenai study were excavated (Schwartz pers. comm.) compared to only 43% in the Susitna area.

- Home Range and Movement Pattern

Mean home ranges and ages for bears older than 2.0 years are given in Table 3.24. The data for these two years are not completely comparable, as different individuals were observed during different seasons. In any case, it appears that these home ranges tend to be larger than has been recorded for black bears on the Kenai Peninsula, that is, 16.7 km^2 for females and 98 km^2 for males (Schwartz and Franzmann 1981). In the Kenai study, however, a more conservative method was used to calculate home-range sizes. In the Susitna study, the home range sizes reported include, for many bears, large areas where no observations were made. This situation is especially true for the 1981 data when many bears moved long distances in late summer to foraging sites; these home ranges could be viewed as two seasonal home ranges connected by a narrow transportation corridor rather than as one home range.

Larger home ranges in 1981, compared to those of 1980, were observed for all groupings of individuals but were significant only for males ($P<0.01$) and for both sexes combined ($P<0.05$). Some of this increase was doubtless caused by the greater number of observations per bear in 1981, but it is evident that home ranges in 1981 were both much more variable and larger than in 1980. The greater movements in 1981 probably reflect the apparent relatively poor 1981 berry crop, which necessitated greater movements to find acceptable foraging areas. In 1981 black bears were observed north of the Denali Highway near Susitna Lodge (R. Halford, pers. comm.), a relatively rare occurrence which also supports the theory that 1981 was a year of atypically extensive black bear movements.

In late summer of 1980 (late July-August), many black bears made seasonal movements to the tablelands between the spruce forests along the Susitna River and the mountains north of the river. It is suspected that these movements were motivated by ripening berries, which may be more abundant in these relatively open areas than in the spruce forests where black bears are more commonly found during the rest of the year. In 1981, the movements were similar, but many more bears moved much greater distances. The supposition is that the apparent scarcity of berries in 1981 in the tablelands prompted these more extensive movements, which are in turn, reflected in comparisons of annual home range sizes. These movements are likely motivated by searches for better forage or for fish as a substitute for the berries that were in short supply. For example, three males moved downstream of the main study area in fall 1981, apparently to fish for salmon downstream of Devil Canyon.

Based on available data and supposition, the pattern of black bear movements can be summarized as follows. In years of normal or acceptable berry crops, many bears in late summer move to somewhat higher country adjacent to the spruce habitats along the river, returning to their lower spring and early summer home ranges to den. Most of these late summer movements are upstream (east) and a bit north. In years of subnormal berry crops, most individuals range more extensively, and many of these move long distances upstream or downstream in search of acceptable foraging areas or areas where salmon are available. Some of the individuals making these extensive movements do not return to their former home ranges, but most do. Females with newborn cubs are exceptions to this rule, making less extensive movements, regardless of the berry crop, than other bears or than they themselves do in years when they do not have cubs. In late summer and fall, especially in poor berry years, the more extensive movements of black bears may bring them in closer contact with areas frequented by brown bears at this time, and this proximity may result in increased mortality of black bears.

- Habitat Relationships

Each black bear location was classified into one of 23 habitat classification categories for 724 observations made from the air. These data were then consolidated into five gross habitat categories; the results are presented on Table 3.25.

Black bear use of spruce habitats, concentrated in the vicinity of the proposed impoundments, was common throughout the year but was least prevalent in late summer. In August, black bears were more commonly found in shrubland habitats adjacent to the spruce forests (Table 3.25). As mentioned, it is suspected that this late seasonal movement was motivated by the relative abundance of ripening berries on these tablelands.

The hypothesis that spruce habitats were used less frequently in late summer (16 July-31 August) was tested by contrasting the percentage of occurrence of radio-collared individuals in spruce habitats during this season (36% of 251 observations) with that of the rest of the year (44% of 547 observations). The difference was significant (Chi square=4.7, 1 d.f., $P<0.05$). There was a significant difference between males and females in late summer use of spruce habitats (Chi square = 4.4, 1 d.f., $P<0.05$). In the late summer, 43% of 126 observations of females were in spruce habitats compared to 30% of 125 observations of males.

- Predation Rates

Black bear predation on moose calves is prevalent on the Kenai Peninsula (Franzmann et al. 1980). Of 23 radio-collared black bears followed in the Kenai study, five (22%) were known to have preyed on moose calves (Schwartz and Franzmann, in press). No predation occurred in areas where moose browse rehabilitation had occurred; all predation occurred in uncrushed areas of regrowth vegetation resulting from a 1947 forest fire (op cit.). If this same model holds true in the Susitna study area, which is comprised of vegetation in a relatively undisturbed state, high levels of predation on moose calves by black bears would be expected.

Daily monitoring of three black bears in the Susitna study area during the period 21 May-22 June 1981 resulted in 73 point locations. During this period, one black bear, (a five-year-old male), was observed on one calf moose kill and one adult caribou kill. This bear was also observed on a kill of an adult radio-collared moose on 22 July. No other predation was observed during the period of intensive monitoring. Subsequent regular monitoring of black bears resulted in no additional known kills of ungulates.

It is believed that calf moose are more important spring prey than indicated by these data. Many kills were likely missed because of relatively infrequent monitoring, the difficulty of spotting kills in heavy vegetation, and the low numbers of intensively monitored black bears.

(viii) Dall Sheep

The study area surveyed for Dall sheep includes all drainages flowing into the Susitna River from Gold Creek to Kosina Creek on the south and from Gold Creek to the Denali Highway on the north. Survey efforts were confined to areas of known or suspected Dall sheep habitat. The results of the sheep surveys are organized below according to well-defined sheep subpopulations.

- Portage - Tsusena Creek Area

During July 1980, a total of 72 sheep (seven legal rams, 12 lambs, and 54 unidentified) was counted in the Portage Creek and Tsusena Creek drainages. The only previous ADF&G survey in this area was a 1977 count of 91 sheep (eight legal rams, 18 lambs, 65 others). The 1977 survey included the Jack River drainage, which was not surveyed in 1980. The sheep sighted were located fairly high up in the drainages and relatively far from the proposed impoundments.

- Watana Mountain - Grebe Mountain Area

During July 1980, only eight sheep (one ram, seven unidentified) were observed in the Watana Mountain-Grebe Mountain area. Observations in 1977 suggested that at least 34 sheep were present on Mt. Watana. Numerous observations exist of sheep in the Terrace Creek area, but no sheep were observed there during the 1980 survey. Either the sheep had migrated from the area, or they were missed during the 1980 survey.

A winter distribution survey was conducted in the same area that had been surveyed in July 1980. During winter, a total of 28 to 30 sheep were observed. If data collected during these two surveys were representative of the sheep population, they would indicate that sheep were migrating into the area during winter. All sheep observations, however, were located on the southern extreme of the count area, well away from the proposed Watana impoundment.

- Watana Hills Area

The Watana Hills area was designated as a population trend count area for Dall sheep by ADF&G in 1967 and since that time has been surveyed eight times. The 1981 count of 209 sheep was the second highest number of sheep recorded for this area. The percentage of lambs was similar to past years and suggests that productivity and survival are remaining constant. Although the 1981 count was relatively high, it is believed to be accurate since the population is suspected to have remained stable or perhaps to have increased slightly.

- Jay Creek Mineral Lick

Observations recorded during the spring of 1980 strongly suggested the presence of a mineral lick on the cliffs along the lower reaches of Jay Creek near its confluence with the Susitna River. The lick is within the Watana Hills area. The possible existence of a mineral lick very close to the proposed Watana impoundment generated detailed studies in 1981.

The mineral lick at Jay Creek was examined on 9 May 1981. Portions of the lick were found to extend below the proposed average maximum pool elevation of the Watana impoundment. Sheep usage of the area ranged from the Jay Creek stream bottom to the top of the bluff and for an undetermined distance away from the bluff. On the day of examination, five Dall sheep were observed actively scraping and eating soil from this area. This further suggests that minerals are the main attraction.

A total of 34 separate observations of sheep using the mineral lick were made over a 50-day period, starting on 6 May and ending on 24 June 1981. The largest single group observed at the Jay Creek site consisted of 15 sheep. This number represents approximately 7% of the observed Watana Hills summer population and approximately 17% of the observed Watana Hills winter population.

Sheep were also observed frequenting other locations adjacent to the Jay Creek mineral site. On 23 and 25 May 1981, two groups of six and 12 rams, respectively, were observed scraping and eating soil on the ridge located on the east side of Jay Creek, directly opposite the main lick area. On seven occasions during June, sheep of different age classes were observed at an area approximately 3 km upstream from the main mineral area. This area also appears to be mineralized.

The use of the Jay Creek lick seems to be confined to May and June. An aerial summer distribution survey was conducted on 28 July 1981, and no sheep were observed at the Jay Creek area. Ten ewes and yearlings were observed, however, actively utilizing a known mineral lick in the drainage of the east fork of Watana Creek, approximately 11 km north of the Jay Creek site.

- Sport Harvest

The 1980 harvest within the Susitna sheep study area was 13 sheep. Eight of these were considered to be trophy quality rams with horn lengths greater than 89 cm (35 in). Most of the harvest occurred in the Watana Hills area.

(b) Furbearers

During 1980 and 1981, a variety of methods were employed to assess furbearer populations in the vicinity of the proposed impoundments and also downstream (Figure 3.19). The species studied included red fox, pine marten, beaver, muskrat, mink, river otter, coyote, lynx, short-tailed weasel, and least weasel. Both the common and scientific names of these furbearer species mentioned in the text are presented in Table 3.8.

Seventeen red foxes and 17 pine marten were equipped with radio collars and relocated at frequent intervals. Radio-equipped animals were relocated both from the ground and with the use of a helicopter. In addition, fox dens were located through a combination of ground and helicopter searches. The diets of both foxes and marten were studied by following trails in snow and noting feeding activity, collecting food remains at dens, and conducting gross analyses of scats and stomach contents.

Another method of assessing furbearer populations was the assignment of transects. Fourteen aerial snow transects were established between Portage Creek and the Tyone River (Figure 3.20). Each transect was oriented perpendicular to the Susitna River and extended for 4.8 km on either side of the river. The transects were then surveyed from a helicopter, and all furbearer tracks were recorded.

The extent of beaver and muskrat populations was investigated in the upper basin during 1980 by means of an aerial survey of both beaver dams and lodges and muskrat pushups. Downstream beavers were surveyed from a point 3 km above the confluence with the Indian River to a point 4 km below the confluence with the Kashwitna River. During 1980 this area was surveyed from a river boat and in 1981 from fixed-wing aircraft.

(i) Red Fox

Red foxes and their sign have been observed throughout the upper Susitna basin. In the vicinity of the proposed Devil Canyon and Watana impoundments, the population of red foxes generally increases from Devil Canyon upstream to the mouth of the Tyone River (Table 3.26). Some red foxes utilize tributaries and deltas of tributaries during autumn, then shift to alpine zones in winter, as both snow depth and the volume of water flowing over the ice increase along the river. Other foxes remain above timberline throughout most of the year. Fox numbers upstream from Vee Canyon and in alpine areas adjacent to the proposed impoundment zones appear to be comparable to those in Denali National Park and Preserve and other portions of interior and southern Alaska (Buskirk, pers. obs.).

The density of red foxes in the Susitna study area appears to be low compared to densities of red foxes in midwestern states. Pils and Martin (1978), Sargent et al. (1975), Scott and Klimstra (1955) and Shick (1952) working in Wisconsin, North Dakota, Iowa, and Michigan, respectively, estimated the density of fox families to be one family per 10 km^2. In summer 1981, six active fox dens were found on a 1,751 km^2 portion of the Susitna study area. On the basis of the sighting of two fox pups at an additional den site, it is likely that at least seven dens were occupied by fox families during 1981. This is one fox family per 250 km^2. In all probability, not all dens in the study area were found. If only half of the active dens were found, the figure is one family per 125 km^2. Correspondingly if only one-third of the active dens were found, the estimate would be one family per 83 km^2 compared to one family per 10 km^2 estimated in midwestern states. Considering the effort spent searching for fox dens during the study period, the estimate of one fox family per 83 km^2 is probably reasonable, if not slightly high.

Trappers have actively pursued red foxes throughout the region. Harvests of red fox pelts have generally been highest upstream from Vee Canyon. Emphasis has been placed on trapping red foxes along the Susitna and Maclaren rivers downstream from the Denali Highway to a few kilometers below the mouth of the Tyone River. A local trapper and fur buyer reported (pers. comm.) that during the late 1950's and early 1960's, another trapper of his acquaintance took 300-350 fox per year in this area.

The fur buyer also recalls that on an April 1959 trip down the Susitna to the Tyone River, he saw 15 to 20 foxes. It is noteworthy that these foxes were present after a heavy trapper-take of foxes occurred during the 1958-59 trapping season. While the historical estimates of red fox numbers downstream from Vee Canyon to Devil Canyon are limited, fox numbers have been low in this area since the mid-1970's; it is felt that their numbers remain consistently low. In substantiation of this belief, during the 1979-80 trapping season, two trappers working along Tsusena Creek took only two foxes; another trapper captured one fox in the Fog Lakes area; a third caught no foxes while trapping around Stephan Lake.

Principal foods of red foxes during spring and summer include Arctic ground squirrels, red-backed voles, and singing voles. Ptarmigan are taken throughout the year, but they are of major importance to foxes during the winter. Trails in snow show that foxes commonly forage in areas above timberline frequented by large flocks of ptarmigan. Murie (1944) states that ground squirrels in McKinley Park (now Denali National Park and Preserve) were abundant and much used by foxes. He has little to say relating to the use of ptarmigan, however, because at the time of his studies, populations of these birds were low in the park.

Foxes take muskrats where available, and they may be relatively important to foxes around large lakes such as Stephan, Clarence, and Deadman. Dispersing young muskrats and muskrats at pushups are particularly vulnerable to predation by foxes. A trapper reported observing foxes hunting muskrats during winter at pushups on Stephan Lake. Aerial and ground observation at Clarence Lake during this study indicates that foxes frequently visit muskrat pushups.

In parts of the study area, carrion may also be important to red foxes. Caribou carcasses appear to be the main source of carrion in the Clarence Lake area, where sport hunting is relatively heavy during fall. Two foxes near Watana Camp also fed on remains of a caribou and on a moose carcass through most of winter 1980-1981. In addition, two foxes were observed in October 1981 feeding on a sheep killed by wolves on the east fork of Watana Creek.

In general, snowshoe hares may be another important component in the red fox diet (Dickson 1938). Snowshoe hares are scarce in the Susitna study area, however, [see Section 3.2(d)] and, therefore, relatively unimportant in the diets of foxes here. No hare remains were noted either at two active fox dens found in 1980 or at six active dens observed during summer 1981. In addition, no evidence of foxes preying on hares was found during trail sampling of foxes in either 1980 or 1981. This scarcity of hares may, in part, be responsible for both the relatively low number of foxes found in the area as well as for the seasonal shifts to higher elevations where ptarmigan are available.

During the study, 19 fox dens were located, six of which were active during summer 1981. Of the 19 dens, 18 were north of the Susitna River, and one was south. Several dens were concentrated in the upper Watana Creek and upper Deadman Creek drainages. While there are probably more dens south of the Susitna River than were located, extensive searches were conducted, and no others were found. Thus, although south of the river, the Stephan Lake - Prairie Creek area appears to be well suited for red fox dens, aspect, physiography, and vegetation are generally more favorable for denning and hunting on the north side of the river. The study's findings corroborated this analysis. The extent of den use varied among these sites. Some sites were comprised of extensive burrow complexes and are probably used every year. Others appeared to be used less frequently, and in some cases, they seemed to serve only as winter resting sites.

Dens of red foxes typically occur between 1,000 and 1,200 m elevation in areas of rolling hills adjacent to mountains. A lake covering four hectares or more or a creek is usually located nearby. Vegetation surrounding den sites typically includes alpine tundra (Dryas-lichen), shrub tundra (medium and low shrub with tussocks, sphagnum dwarf birch, low willow, and ericaceous shrub-sedge) and mat and cushion tundra (Dryas-sedge, willow, and ericaceous shrubs).

Red fox dens are found on prominences up to 5 m higher than the surrounding area. The soil type is usually silt and relatively rock free. Murie (1944) reported: "Red fox dens in McKinley Park [Denali National Park] were in the open and in the woods, on sunny knolls far up the slopes, and on the flats. Most of them were dug in sandy loam . . . . "

Murie's findings are similar to those of this study except that ground and air searches did not reveal fox dens in the woods. Allison (1971), working in Denali National Park, recorded dens in habitats similar to the denning habitats observed during this study. Except for alder, Allison mentioned no plants over four feet (1.2 m) high near dens. On the other hand, some fox dens have been seen in the woods in Denali National Park (Buskirk, pers. obs.).

Red fox dens usually had a complex of burrow entrances, most oriented to the south but some facing west. The number of entrances present per den ranged from three to 27, with one alternative den generally located within 200 m of the main den.

All active dens located were in or near areas of medium to high ground squirrel density. As noted above, ground squirrels are an important food item during the denning season.

Red foxes begin denning activities in the Susitna basin during late April or early May. One female in the study, over a two-day period, moved almost 16 km from her winter range to a den site. In another instance, an adult female reared pups in 1981 at a den where she had been a pup in 1980.

Ranges remained constant throughout the summer. An adult male occupied a minimum summer range of 36.8 km^2 in 1981. Another male occupied a range of approximately 20 km^2. From late August into October, juveniles utilized progressively larger areas around natal dens.

Dispersal occurred in early to mid-October. Allison (1971) reported that in Denali National Park, fox families vacated dens by mid-August. Storm (1972) found that foxes in Iowa and Illinois used den sites until late July and remained together as a family unit into October. Sheldon (1950) observed that some fox families in his central New York study area stayed together until September and that the latest date for an occupied den was 10 July 1947. The latest date reported for foxes at dens in Alaska is 11 August (Magoun, pers. comm.). Findings in the Susitna area suggest that a period of roughly one month may pass between abandonment of the den site and dispersal of the young. This period contrasts with the three months between abandonment of the den site and dispersal in Storm's study area in Iowa and Illinois.

Recorded dispersal distances ranged from 16 km to 64 km. Of ten juvenile red foxes collared in 1981, nine have completely left the area. Extensive aerial searches with radio receivers failed to produce signals from any juvenile foxes within 80 km of their natal dens.

Large creeks as well as the Susitna River appear to present no barrier to foxes intent on crossing them. For example, one adult male regularly crossed Deadman Creek, and two juvenile red foxes crossed the even larger Susitna River in October, when slush ice was flowing down the main channel.

(ii) Pine Marten

Pine marten are locally abundant in the vicinity of the proposed Devil Canyon and Watana impoundments. Information from former and present trappers indicates that marten have historically been important to trappers and are presently the most economically important species to trappers in the vicinity of the impoundment zones.

Data from aerial transects flown in November 1980 (Table 3.26) indicate that marten are present along that portion of the Susitna River that was surveyed (Portage Creek to Tyone River), with the highest concentration of marten tracks between Devil Creek and Vee Canyon. In terms of elevation, marten were most numerous below 1,000 m, probably because forested vegetation communities (coniferous, deciduous, and mixed) are likewise restricted to elevations below 1,000 m.

Diets of marten were studied by identifying food remains in scats and in the gastrointestinal tracts of animals caught locally by trappers. Over 450 gastrointestinal tracts and scats were collected. Data from an earlier study in Alaska (Lensink 1954) indicated that mice were the principal food of marten south of Lake Minchumina. Similarly, gross examination of scats at the time of collection suggests that mice are the principal food of Susitna marten; however, major seasonal shifts in the diet of Susitna marten are suspected. The results of scat examination and snow tracking also indicate that the fruits of bog blueberry, mountain cranberry, crowberry, and prickly rose are eaten in autumn and winter.

Based on data collected during 1980, the home ranges of three male marten covered a minimum of 4.74 km^2, 5.44 km^2 and 4.87 km^2, respectively. These estimates assume the following:

1. Creeks and the Susitna River form home range boundaries during summer.

2. Marten home ranges do not extend above treeline during summer. Movements of marten beyond the home ranges depicted by some resting locations may be significant and could indicate considerably larger home range sizes.

Many estimates of North American marten home ranges reported in the literature (for example, Hawley and Newby 1957 and Lensink 1954) are based upon capture-mark-recapture methods. Archibald (1980) has shown that, for the same animals, home range sizes determined by telemetry are greater than home range sizes determined from trapping grid methods. Archibald found that telemetry-based home ranges for five marten over one year in age (two males, three females) averaged 4.1 km^2. Also using radiotelemetry, Mech and Rogers (1977) found four marten (three males, one female) in Minnesota to have an average home range size of 12.8 km^2.

Data from radiotelemetry work show that fidelity to home ranges varies considerably. For instance, while home ranges of adult male marten appear to be mutually exclusive, overlap with home ranges of other sex/age class marten does occur. In addition, marten do not readily cross bodies of water which require them to swim. Thus, the Susitna River and larger tributary creeks form home range boundaries for many marten. Home range data on four male marten captured during 1980 are presented on Table 3.27 and Figure 3.21.

A female marten of unknown age and a juvenile male both possessed home ranges with two centers of activity separated by several kilometers. The highest elevation of any marten radiolocation was 810 m, but in one instance, marten scats were found at an elevation of 970 m. As noted above, however, it appears that marten seldom travel higher than 1,000 m.

In general, marten rest above ground during summer months and below ground in winter. Winter resting sites of marten consist almost exclusively of active red squirrel middens. Consistent with this behavior, of 34 marten resting sites found during the study, 26 were active red squirrel middens, two were inactive red squirrel middens, three were red squirrel grass nests in white spruce trees, and three were burrows or holes of unknown origin in soil. All of these resting sites were in forest or woodland vegetation types.

(iii) Beaver and Muskrat

Beavers and muskrats occur throughout the Susitna drainage from the delta of the Susitna River on Cook Inlet upstream along the river and its tributaries to elevations above 1,000 m. Both species occur in lakes and marshes from sea level to above 1,000 m. Populations of beavers or muskrats or both are present along slow-flowing sections of most larger creeks, particularly where lakes drain into streams. Examples include the Stephan Lake/Prairie Creek drainage and the Deadman Creek/Deadman Lake drainage.

During early winter, muskrats construct small lodges, or pushups, in the forming ice cover on ponds. These pushups are used as feeding sites, resting areas, and defecation sites. They remain intact until breakup and can be used as an indication of muskrat presence and general abundance. During the spring 1980, aerial surveys for pushups upstream from Gold Creek showed muskrats occurred in only 27 of the 103 lakes and ponds sampled.

Trapping for beavers and muskrats has historically been common along the Susitna below Devil Canyon, along major tributaries, including Indian River and Portage Creek; and around larger lakes, such as Stephan Lake.

Sign of both species is also common in suitable aquatic habitats above timberline. Trappers' reports suggest that they seldom pursue beavers or muskrats inhabiting alpine streams and lakes because the reward does not justify the effort involved. While these animals do represent an important fur resource, both species, at higher elevations, are also particularly vulnerable to environmental alterations and/or to overharvest because of their dependence upon small, isolated riparian habitats.

The farther downstream from Devil Canyon one moves, the greater is the beaver and muskrat use of riparian habitats along the Susitna River. Surveys of their sign, conducted from river boats during summer 1980 (Table 3.28) and from fixed-wing aircraft during summer 1981, indicate that between Devil Canyon and Talkeetna, beavers are limited to occasional foraging sites and lodges along protected banks of the river, sloughs, and lower reaches of feeder streams. No sign of muskrats was noted along this section of the Susitna. Between Talkeetna and Montana Creek, sign of beavers is common along sloughs, in deltas of tributaries, and along stable banks of braided river channels. Sign of muskrats in this stretch is limited to sloughs and marsh areas near the mouths of feeder streams. From Montana Creek to Delta Islands, sign of beavers is present almost continuously. The numerous islands and sloughs provide ideal habitats for foraging, caching food, and building lodges.

Results of this survey agree with the findings of Boyce (1974) and Hakala (1952), who reported that beavers in Alaska favor lakes or slow-flowing streams bordered by subclimax stages of shrub and mixed coniferous and deciduous forests. This description fits the area between Montana Creek and the Delta Islands, and the earlier findings were corroborated by this study. Similarly, this study and an earlier study (Retzer 1955) confirmed that large rivers with narrow valleys and high velocity flows, such as the area between Devil Canyon and Talkeetna, are generally sparsely populated by beavers.

(iv) Mink

In the upper basin, mink tracks were observed along all major tributary creeks below 1200 m in elevation and near some streams and lakes. A total of 34 mink tracks were counted along aerial transects in November 1980 (Table 3.26). Of these, 27 were in riparian or lake shore habitats. In addition, mink tracks were noted along the lower Susitna River during the downstream beaver survey.

(v) River Otter

Tracks of river otters were often sighted along the river, on tributary creeks to 1200 m elevation, and around Stephan and other large lakes. In November 1980, an unusually high incidence of otter tracks was noted on shelf-ice along the Susitna River in the proposed impoundment zones. A survey was carried out in which 37 points on the river between Portage Creek and the Oshetna River were examined for the presence of otter tracks (Figure 3.20). Forty-three otter tracks were present at 17 of these points (Table 3.29). Although the significance of these tracks is not clear, they may represent upriver or downriver movements of otters prior to freeze-up. Another possibility is that otters were concentrated along the river to feed on grayling leaving tributaries at freeze-up to overwinter in the Susitna River.

Other trails observed were of otters traveling cross-country, away from bodies of water. Such tracks may represent dispersal of subadult animals and have been noted by members of the furbearer study team in other areas of southcentral Alaska. Local trappers seldom take river otters because they are relatively difficult to trap and their pelt values have usually not been high enough to justify the effort.

(vi) Coyotes

Coyotes occur in the study area, but their distribution is generally restricted to areas downstream from Devil Canyon. No coyotes or their tracks were observed by the furbearer team. On 12 September 1980, a coyote was heard howling a short distance southwest of the Stephan Lake Lodge. An employee of the Alaska Railroad at Gold Creek reported trapping one coyote and seeing tracks of others during the winter of 1979-80. During the past several years, coyotes have been commonly noted in the Indian River-Canyon area, their howling heard often. Upstream from Devil Canyon, however, coyotes are less common. None of the trappers contacted during the course of this study reported seeing or trapping coyotes upstream from Devil Creek. The distribution and abundance of coyotes in the region is probably limited by wolves rather than by habitat and/or food availability. Within their home range, wolves are usually aggressive toward coyotes.

(vii) Lynx

Lynx occur in the study area, but their distribution is very limited. On 19 November 1980, probable lynx tracks were observed on the Susitna River bar across from the mouth of Goose Creek. On 22 October 1981, this area was visited by members of the furbearer study team, and a dense concentration of lynx tracks and scats was discovered. On 30 October 1981, two team members also found lynx tracks at the mouth of Jay Creek, and on 3 November 1981, lynx tracks were noted along Goose Creek 1.6 km from the mouth. Two trappers from Glenallen reported taking lynx in the vicinity of the mouth of the Oshetna River during winter 1976-77. Their impression was that lynx had not been numerous before or since that time. In the vicinity of the proposed impoundments, trappers reported no sightings of lynx or their tracks. Reports from trappers in the Gold Creek area suggest that in recent years, lynx have been uncommon downstream from Devil Canyon.

Although, with the exception of the upper reaches of the proposed Watana impoundment, lynx appear to be uncommon in the study area at present, populations may have been significantly higher in the past. The historical frequency of natural fire appears to increase between Portage Creek and the Tyone River. It may be that in these burned areas in the past, snowshoe hares, upon which lynx feed, have periodically been numerous and that at those times, lynx numbers were correspondingly higher.

(viii) Short-tailed Weasel

Short-tailed weasels are locally abundant in the study area. Their tracks have been observed in a variety of habitat types from the banks of the Susitna River to elevations over 1500 m. Seven hundred and forty-six tracks of short-tailed weasels were observed during transect surveys in November 1980 (Table 3.26); 328 (44 %) were counted on a single transect near the Tyone River. Four hundred and eighty-nine (66%) of the tracks were observed in woodland white or black spruce vegetation types, and an additional 190 (25%) were counted in medium (Betula) shrub types. Trappers on upper Tsusena Creek, in the Fog Lakes area, and elsewhere in the study area take short-tailed weasels both intentionally and incidentally to the trapping of other species.

(ix) Least Weasel

Observations suggest that least weasels occur sparsely throughout the study area. Several sets of tracks believed to be those of least weasels were observed on lower Watana Creek in March 1980. The carcass of a least weasel taken by a trapper at Fog Lakes was obtained in February 1981, and a live least weasel was observed near the southeast edge of proposed Borrow Area A on 25 October 1981. While not abundant throughout the study area in general, least weasels may be locally common; however, their small size and secretive behavior make confirmation of their presence difficult.

(x) Furbearer/Habitat Relationships

Over 800 fox-habitat sample points obtained through trailing in winter, aerial surveys (Table 3.30), and radio-tracking show that foxes prefer two basic habitat groups: a combination of black spruce woodland and medium shrub tundra and a combination of alpine tundra, low shrub tundra, and mat and cushion tundra. The vegetation types in each group were found to be in close association in the study area.

Habitat preferences of foxes were sampled throughout the year. The black spruce woodland and medium shrub tundra group accounted for 46.5% of all sampled locations, and the alpine tundra, low shrub and mat and cushion tundra group covered 48% of all locations.

Pine marten favor conifer-dominated forest and woodland habitat types for foraging and resting. Of 1,353 marten tracks located in identified habitat types in November 1980, 605 (45%) were in woodland black spruce, 525 (39%) in woodland white spruce, 54 (4%) in mixed forest, and 29 (2%) in mixed woodland (Table 3.30). Of 34 marten resting sites located by radiotelemetry, 13 (38%) were in mixed forest, eight (24%) in white spruce forest, eight (24%) in mixed woodland, and five (15%) in other woodland types. Although marten do make occasional forays into shrub tundra and marsh types, the proximity of trees is clearly important. In late summer and autumn, bogs and *Carex* marshes are important foraging sites. Vegetation types avoided by marten include higher alpine types and large, pure stands of deciduous trees.

In the vicinity of the proposed impoundments, beaver dams, lodges, food caches, and foraging sites were noted to elevations above 1,000 m on many slow-flowing sections of creeks and near the outlets of lakes. In alpine areas, willow appears to be the major food, but some dwarf birch and alder are utilized. Along forested banks of creeks in the impoundment zones and along the Susitna River below Devil Canyon, beavers prefer aspen and cottonwood where available, although willow and some birch are utilized. Sign of beavers is increasingly abundant along sloughs and slower-moving channels of the Susitna River downstream from Gold Creek to Delta Islands.

Muskrats occur in lakes, ponds, small streams, sloughs, and marshes throughout the study area. Shallow areas with aquatic vegetation, particularly sedges, are preferred foraging sites.

Data from aerial transects and direct observation of sign confirm that habitats most important to mink in the study area, as elsewhere, are creek and river banks, lake shores, and marshes. For most of the winter, mink utilize areas under ice.

Results of aerial transects and direct examination of otter sign show that otter forage almost exclusively in riverine and lacustrine habitats. Otters make use of under-ice habitats during winter, although the extent and nature of this utilization is unknown.

Short-tailed weasels exhibit much broader habitat preferences than other small mustelids. Of 746 weasel tracks classified during November 1980 aerial transects (Table 3.30), 401 were found in black spruce woodland, 190 in medium (primarily *Betula*) shrub tundra, 88 in white spruce woodland, and 29 in mat and cushion tundra. Direct observation of sign supports the inference that short-tailed weasels can meet their food and cover needs in a variety of structurally and phytologically diverse habitat types.

Lynx appear to be concentrated in the limited riparian communities and the recently burned areas where hares are present.

(c) Birds

Field studies were conducted during the following periods: 6 July to 4 October 1980, 8 to 10 February 1981, and 17 April to 23 October 1981. Activities included helicopter surveys of raptor cliff-nesting habitat and, during waterfowl migration, of selected waterbodies; 385 party-hours of breeding bird censusing; 53 party-hours of ground censusing of water-birds; 44 party-hours of ground observations of raptor/raven nest sites; and more than 630 party-hours of general bird surveys. The common and scientific names of birds mentioned in the text are presented on Table 3.31.

(i) Species Composition and Relative Abundance

To date, 135 species of birds have been recorded in the upper Susitna River basin study area. The relative abundance of these species (see Table 3.32 to 3.35) is largely a function of habitat availability, with common redpoll, savannah sparrow, white-crowned sparrow, lapland longspur, and tree sparrow the most abundant species. Redpolls are habitat generalists, while the other abundant species are birds of the shrublands (dwarf, low, and medium shrubs), vegetation types that cover 67% of the region (APA 1981).

On the basis of current information, 13 species are ranked as rare in the region: three raptors (osprey, American kestrel, boreal owl); three species of prairie ducks (gadwall, blue-winged teal, ring-necked duck); three sandpipers (upland sandpiper, surfbird, sanderling); three small land birds (black-backed three-toed woodpecker, western wood pewee, yellow warbler); and ruffed grouse. Most of these birds are at the periphery of their geographic ranges, although lack of appropriate habitat may limit a few. All, however, are represented by larger, healthy populations in other portions of Alaska.

An eastern kingbird, spotted on 11 July 1980, is considered accidental in the region. In Alaska this species is a regular visitant only in the southeast; it is casual elsewhere in the state (Kessel and Gibson 1978).

(ii) Breeding Bird Densities

Breeding bird censuses, using the territory mapping method (International Bird Census Committee 1970), were conducted between 20 May and 3 July 1981. Twelve square, ten hectare (25-acre) census plots were selected in relatively uniform patches of vegetation that represented each of the major woody avian habitats (after Kessel 1979) present in the region. Eight early-morning censuses were taken on each plot to determine the avian population levels supported by the different habitats and the density of territories of each bird species in each habitat.

Avian population levels varied greatly among the different habitats (Table 3.36), as, of course, did the level of use of each habitat by different species (Table 3.37). The presence or absence of a given species in a habitat is largely a function of species' habitat preferences (see below), but habitat occupancy levels are affected by a number of factors, including in interior Alaska, habitat structural complexity and primary productivity (Spindler and Kessel 1980).

Generally, in the upper Susitna River basin, the forest and woodland habitats supported higher densities and/or biomasses of birds than did the shrub communities. Highest densities in forests were found at the downstream (Sherman) balsam poplar forest plot, which supported 60.9 bird territories/10 ha, and lowest densities were found in the white spruce forest plot at the mouth of Kosina Creek (15.7 territories/10 ha). Of the shrub habitats, low-medium willow shrub had the highest densities (45.4 territories/10 ha), and the dwarf shrub-alpine tundra the lowest (<11 territories/10 ha). Tall alder shrub was also low (12.5 territories/10 ha). Alpine tundra areas of upland cliffs and block-fields and of mat and cushion tundra had the lowest bird usage but supported some bird species not generally found in other habitats. Species in the alpine tundra included white-tailed ptarmigan, horned lark, wheatear, water pipit, gray-crowned rosy finch, and snow bunting.

Preliminary comparisons between occupancy levels in habitats of the upper Susitna River basin and those in similar habitats in the upper Tanana River valley (Spindler and Kessel 1980) show many parallels. In both regions, white birch forest and the mixed deciduous-coniferous forest supported intermediate levels of bird populations and coniferous forest the lowest levels. The scattered woodland and dwarf forest habitats, with their openness and added shrub components, however, also supported intermediate occupancy levels, even with major coniferous components. The lower-height shrub thickets had low numbers of species, apparently because of relatively simple habitat structure, and there were differences in occupancy levels between plots with a dry substrate and ones with high substrate moisture. Habitat diversity and a wet substrate probably allowed higher occupancy levels on the Susitna low-medium willow shrub plot compared to other shrub plots.

The most conspicuous difference between the upper Susitna and Tanana valleys was in the tall shrub thickets. Tall shrubs in interior Alaska supported the highest avian occupancy levels of any habitat (Spindler and Kessel 1980), but unlike the Susitna study area, these thickets were dominated by willow, thinleaf alder, and balsam poplar, which have average to above average levels of primary productivity. The tall shrub thickets of the Susitna study area were composed almost entirely of American green or Sitka alder, which have relatively low levels of primary productivity (Spindler and Kessel 1980) and which, in interior Alaska and on the Seward Peninsula, also support relatively few birds (Kessel pers. obs.).

(iii) Waterbird Use of Wetlands

- Summer Populations

In respect to both numbers of species and numbers of individuals, the wetlands of the region supported relatively few waterbirds during the summer. The relative abundance of loons, grebes, and waterfowl determined from all observations is shown in Table 3.32. The number and density of adults and broods of waterbirds observed during the intensive ground surveys of 28 ponds and lakes during July are shown in Table 3.38.

The density of adult birds derived from the intensive ground survey of 20.5 km^2 of wetlands was 23.8 adults/km^2. By comparison, a similar census of 13 of the more productive waterbodies of the upper Tanana River valley, east-central Alaska, in 1977 and 1979 showed 183.3 and 110.9 adults/km^2 of wetlands, respectively (Spindler et al. in press). Regional comparisons of densities obtained by the waterbody census method can only be made if the distribution of waterbody size classes is similar between regions (ibid)., which was the case for the sets of sampled waterbodies used here. The number of broods directly corresponded to the low bird density, with 2.9 broods/km^2 of wetlands in the upper Susitna River Basin in 1981, compared to an average of 6.2 broods/km^2 in the upper Tanana River valley (ibid.). In 1979, productivity in the eastern portion of the upper Tanana River valley study area was 30-40% lower than historical levels at some of the most productive Alaskan wetlands, like Minto Lakes and the Yukon Flats (J. G. King, U.S. Fish and Wildlife Service, pers. comm.). Thus, during the summer, the waterbodies of the upper Susitna River basin appear to support a relatively impoverished waterfowl population.

The species composition of waterfowl in the region showed some differences from that of central Alaska as a whole, in part reflecting the subalpine nature of much of the study area. Oldsquaw and black scoter were the most productive of the waterfowl in 1981 (Table 3.38). Both species are primarily tundra nesters, and the Alaska Range is the only inland nesting location known for the black scoter in Alaska (Gabrielson and Lincoln 1959). On the other hand, the pintail, which is one of the most numerous ducks in central Alaska, occurred in relatively small numbers in the study area, in spite of the fact that because of severe drought in the Canadian prairie provinces, both 1980 and 1981 were high population years for pintails in Alaska (King and Conant 1980, Conant and King 1981).

Trumpeter swans bred commonly at the eastern end of the study area, from the vicinity of the Oshetna River at least to the MacLaren River. On a random flight over the ponds of this area on 4 August 1981, 19 observations of trumpeter swans were made. Forty adult birds were counted, including nine pairs with broods, totaling 28 cygnets. This area is the western edge of the Gulkana Basin trumpeter swan population, which has more than doubled during the past five years (J. G. King, U.S. Fish and Wildlife Service, pers. comm.).

- Populations During Migration

Studies covered one spring and two fall migratory periods. Aerial surveys were begun earlier and conducted more frequently in fall 1980 than in 1981 because during the first year, it was necessary to learn the use patterns in the region. The fall 1981 surveys were begun later in September than those of 1980 and continued until most of the waterbodies were frozen. An attempt was made to time the first 1981 survey to catch the peak of waterfowl migration, but that effort apparently failed because of a somewhat earlier movement of wigeon, pintail, and scaup that year. During both fall periods, however, the patterns of migration and of waterbody use were similar.

Summaries of the numbers and species composition of loons, grebes, and waterfowl enumerated in the upper basin during aerial surveys in fall 1980 and 1981 and spring 1981 are given in Tables 3.39 to 3.41. Relative abundance rankings for species in fall and spring appear in Table 3.32. Based on these data, the upper Susitna River basin, which is on a high plateau between the Alaska Range and the Talkeetna Mountains, does not appear to be a major migration route for waterbirds (contra U.S. Army Corps of Engineers 1977).

Scaup, including both lesser and greater scaup, were the most numerous species group during both spring and fall. Relatively large numbers of mallards and American wigeon also moved through during both seasons (although the fall 1981 surveys missed the peak wigeon migration). Pintails were common during spring migration but uncommon in fall. Few geese or cranes were seen at either season.

The upper Susitna River basin was less important to migratory waterfowl in spring than in fall. The difference was probably due largely to the ice breakup, which occurred after the main spring migratory movement of many species, especially the dabbling ducks and the common goldeneye.

During their migration, early migrants used both the Susitna River itself and the thawed edges of lakes. Use of the region's waterbodies increased toward the end of May, concurrent with more open water and with the influx of the later-arriving loons, grebes, scaup, oldsquaw, scoters, and mergansers.

On 7 May 1981, an aerial survey was done along the Susitna River from Devil Canyon to Cook Inlet to ascertain the magnitude of waterfowl use during spring migration. The results are presented in Table 3.42. In general, comparatively few waterfowl were noted using the river. Waterfowl abundance appeared to increase as one progressed downstream from Devil Canyon, probably because of changes in river morphology that correspond to various reaches of the Susitna River. That portion of the river between Cook Inlet and the Delta Islands is highly braided and is characterized by slow-flowing sloughs and, thus, provides a greater area of water suitable for waterfowl use. The upper reaches of the river, near Devil Canyon, are more channelized, faster flowing, and, therefore, less suitable for resting migrants.

(iv) Breeding by Cliff-nesting Raptors, Ravens, and Eagles

Information on use of the region by breeding raptors and ravens was derived from 1) helicopter surveys on 6 July 1980 and on 16 and 17 May 1981, of all cliff habitat along the Susitna River and its tributaries, from Portage Creek (1980) and Indian River (1981) to the mouth of the Tyone River, and on 3 and 5 July 1981, of habitats along the proposed access routes; 2) ground visits between 20 May and 13 July 1981 to all 1980 and 1981 active nest sites; 3) special ground and aerial searches of vegetated cliff habitat to discover potential peregrine habitat; 4) supplemental observations made whenever flying over or working near raptor habitat, and 5) miscellaneous observations made throughout the study period.

During the ground visits, photographs as well as verbal descriptions were obtained for each active nest site, and all the cliff habitat along the river system was classified according to its apparent quality for nest sites. "A" cliff habitat had cliffs large enough to support a nest, had ledges and nooks for nest placement, and had little loose material; "B" cliffs had these same attributes but were smaller and perhaps not large enough to support a nest; and "C" cliffs had loose substrates (dirt and rock banks or loose talus) and probably would not have been used by raptors.

- Summer Populations

In all, 43 raptor/raven nest sites were located during 1980 and 1981, 20 of which were inactive in both years. Presumably, these inactive sites function either as alternative sites or are used in years of higher population levels. Of the 23 nests that were active in at least one year, at least five were used both years, each by the same species (Table 3.43). Active sites during the two years of study included those of ten golden eagle, six bald eagle, four common raven, one and perhaps two gyrfalcon, and one goshawk.

In 1974, White (1974) found ten active nests within this same geographic area: two gyrfalcons, one bald eagle, and seven common ravens. He reported 14 inactive nests, ascribing eight to ravens and three each to golden and bald eagles. The reason for the substantially different species composition between the two sets of surveys, that is, more ravens and fewer eagles in 1974, is unknown.

The density of active golden eagle nests in both 1980 and 1981 (one pair per 14.8 km) was similar to that along the Dalton Highway through the Brooks Range in 1979 (one active nest per 15.7 km) (D. G. Roseneau, pers. comm.)--the Brooks Range having one of the highest populations of golden eagles in Alaska. Murie (1944), in Mt. McKinley (now Denali National Park) National Park, found active nests as close as 1.6 and 2.4 km to each other in 1941 and 1939, respectively. Pairs of golden eagles regularly build and maintain a number of simultaneous nests, which they use as alternative sites in various years (Brown and Amadon 1968), some several kilometers apart (D. G. Roseneau, pers. comm.). It has been suggested (White et al. 1977) that local populations increase during years of high hare populations, but hares were relatively scarce on the upper Susitna in 1980 and 1981. Murie (1944) also found that ground squirrels were a major prey of golden eagles in Mt. McKinley National Park in 1939-1941, and this species was abundant in the Susitna area during our study.

Bald eagle densities in the upper Susitna River drainage appear slightly lower than those of interior Alaska, where Roseneau et al. (1981) reported 44 nests, 25 active in 1980, in the vicinity of the Alaska Highway and Tanana River between Fairbanks and the U.S.-Canada border, a distance of approximately 480 km.

On 26 June 1981, an aerial survey was taken along the Susitna River from Cook Inlet to Portage Creek in order to ascertain the use of the lower river by nesting bald eagles. A similar survey was done in early April 1980 by the U.S. Fish and Wildlife Service (USF&WS). An attempt was made during the 1981 flight to locate all nests previously reported by the USF&WS. During the 1981 survey, nine active eagle nests were found (Table 3.44), five of which had previously been noted by the USF&WS. In addition, 13 bald eagles (ten adults and three immatures) were sighted. Based on the discovery of nine nests and on the sighting of five adult birds in the vicinity of nests which, although reported by the USF&WS, were not located during this survey, it is likely that a minimum of 14 to 15 active nests are present between Cook Inlet and Portage Creek. Since weather conditions impaired the effectiveness of the 1981 survey and thus limited the total number of nests located, it is reasonable to speculate that the actual number of active nests could be closer to 20.

Compared to eagle abundance, gyrfalcons are uncommon in central Alaska, but they nest throughout the Alaska Range. Cade (1960) estimated the total Alaska population at about 200-300 pairs, whereas Roseneau et al. (1981) thought there were more, but fewer than 500 pairs. Numbers in a given area may vary considerably from year to year (Cade 1960, Roseneau 1972) but probably not over large geographic regions (Roseneau 1972). For example, gyrfalcons in northern and western Alaska have low site fidelity from one year to the next (Cade 1960, Roseneau 1972). In the Alaska Range, however, most sites are used every year (Bente 1981).

There were no confirmed sightings of peregrine falcons in the region during our study, in spite of the many hours spent in ornithological field work and in raptor habitat. White (1974), however, saw two individual peregrines during his June 1974 survey but found no sign of nesting. One bird was a "single adult male. . .roosting on a cliff about 4 miles upriver from the Devil Canyon Dam axis," and the other was a "sub-adult . . . about 15 miles upriver from the Devil Canyon Dam axis." White (ibid.) stated that the Yentna-Chulitna-Susitna-Matanuska drainage basin "seemingly represents an hiatus in the breeding range of breeding peregrines. . .," and Roseneau et al. (1981) stated that "the Susitna and Copper rivers both provide . . . [very few] . . . potential nesting areas for peregrines."

Only one osprey was observed during the two seasons of study, on 23 May 1981 (John Ireland, pers. comm.) at one of the lakes near Stephan Lake.

- Breeding Chronologies

No special effort was made to obtain data on the breeding biology of raptors and ravens in the Susitna study area. Because the breeding season is a period when most birds are relatively sensitive to disturbance, attempts were not made during this study to establish breeding chronologies for nesting species. Table 3.45, however, shows the breeding chronologies of eagles, gyrfalcons, and common ravens in interior Alaska.

(v) Avifauna/Habitat Relationships

A general overview of bird habitat preferences can be obtained from the density of territories of various species in the habitats represented by the bird census plots (Table 3.37), the assumption being that species occur in greatest densities in their preferred habitats. Similarly, some information on habitat preferences can be obtained from our general surveys, in which we recorded the number of individuals of each species seen per kilometer in various habitats (data not shown).

The following, based on data from the bird censuses and the general bird surveys, is a list of the most abundant species found during the summer in each of the major avian habitats of the upper Susitna River basin:

- Lacustrine waters and shorelines: Arctic tern, mew gull, lesser and greater scaup, common loon

- Fluviatile waters, shorelines, and alluvia: spotted sandpiper, mew gull, violet-green swallow, harlequin duck

- Upland cliffs and block-fields: gray-crowned rosy finch, common redpoll, horned lark, American golden plover, water pipit

- Dwarf shrub mat: water pipit, American golden plover, horned lark, lapland longspur, rock ptarmigan

- Low shrub: savannah sparrow, tree sparrow, lapland longspur, white-crowned sparrow

- Medium shrub: tree sparrow, white-crowned sparrow, savannah sparrow, Arctic warbler, Wilson's warbler

- Tall shrub: hermit thrush, Wilson's warbler, fox sparrow, white-crowned sparrow, tree sparrow

- Scattered woodland and dwarf forest: white-crowned sparrow, American robin, Bohemian waxwing, tree sparrow, ruby-crowned kinglet

- Mixed deciduous-coniferous forest: hermit thrush, dark-eyed junco, yellow-rumped warbler, Swainson's thrush, varied thrush

- Deciduous forest: yellow-rumped warbler, common redpoll, Swainson's thrush, blackpoll warbler

- Coniferous forest: ruby-crowned kinglet, varied thrush, dark-eyed junco, yellow-rumped warbler, Swainson's thrush

(d) Non-game (Small) Mammals

(i) Species Composition and Relative Abundance

Sixteen species of small mammals were recorded in the upper Susitna River basin during the two years of study (Table 3.46).

Trapline surveys conducted during one spring and two fall periods involved a total of 16,776 trap-nights of effort and resulted in the capture of 1,753 microtine rodents (six species) and 1,747 shrews (four species). The two most abundant animals, constituting 67% of total captures, were northern red-backed voles, represented by 1,382 specimens, and masked shrews, represented by 1,286 specimens. Other shrews captured were Arctic shrews (297 specimens), dusky shrews (153), and pygmy shrews (11). *Microtus* specimens included 203 tundra voles, 68 meadow voles, and 75 singing voles. Brown lemmings (20) and northern bog lemmings (4) were also taken.

Capture results from 12 sites sampled during all three trapping periods indicated a pronounced temporal difference in small mammal abundance (Fig. 3.22). Trapping in fall 1980 resulted in 941 captures, compared to 125 the following May and 1,231 in fall 1981. Comparison of fall numbers shows that tundra voles were twice as abundant in 1981 as in 1980, red-backed voles 1.7 times more abundant, and masked shrews 1.3 times more abundant. Fall capture numbers of meadow voles, Arctic shrews, and pygmy shrews were about equal, while dusky shrews were sharply lower. Brown lemmings (six specimens) and bog lemmings (three) were taken in 1981 only. The low number of captures in May 1981 probably resulted from cessation of breeding in late fall and from overwinter mortality. Regardless of the temporal differences in population levels, the relative abundance ranking among species remained the same, that is, the common species remained common and the rare continued to be rare.

Six additional small mammal species occurred in the study area but were not caught on trapline surveys. For example, Arctic ground squirrels were abundant and widespread in the high country, while two other alpine species, collared pikas and hoary marmots, were only locally common. At lower elevations, red squirrels were fairly common. Porcupines were uncommon. Snowshoe hares, nowhere numerous, were generally restricted to areas east of Watana Creek. Localized "pockets" of hares were reported in the vicinities of Jay Creek, Goose Creek, and the Oshetna River. The scarcity of hares in the study area was probably due more to a scarcity of suitable habitat than to a low stage of a population cycle. Noticeably absent from the Susitna basin were recent burns and riparian shrub thickets, habitats most preferred by hares in other areas of central Alaska.

(ii) Small Mammal/Habitat Relationships

Standardized trapline transects were established on sites representing the small-mammal habitats of the region. Using a cluster analysis technique (Dixon and Brown 1979), 42 trapping sites were classified on the basis of their floristic similarity into three main vegetation types: 1) herbaceous dwarf and low shrub sites; 2) coniferous forest sites; and 3) mixed deciduous-coniferous forest, deciduous forest, and tall shrub sites. Figure 3.23 shows small mammal abundance patterns across this spectrum of habitat types.

Shrews and red-backed voles occupied a broad range of habitat types. Masked shrews, the numerically dominant shrew species, were caught on all 42 sites, while Arctic shrews were taken on 29, dusky shrews on 23, and the locally rare pygmy shrew on only four (not shown on figure). Generally, shrews were most abundant in balsam poplar forest, grassland, and alder shrub communities.

Red-backed voles, the dominant microtine of the region, were found on all but five sites, indicating this species' ecological flexibility. Across this broad range of occupied sites, red-backed voles were most numerous in forest and shrubland communities, particularly open and woodland spruce, and balsam poplar forest. Herbaceous meadows, especially wet sites, were generally avoided.

Microtus species had a more restricted habitat distribution. Tundra voles and meadow voles occurred primarily in herbaceous meadows and bogs dominated by sedge and grass vegetation. Such sites included wet sedge-grass, riverine herb/low shrub meadows, and sedge tussock seepages in black spruce woodland. Tundra voles occurred on 22 sites, compared to ten for meadow voles, suggesting the former species had greater habitat tolerance. Colonies of singing voles were found only above treeline in tundra and shrub habitats. They were most abundant in open willow-birch shrub communities on relatively dry sites.

Brown lemmings were trapped irregularly at or above treeline in herbaceous and shrub communities. Bog lemmings (not shown on figure) were caught at lower elevations in wet sedge-grass/low shrub sites (two captures), grassland (one), and near a seepage in white spruce forest (one).

Arctic ground squirrels dominated well-drained herbaceous and shrub tundra habitats above treeline, while collared pikas and hoary marmots were more restricted to rock habitats at the higher elevations. Red squirrels were confined almost exclusively to coniferous and mixed coniferous-deciduous forests and to woodlands within the river basin. Porcupines were encountered in a variety of forest and woodland communities. Snowshoe hares were in forest, woodland, and tall shrub habitats.

3.3 Description of Fish Resources

The baseline information described in this section is based primarily on reports prepared by the Alaska Department of Fish and Game (ADF&G) on Susitna River investigations conducted during the winter of 1980-81 and through 1981. These reports included studies on the adult anadromous species and on juvenile anadromous and resident species as well as on aquatic habitat and instream flow. Previously completed ADF&G reports and other pertinent literature have been used, where possible, to supplement this information.

The contribution to Cook Inlet of the Susitna River above Talkeetna can be estimated using the ADF&G 1981 salmon studies, the Cook Inlet commercial fishery harvest information, previous ADF&G salmon studies on the Susitna River, and standard harvest to escapement ratios for the five Pacific salmon species.

In the adult anadromous studies, the locations of the sonar counting and fishwheel field stations are shown in Figure 3.24. The locations of the primary tributaries and sloughs in the Susitna River downstream of Devil Canyon are shown in Figures 3.25 through 3.30.

For the lower Susitna juvenile anadromous and resident fishes investigations, the study area was divided into two reporting reaches: Cook Inlet to Talkeetna, which was the first 157 km of the Susitna, and the Talkeetna to Devil Canyon segment, which was approximately 86 km in length. Thirty-nine habitat locations and 44 sampling sites were located. These are listed in Table 3.47.

Based on a preliminary reconnaissance of the upper Susitna River basin, eight major tributaries were selected for more detailed fisheries studies. These tributaries were: Fog and Tsusena creeks in the vicinity of the proposed Devil Canyon impoundment and in the proposed Watana impoundment, Deadman, Watana, Kosina, Jay, and Goose creeks and the Oshetna River. For the purpose of this study, the first 1.6 km of these streams from their confluence with the Susitna River were designated as habitat locations. Sampling at the confluences included areas 90 m upstream and downstream of the respective confluence to assess mainstem utilization. Sampling evidence was placed on the tributaries, however, and not on the Susitna mainstem because it was thought that the tributaries contained the major fish resource in this region during the summer.

The aquatic habitat and instream flow studies during the summer field season involved data collection and analyses on water quality and hydrologic conditions in addition to the mapping of designated habitat sites between Cook Inlet and the Oshetna River. These areas included mainstem regions, sloughs, tributary confluences, and some upstream tributary localities. In all references to river kilometers in the text, it should be noted that distances are measured beginning with the river mouth as river kilometer 0.

Several sites in the study area were examined in greater detail than were other areas in order to evaluate the relationships between mainstem hydraulic and water conditions and fisheries habitat in slough areas between Talkeetna and Devil Canyon. The study was divided into two segments: 1) water quality and discharge data collection and (2) surveying and discharge measurements.

In order that impact analyses and mitigation assessments be made, a substantial amount of information and data generated by other project participants was utilized. Engineering and hydrological information provided by Acres American as well as hydrological and water quality information supplied by R&M Consultants and the United States Geological Survey (USGS) were used in conjunction with the available baseline fisheries data.

Since the above studies did not deal with the fish resources of the proposed northern transmission corridor from Healy to Fairbanks, a description of those resources is presented here. The Tanana River probably possesses the most valuable fish resource, with chinook, chum, and coho salmon found in the system. Throughout this northern region, several resident fish are known to occur. These include Arctic grayling, Dolly Varden, sheefish, burbot, northern pike, and several species of whitefish (ADF&G 1978). Fish resources in the southern segment of the transmission line corridor are essentially the same as those discussed in the following fish ecology report.

(a) Anadromous Species

(i) Salmon

In the following discussion of Pacific salmon species, the common names of chinook, sockeye, pink, chum, and coho salmon have been used. There are many other common names used throughout the geographic ranges of these species, and their indiscriminate use can result in a good deal of confusion.

For chinook salmon, the other most frequently used common name is king salmon. Sockeye salmon are also referred to as red salmon. It should be mentioned that the land-locked form of the sockeye is called kokanee. For the pink salmon, other frequently used common names are humpback salmon or simply, humpback. Chum salmon are also referred to as dog salmon, and coho salmon can be called silver salmon. The scientific names for the salmon species mentioned above and for all other fish species discussed in the fish ecology report are listed in Table 3.48.

Throughout the discussion of salmon, reference is made to Devil Canyon's being a natural barrier to salmon migration, a phenomenon which had previously been assumed but with little investigative support. Fisheries and hydrologic studies conducted during the past year have confirmed that salmon do not migrate through Devil Canyon, despite the fact that fish were reported to exhibit milling or holding behavior in the lower portion of Devil Canyon.

In the following discussions on salmon migration periods, reference is made to the peak migration periods. This was usually determined by plots of fishwheel catches per hour throughout the sampling season. The time period in which the catches of individuals was the greatest was determined to be the peak migration period. In discussing migration time rates, these rates are valid only if there is no fundamental variation in migrational timing between Susitna River stocks of the various salmon species.

It is known, at least in some cases, that salmon migration rates are influenced by variations in river discharge patterns. This phenomenon was seen in the fishwheel and sonar counting studies made on chinook salmon. Comparisons of catch rates and provisional USGS discharge data indicated a resumption of upstream migration following periods of high water.

- Adult

  o Chinook Salmon

In the lower Susitna River, the adult chinook salmon migration begins in late May and ends in early to mid-July. Historically, by 1 July, 90% or more of the escapement have migrated past the Susitna Station region, 41 km upstream of Cook Inlet (ADF&G 1972).

Field studies conducted during the 1981 season substantiated that the migration run had already begun before fishwheel sampling was operational on 19 June. As a result, the precise onset of migration in the lower Susitna River could not be determined. At Yentna Station, mean hourly fishwheel catches indicated that the migration was over by 9 July.

Similarly, sonar counts made during the initial days of operation at Sunshine Station suggested that a significant segment of the escapement had already migrated past this location prior to the 23 June sonar counter installation. This occurrence was also the case at the Talkeetna site, where a sizable portion of escapement had already passed before 22 June, when the sonar counters were initially operational. Migrating chinooks were already found to be present at Curry, upstream of Talkeetna, on 16 June.

Fishwheel catches and sonar counter data indicated that the peak of upstream migration at Sunshine Station occurred on 23 June and that migration ceased about 10 July. No peak migration period could be determined at Talkeetna, but migration had stopped by 7 July. The peak of the migration at Curry occurred on 23 June, while the run was essentially over in this region by July 4. Sonar counter data for chinook salmon is shown in Table 3.49.

The majority of Susitna Station fish sampled for age analyses were found to be three- and four-year-old individuals. Five- and six-year-old fish were present but in smaller numbers. At the Yentna Station, four-year-old fish, followed by six-year-olds, were the two dominant age classes in the migration run.

Age samples collected at Sunshine, Talkeetna, and Curry Stations can be considered characteristic of the chinook escapement. There was a higher percentage of younger fish, mainly three-year-olds, sampled at Sunshine Station than at either the Talkeetna or Curry Stations. Four-year-old individuals were dominant in the samples, except at Talkeetna, where six- and four-year-olds were equally abundant. Seven-year-old fish were relatively scarce at Sunshine and Talkeetna. None was identified from the Curry Station sample.

Radio telemetry studies indicated that the confluence of the Talkeetna, Chulitna, and Susitna rivers may be a milling area for migrating adult chinook salmon. All of the fish tagged at the Talkeetna site (which is 165 km upstream of the confluence) moved downstream and remained either at the confluence or downstream of this area for several days or weeks before moving upstream. This downstream movement was not seen in fish radio tagged at the Curry site.

Some fish were found to enter one or more tributaries on their migration run to their natal stream. Also, two radio tagged individuals were found milling in lower Devil Canyon, approximately 240 km upstream of Cook Inlet, and later entered tributaries downstream of Devil Canyon.

Chinooks spawn in the tributaries of the Susitna River system and do not utilize the mainstem Susitna for spawning purposes. Some of the more notable spawning tributaries include: Alexander Creek, Deshka River (Kroto Creek), Willow Creek, Clear Creek (Chunilna Creek), Chulitna River, Peters Creek, Lake Creek, and Talachulitna River. In the Susitna system upstream of Talkeetna, Indian River and Portage Creek are important spawning tributaries. Essentially, July and early August constitute the spawning period for chinooks in the Susitna River system.

The escapement counts for the east side Susitna River tributary streams between 1976 and 1981 were rated as only "fair" to "poor." Surveys conducted in 1981 on Indian River and Portage Creek, however, rated the escapements for these two streams as above average.

Given the lack of total Cook Inlet escapement data, the Susitna River contribution of chinook salmon is not known. The basis for estimating chinook salmon escapement is primarily index counts of clear water tributary streams. The Susitna drainage estimate for chinook production is in the range of 105,000 to 115,000 salmon. Between one and 2% of the Susitna escapement use the Susitna River above Talkeetna, the area of most profound impact.

o Sockeye Salmon

Apportioned sonar counts and a summary of fishwheel catches discussed below for sockeye salmon are shown in Tables 3.50 and 3.51, respectively. Tag/recapture estimates are shown in Table 3.52.

At Susitna Station, the sockeye salmon migration principally extended from 29 June to 24 August, with the midpoint of the run occurring on 17 July. A total of 340,232 individuals were counted by Side Scan Sonar (SSS) counters, while 75% of the escapement passed during a 13-day period from 11 July to 23 July. Fishwheel operations indicated that the peak migration occurred between 10 and 19 July.

A total of 139,401 sockeye were counted at the Yentna Station. The migration commenced on 1 July, and the midpoint of the run was determined to occur on 16 July. The migration run had ended by 3 August. The majority of the total fish count was made between 12 and 23 July. Fishwheel catches indicated that the migration peak was between 13 and 15 July.

Sonar counts at Sunshine Station totaled 89,906. The migration began on approximately 16 July, reached a midpoint on 23 July, and ended on 20 August. Seventy-five percent of the sockeye migrated past this location between 19 and 28 July. Based on fishwheel catch records, the peak of the migration occurred between 18 and 23 July.

At Talkeetna Station, 3,464 sockeye were counted. The migration commenced on 23 July and was completed by 8 August. The midpoint occurred on 31 July. A significant majority of the total count was made between 23 July and 6 August. It appeared from fishwheel catch data that the migration peak occurred between 27 July and 1 August.

The Curry Station fishwheel counts totaled 470 sockeyes. Results indicated that the migration commenced on 18 July, reached a midpoint on 5 August, and was not over until 29 September.

From the sonar data, the migrational timing of sockeye salmon indicates that those fish passing Susitna Station enroute to the Yentna River made the 10 km trip in one day or less. Individuals migrating past Susitna Station toward Sunshine Station covered this distance in an average of 8 days (11 km/day) and reached Talkeetna Station in an average time of 13 days (7.4 km/day).

Tag/recapture data indicated that the minimum travel time between Sunshine and Talkeetna Station and Curry Station was approximately five days or a travel speed of approximately 5.6 km/day.

Based on tagging operations, population estimates were calculated; these estimates may not accurately reflect the actual number of fish utilizing the various portions of the Susitna system. Sockeye population estimates derived from tagging operations indicated that approximately 130,489 sockeye were present at Sunshine; 4,809 at Talkeetna; and 2,804 at Curry Station.

Sockeye salmon age composition analyses indicated that a significant majority of the sockeye samples at each station were age 5_2 that is, five years old with two years in fresh water. The second most abundant age class was 4_2, followed by age 6_2. Five-year-old fish comprised approximately 86% of the return at Susitna Station and Yentna Station, 73% at Sunshine and Talkeetna Station, and 70% at Curry Station.

In the Talkeetna to Devil Canyon reach, adult sockeyes were observed in Sloughs 3B, 3A, 6A, 8A, 9, 9A, 9B, 11, 17, 19, 20, and 21 and in lower McKenzie Creek (Figures 3.25-3.30). Peak spawning occurred during the last week of August and the first three weeks of September. Of the locations listed, sockeyes were most numerous in Slough 8A, 9B, and 11, where peak spawning ground counts were 177, 81, and 893 sockeye salmon, respectively.

The 20-year average Cook Inlet harvest for sockeye salmon was 1,168,198. Sockeye salmon escapement and stock separation information for Cook Inlet show that approximately 23% of the 1979 Cook Inlet run and approximately 19% of the 1980 run were classsified as originating from the Susitna River. Approximately 5% of the Cook Inlet sockeye run escapes at Susitna Station and approximately .05% in the reach above Talkeetna.

o Pink Salmon

Apportioned sonar counts and a summary of fishwheel catches discussed below for pink salmon are shown in Tables 3.50 and 3.51, respectively. Tag/recapture estimates are shown in Table 3.52. The adult migration for pink salmon in the Susitna River system was found to begin essentially around 10 July and to terminate during the third week in August. In the vicinity of Talkeetna and Curry stations, the peak migration period lasted from the last week of July until the middle of August.

Sonar counts at Susitna Station totaled 113,349 pinks. The migration period started approximately on 10 July, with the midpoint occurring on 25 July. The migration run at Susitna Station terminated on 21 August. Seventy-five percent of the escapement passed this region between 15 July and 29 July. Fishwheel catches indicated that the migration peak had occurred between 21 July and 3 August.

At the Yentna Station, 36,053 pink salmon were enumerated by the sonar counters. The migration began here on approximately 14 July; the migration's midpoint was 27 July; and its cessation date was 20 August. Between 21 July and 2 August, a significant percentage of the total pink salmon run counted at the Yentna Station had passed this station. Fishwheel catches indicated that the migration peak lasted from 21 July to 6 August.

The number of individuals counted at the Sunshine Station sonar site totaled 72,945. The migration run did not begin at

Sunshine Station until approximately 23 July, essentially two weeks later than at Susitna Station. The midpoint date for the run was 1 August, with completion on 20 August. Seventy-five percent of the migration was counted between 28 July and 9 August. Fishwheel catches showed the migration peak to have occurred between 29 July and 9 August.

Talkeetna Station counts totaled 2,529 pink salmon. The migration period was found to be similar to that at Sunshine Station: the migration run at Talkeetna essentially began on 27 July, reached a midpoint on 6 August and had ceased on 20 August. Seventy-five percent of the escapement passed Talkeetna Station between 29 July and 9 August. Peak fishwheel catches occurred between 1 and 10 August.

At Curry Station, the pink migration began on 31 July, reached a midpoint by 8 August, and terminated approximately 19 August. Between 4 and 19 August, 75% of the escapement passed Curry Station.

Population estimates derived from tag and recapture data indicated that approximately 53,101 pink salmon were present at Sunshine Station; 2,335 at Talkeetna Station; and 1,146 present at Curry Station. It should be emphasized that these results are from the odd-year pink run, and population estimates would be substantially higher during the even-year run.

The migrational rates based on plots of sonar and fishwheel catch data indicated that pink salmon took an average of three days to reach Yentna Station from Susitna Station, a distance of approximately 10 km. This represents an average travel speed of roughly 3 km per day. Between Susitna Station and Sunshine Station, the average travel time was 9 days with a travel rate of 10km/day. Travel time between Susitna Station and Talkeetna Station was approximately 12 days with a travel rate of around 10 km/day. Tag and recapture data on pink salmon indicated that travel time between Sunshine and Talkeetna Station ranged from .2 to 30 days. Pink salmon averaged three days of travel time or 10 km/day between Talkeetna and Curry Stations with a range of travel time between one and 13 days.

Spawning pink salmon were found in Sloughs 3A, 8, and A and also in Whiskers Creek, Chase Creek, Lane Creek, Fourth of July Creek, Fifth of July Creek, Skull Creek, Sherman Creek, Indian River, and Jack Long Creek (Figures 3.25-3.30). The highest peak spawning count within an index area was in Lane Creek, where 291 fish were recorded. Peak spawning occurred in a ten-day period from 19 August to 28 August. The stream survey counts are index counts and do not reflect total number of spawning fish present in the stream surveyed.

The average even-year pink salmon Cook Inlet harvest for 20 years is approximately 1,671,194. It is also estimated that 85-90% of the Cook Inlet harvest originates in the Susitna. In 1981, odd-year pink salmon data were collected by ADF&G. The 20-year average for odd-year pink salmon harvest from Cook

Inlet is 148,073 fish, but with a range of 23,963 to 554,184. The harvest to escapement ratio of 3.8 to 1 for pink salmon indicates that 19% of the Cook Inlet run escapes back to the Susitna River drainage for spawning and rearing. This 19% of the Cook Inlet run is equal to 100% of the odd-year Susitna pink salmon that pass Susitna Station. Roughly 3% of these fish use the area above Talkeetna for spawning. Thus, 97% of the Susitna pink salmon run use other reaches of the river for spawning.

o <u>Chum Salmon</u>

Apportioned sonar counts and a summary of fishwheel catches discussed below for chum salmon are shown in Tables 3.50 and 3.51, respectively. Tag/recapture estimates are shown in Table 3.52.

The chum salmon migration began during the second week of July and ended during the beginning of September. In the Susitna River upstream of Talkeetna, the period from late July until the end of August was the peak migration period. Unlike the pink salmon, a peak migration period of seven to ten days could not be established for chum; rather, the chum migration seemed to be distributed over a longer period of time.

A total of 46,461 chums were counted at Susitna Station by the SSS counters. The migration arrived at Susitna Station on 10 July, reached a midpoint on 27 July, and ended on 25 August. Seventy-five percent of the escapement was counted between 15 July and 6 August. Fishwheel catches indicated that the migration peak occurred between 3 August and 7 August.

The Yentna Station enumerated 19,765 individuals. The migration run essentially began at Yentna Station on 13 July, reached its midpoint on 29 July, and ceased on 24 August. A significant majority of the fish were counted between 18 July and 15 August. Fishwheels operated at Yentna Station indicated that the migration run reached its peak between 20 and 23 July.

Counts at the Sunshine Station totaled 59,630 chums. The migration run at this location commenced on 22 July, reached a midpoint on 6 August, and ended on approximately 6 September. Seventy-five percent of the fish were counted between 27 July and 24 August. The peak of chum migration at Sunshine Station, as indicated by fishwheel catches, occurred between 17 and 19 August.

A total of 10,036 chum salmon were counted at Talkeetna Station. The beginning of the migration was approximately 28 July. The midpoint was reached on 8 August, and the migration ended on 29 August. The majority of the escapement was counted between 30 July and 29 August. No narrowly defined peak period was ascertained from the fishwheel catches.

Fishwheel catches at Curry Station indicated that the chum migration began approximately 29 July. The run's midpoint was 16 August, and the migration terminated on 2 September.

Chum salmon averaged four days of travel time between Susitna Station and Yentna Station for a travel speed of 2.5 km/day. Average travel time between Susitna Station and Sunshine Station was 10 days, which is a travel rate of 9 km/day. The migration period between Susitna Station and Talkeetna Station averaged 14 days or approximately 9 km/day.

Chum salmon tagged at Sunshine Station took between two and nine days to reach Talkeetna Station. Between Talkeetna Station and Curry Station the number of travel days ranged from one to 24 days with an average travel time of approximately 4.5 days and a travel rate of aproximately 6 km/day.

Tag and recapture data determined that approximately 262,851 were present at Sunshine; 20,385 at Talkeetna Station; and 13,068 at Curry Station. Although these are estimates, the relative abundance at the various river regions can be seen.

At each site, age 4 chum salmon from the 1977 brood year dominated the catch, comprising, on the average, 86% of the sample. Second in abundance were age 5 fish, followed by age 3 individuals. The most noticeable difference in age class structure occurred among the chums sampled at Curry Station. At this site, the percentage of age 5 fish was higher than at other locations, while the percentage of age 3 fish was lower.

Another result of this study is that chums were found to spawn in the Susitna mainstem. Of the 12 mainstem sampling sites, evidence of chum spawning was found at ten. Several of these sites were located in the river mainstem of the Curry Station.

Chum salmon were present in Sloughs 1, 2, 6A, 8, 8B, Moose, A^1, A, 8A, 9, 9B, 9A, 11, 13, 15, 17, 19, 20, 21, and 21A (Figure 3.25-3.30). They were also found within the survey reaches of Whiskers Creek, Chase Creek, Lane Creek, Lower McKenzie Creek, Skull Creek, Sherman Creek, Fourth of July Creek, and Indian River. The peak spawning activity in the sloughs occurred during the last two weeks of August and the first two weeks of September. The highest counts were recorded in Sloughs 8, 8A, 9, 11, and 21, where 302, 620, 260, 411, and 274 chums, respectively, were found spawning. Based on the limited stream survey data, the peak spawning period was approximately one week earlier than that observed in slough spawning areas. The highest peak count in an index area was registered in Lane Creek, where 76 chums were counted on 23 August.

Eleven chum salmon were radio tagged between 30 July and 12 August. Their movements were monitored from 30 July through

August 1981. Ten of the 11 fish were tagged between 6 and 12 August. Seven fish were tagged at Curry Station, and four were tagged at Talkeetna Station; five were females, and six were males.

The primary destinations of radio tagged chums were Susitna River sloughs, clear water tributaries, and the confluence zones of tributary streams. Four fish entered Susitna River sloughs 21, 11, Moose, and an unnamed slough near rkm 156, respectively (Figures 3.25, 3.29 and 3.30). Three fish entered the Indian River. One fish entered Sherman Creek before returning to the mainstem Susitna River, where it held within 4.8 km of the Fourth of July Creek confluence zone. Another fish stayed in the mainstem Susitna River at river kilometer 191. One individual swam down the Susitna River and entered the Chulitna River, while another fish was last detected at river kilometer 203.2 in the Susitna River. Radio tagged chums entered spawning areas between 8 August and 23 August.

Maximum sustained yield total run for Cook Inlet chum salmon harvest are estimated at approximately 1,000,000, based upon a historic sustained harvest of 700,000 fish and a harvest to escapement ratio for chum salmon of 2.2 to 1. The Susitna River proportion of the harvest, based upon historic data and assuming that 90% of the Cook Inlet chum salmon harvest originates from the Susitna, totals apprixmately 630,000 fish. Thus, it is estimated that on the average, 280,000 ± chum salmon return to the Susitna River to spawn each year. This figure means that approximately 28% of the Cook Inlet run of 1,000,000 chum salmon escapes to the Susitna. For a worst case estimate, using 1974 data, the estimated Susitna escapement would be approximately 160,000. Based upon available data and ADF&G's 1980 study program, the best estimate of chum salmon escapement in the reach of the Susitna River above Talkeetna is in the 20,000 to 30,000 range. This number is approximately 20% of the total Susitna run, which is considered a fairly liberal percentage.

o Coho Salmon

Apportioned sonar counts and a summary of fishwheel catches discussed below for coho salmon are shown in Tables 3.50 and 3.51, respectively. Tag/recapture estimates are shown in Table 3.52.

For the Susitna River system as a whole, the adult coho migration period runs from approximately the third week of July until early October. The coho are the last species of Pacific salmon to migrate up the Susitna. Late July through August is the major migrational period for the coho in the Susitna River segment above Talkeetna. Field investigations conducted in fall 1981 indicated, however, that coho salmon were still spawning in early October (Barrett, pers. comm. 1981).

A total of 33,470 coho salmon were enumerated across the SSS counters at Susitna Station. The migration began, reached a midpoint, and ended on 20 July, 28 July, and 25 August, respectively. Approximately 75% of the fish passed in the time period between 23 July and 16 August. Fishwheel catches indicated a migration peak occurring between 25 July and 30 July.

At the Yentna Station, 17,017 coho were enumerated by the sonar counters. The migration essentially began on 22 July, reaching a midpointon 31 July and ending on 20 August. The major portion of the run passed this location between 23 July and 16 August. The peak of migration, shown from fishwheel catches, occurred between 23 July and 6 August.

SSS counters at Sunshsine counted 22,793 coho salmon. The beginning of the migrational period was 29 July, reaching a midpoint on 18 August and ending on 5 September. Seventy-five percent of the migration run was counted between 4 August and 24 August. Fishwheel catches indicated a peak migration period between 18 August and 25 August.

At Talkeetna, 3,522 coho were enumerated by sonar counters. July 30 was the beginning of the migration run, 24 August the midpoint, and 11 September the termination. The majority of coho were counted between 11 August and 1 September. Fishwheel catches indicated a migrational peak period occurring between 19 August and 30 August.

Curry Station fishwheel catches indicated that the coho migration began in this location on 5 August, was at its midpoint on 22 August, and ended on 4 September.

Population estimates derived from tagging and recapture operations indicated that approximately 19,841 salmon were present at Sunshine Station; 3,306 at Talkeetna Station; and 1,041 at Curry Station. The majority of individuals sampled for age analyses were age 4_3, from the 1977 brood year, followed by age 3_2, from the 1978 brood year. Less than 10% of the coho escapement consisted of other age classes.

The average migrational travel time for coho salmon between Susitna Station and Yentna Station was two days, which was a travel rate of approximately 5 km/day. An average of fourteen days were required to reach Sunshine from Susitna Station. Total travel time from Susitna Station beyond Sunshine Station to Talkeetna Station was approximately 24 days and represented a migration rate of 6.2 km/day to Sunshine Station from Susitna Station and 5 km/day between Susitna Station and Talkeetna Station.

Tag recapture of marked coho indicated that between Talkeetna and Curry Stations, the migration took between two and 15 days with an average travel time of 4.5 days. This was a migrational rate of approximately 6 km/day.

Coho salmon were reported to spawn in the Susitna River mainstem at three of the 12 study sites. At one site, coho were found spawning in the same area as chum salmon. Two of the three mainstem sites were located in the vicinity of Curry Station.

Coho were also seen in Slough 9; however, the vast majority of spawning fish were located in various tributaries. These included Whiskers Creek, Chase Creek, Lane Creek, Gash Creek, Lower McKenzie Creek, Fourth of July Creek, Indian River, and Portage Creek (Figures 3.25-3.30). The highest densities of coho, based on peak index counts, were in Whiskers Creek, Chase Creek, Gash Creek, and Indian River, where 70, 80, 141, and 85 coho salmon, respectively, were recorded spawning in a single survey. The survey data indicate that the spawning peak probably occurred in the second and third week of September.

Ten coho salmon were radio tagged from 31 August through 4 September, four at Curry Station and six at Talkeetna Station. Coho displayed one or all three types of directional movement: downstream, upstream, or multi-directional. Coho movement did not appear to be influenced by flow conditions within the Susitna River.

In any case, about 8% to 10% of these fish reach the area above Talkeetna. Using the harvest versus escapement ratios of 2.2 to 1, the 1981 sonar counts at Talkeetna indicate that from 7,000 to 8,000 Cook Inlet coho salmon harvested for 1981 can be attributed to this reach of the river. A significant sport fishery exists for coho in the river above Talkeetna, but this harvest is probably a small fraction of the total harvest and has not been included in these figures.

- Juvenile

It should be noted that a significant portion of the discussion on juvenile salmon is presented as the percent occurrence at respective sampling locations. The actual number of individuals collected at some of the sampling sites was quite small and translates into low catch per unit effort values. These percent occurrences are indicative of the overall general distribution of the species under discussion and are not intended to present definitive findings as to the relative abundance of juvenile salmon in the specific habitats of the Susitna River system. This is particularly true in regard to winter sampling data which was minimal.

o Chinook

During the winter, the majority of juvenile chinook salmon were captured at slough and mainstem Susitna River sites. In summer, most of the chinook juveniles were collected at tributary mouth sites. Two age classes, (0+ and 1+) were identified. Age 1+, however, were not captured after July in the Talkeetna to Devil Canyon stretch and not after August in the Cook Inlet to Talkeetna reach.

Sites associated with tributary mouths appear to provide important milling areas for juvenile chinook salmon in the Cook Inlet to Talkeetna reach. The change to clear water conditions which occurs during the winter makes the Susitna River and its sloughs primary overwintering sites as icing and lowered flow conditions develop in the tributary streams. A more detailed narrative is included below.

The vast majority of juvenile chinook salmon in the Susitna River basin spend one winter in fresh water before migrating to the sea. A comparison of the freshwater ages of chinook sampled at Susitna and Yentna stations indicated that nearly all of these fish had migrated to sea after spending one winter in fresh water. Similarly, at Talkeetna and Curry stations, nearly 95% had migrated to the ocean after spending one winter in fresh water. The remaining population had smolted before their first winter at Sunshine. Only 5% of the Sunshine Station fish sample had smolted prior to their first winter, while 95% did so after spending one winter in the system.

Juvenile chinook salmon were captured beginning with the first winter sampling conducted in November 1980. Surveys continued through May and pointed up the presence of rearing chinooks from Alexander Creek upstream to Portage Creek.

Eleven of 18 (61%) habitat location sites sampled in the Cook Inlet to Talkeetna reach from November through May contained juvenile chinook salmon. Some were collected at four of six (67%) mainstem and slough habitat locations and at seven of 12 (58%) tributary mouth habitat location sites in this reach. Consistent catches were observed at Sunshine Creek and Rustic Wilderness (Figure 3.32). The highest catch rate for juvenile chinooks in this reach occurred during March at Rustic Wilderness, where 2.7 fish per trap were captured.

Juvenile chinooks were captured at eight of the 12 habitat locations sampled between Talkeetna and Devil Canyon from January through April 1981. More specifically, they were collected at seven of eight (88%) mainstem and slough habitat locations and at one of four (25%) tributary mouth habitat locations in this reach. Although rearing chinooks were consistently noted at Slough 8A, Slough 10, and Slough 20, the highest individual catch of juveniles during winter sampling was observed in March in an open lead at Slough 6A (Figures 3.26, 3.28, and 3.29). Twenty fish were captured in a single trap set at this location.

Sampling took place on Indian River and on Portage Creek from February through April 1981. Indian River was surveyed from its mouth to approximately 13 km upstream, while Portage Creek was surveyed from its mouth to approximately 10 km upstream.

During March, small numbers of juvenile chinooks, all from the 1979 brood class, were observed in Indian River, while April surveys showed the presence of both 1979 and 1980 brood classes. The highest catch rate of 0.3 fish per trap was recorded during March at a spot 4.3 km upstream in the Indian River. Juvenile fish, also all from the 1979 brood class, were likewise observed in March at Portage Creek. The highest catch rate of 0.8 fish per trap was recorded in an area of Portage Creek 15.2 km upstream from its mouth.

During sampling conducted in the period from 1 June to 30 September 1981 of the summer field season, juvenile chinook salmon were captured at habitat location sites from Alexander Creek upstream to Portage Creek. Moreover, selected fish habitat sites located on Indian River and Portage Creek produced catches of juvenile chinooks when sampled in June, August, and October. During the 1981 studies, chinook juveniles were not observed, however, above Susitna River kilometer 238.

Juvenile chinooks were captured at 43 of 44 (97.8%) of the habitat location sites surveyed between Cook Inlet and Devil Canyon during the summer months. In fact, Kroto Slough mouth was the only habitat location site where juveniles were not observed. Beginning in April, with the first captures of juvenile chinooks from the 1980 brood year, two age classes, age 0+ and age 1+, were present.

Chinook juveniles were observed at over 50% of the habitat location sites surveyed in the Cook Inlet to Talkeetna reach from June through September 1981. The highest incidence of juveniles was recorded during early July and late September, when over 75% of the sites surveyed produced fish. Ten (37.0%) of the habitat sites in this reach showed a 100% incidence of juvenile chinooks for the surveys, while 19 (70.4%) of the sites had at least at 50% incidence of occurrence.

In this reach, catches during the June through September surveys were generally higher at tributary location sites than those observed at mainstem river or slough sites. Catches at tributary mouth habitat location sites illustrated a high incidence of occurrence throughout the summer, ranging from 60.0% of the sites sampled in early June to 93.3% in early July.

On the other hand, throughout most of the summer in this reach, a lower percentage of incidence was recorded at mainstem and slough sites than at tributary mouth sites. The percentage of incidence of juvenile chinooks in mainstem slough habitat site catches ranged from 27.3% in early August to 87.5% in late September.

Two age classes of juvenile chinook salmon, 0+ and 1+, were collected at habitat location sites in the lower Susitna River from June to September 1981; these age classes represented brood years 1979 and 1980. The catch per unit effort of chinook salmon age 0+ for the Talkeetna to Devil Canyon reach ranged from 0.0 fish per trap at Mainstem-Curry throughout the season to a catch rate of 12.0 fish per trap recorded at Fourth of July Creek. As the season progressed, however, an increase in catch per unit effort of age 0+ fish was apparent at most habitat locations in this reach. This increase was most obvious in the late September survey at Whiskers Creek Slough, Slough 6A, Slough 10, and Slough 20 (Figures 3.25, 3.26, and 3.29). As none of these sites are known spawning areas for chinook salmon, this seasonal change indicates a redistribution of chinooks age 0+ from areas of high post-emergent density to more favorable conditions as fish size increased and the season progressed.

The percentage of incidence of age 0+ chinook salmon in habitat location catches in the Talkeetna to Devil Canyon reach increased from 15% of the locations sampled in late June to 92% of the locations in early September.

The chinook salmon age 1+ catch rates recorded during the summer in the Talkeetna to Devil Canyon reach were low compared to those catch rates observed in this reach during the winter surveys. Winter catch rates reached a high of 10.0 fish per trap compared to a high of 0.4 fish per trap for summer surveys. This reduction in catch rate indicated that a majority of age 1+ chinook salmon had moved out of the Talkeetna to Devil Canyon reach prior to the initiation of sampling in early June.

Age 0+ chinook catches were recorded at 80-100% of the tributary mouth habitat locations surveyed from early July through late September. As the season progressed, mainstem slough habitat location catches indicated a net increase in percentage of incidence from a low of 20.0% in late June to a high of 87.5% in early September. Age 0+ chinooks appeared to extend their distribution from tributary streams and stream mouth sites into mainstem and slough sites as the summer advanced. Indian River mouth was the only habitat location in this reach producing chinooks age 0+ for 100% of the surveys.

Chinook salmon age 1+ were observed at 45% of the sites surveyed during the first two weeks of June. This figure decreased through late July, however, and these chinooks completely disappeared from this reach prior to the early August survey. It is presumed these age 1+ chinooks were smolts undertaking a seaward migration, with the peak movement occurring prior to the early June sampling. No chinook salmon age 1+ were captured between Talkeetna and Devil Canyon after the last two weeks of July.

At Indian River selected fish habitat sites, juvenile chinook salmon were captured during all three sampling periods. All sites sampled in August and October recorded the presence of juvenile chinooks, with the highest catches occurring in August at site 2, 11.5 km up the Indian River, where 7.0 fish per trap were observed. Indian River selected fish habitat site 3A, 19.2 km up the Indian River, produced the highest catch in October - 1.9 fish per trap.

No juvenile chinooks were captured in Portage Creek during the June survey. The highest catch for Portage Creek was observed at site 1 (7.2 km up Portage Creek) in August where 10.4 chinook salmon age 0+ per trap were recorded. In October, the fish per trap at this site had decreased to 4.4.

Two age classes of juvenile chinook salmon were present in habitat site catches made during early June between Cook Inlet and Talkeetna. Analysis of length frequency composition for 3,646 juvenile chinook salmon measured by two-week periods from June through September indicates that age 1+ chinooks were no longer present in this reach after August 31. On the other hand, age 0+ chinook salmon remained throughout the summer. The range of lengths for age 0+ and age 1+ can be approximated from the length frequency data; however, it is impossible to determine the extent of overlap or to establish accurately a point of division between these two ages of chinook salmon in the Cook Inlet to Talkeetna reach of the Susitna River.

o Sockeye

Winter sampling in March and April produced 25 sockeye fry at Slough 11, one individual each at Slough 9, and an individual downstream of Talkeetna. Sockeye fry were collected at Alexander Creek, Birch Creek, and Cache Creek in September. The outmigration period for sockeye is thought to occur during May and June.

o Pink

In both Slough 11 and Indian River, sac fry of pink salmon appeared on 23 March. Pink salmon fry were collected at Mainstem Slough, Slough 8A, Fourth of July Creek, and Slough 10 during June and July. The outmigration period for pink salmon occurs primarily during the month of May.

o Chum

Approximately 1,700 juvenile chum salmon were captured during the sampling effort conducted in the summer field season of 1981. Beach seining at Slough 11 (Gold Creek area) on 19 June accounted for 1,650 chum fry, while 13 chum fry were captured by beach seine in Slough 19. Chum fry were also captured in Alexander Creek during July. The outmigration period for chum salmon is believed to occur during May and June.

o Coho

Juvenile coho salmon were collected throughout the study area with the majority of individuals captured at tributary mouth sites during both winter and summer. Between Talkeetna and Devil Canyon, the occurrence of individuals was greater at slough sites in the winter and at tributary mouth sites in summer. Three age classes (0+, 1+, 2+) were identified. Age 2+ individuals were not captured after May in the Talkeetna to Devil Canyon reach and not after mid-June in the Cook Inlet to Talkeetna reach. A detailed narrative of these findings is given below.

Age class determinations were made by correlating complementary length/frequency and scale analysis data. Discussion of distribution and relative abundance is provided by age class for juvenile coho salmon in the Talkeetna to Devil Canyon reach only. Because of the extensive overlap in lengths for age classes of juvenile coho captured downstream of Talkeetna, distribution and relative abundance of all age classes will be discussed collectively for this reach.

Juvenile coho were captured at a total of 11 of the 18 (61%) habitat location sites sampled in the Cook Inlet to Talkeetna reach from November to May. During this time, juvenile coho were collected at two of six (33%) mainstem habitat location sites and at nine of 12 (75%) tributary mouth habitat location sites. Juvenile coho salmon occurred in greater than 40% of the habitat location site catches each month from November to May, except during December and April, when no catch was recorded.

The highest individual catch per unit effort for the Cook Inlet to Talkeetna reach was 1.2 fish per trap day, observed at the mouth of Sunshine Creek. Relatively high catch rates were also recorded in January and again in March at a side channel habitat location site located near Rustic Wilderness and in November, at the mouth of Montana Creek.

From December 1980 to April 1981, juvenile coho were captured at six of the 12 (50%) habitat location sites sampled between Talkeetna and Devil Canyon. During this time, juveniles were collected at five of eight (62%) mainstem habitat location sites and at one of four (25%) tributary mouth habitat location sites. Of these latter four sites, only Whiskers Creek, sampled during March contained any juvenile coho. In addition, no juveniles were encountered at the mouths of Lane Creek, Indian River, or Portage Creek in 1980-81 winter sampling.

Juvenile coho salmon were present, however, at 50% or more of the mainstem and slough habitat location sites sampled in the Talkeetna to Devil Canyon reach each month from February 1981 to April 1981. No juvenile coho salmon were collected during January at any habitat location sites upstream from Talkeetna.

Five selected fish habitat sites on Indian River, with the farthest upstream being 12.8 km, and six selected fish habitat sites on Portage Creek between 4.8 km and 18.9 km upstream were sampled in February, March, and April 1981. Although a single juvenile coho was collected at Indian River (1.8 km upstream) during April, no juveniles were encountered in Portage Creek in any of these months.

The highest individual catch per unit effort was 8.0 fish per trap, observed at Slough 6A in March 1981. Relatively high catch rates were also recorded at Whiskers Creek mouth in March and, also in March, at Slough 8A.

From June to September 1981, juvenile coho salmon were collected at 86.7% of the habitat location sites in the lower Susitna River. These sites extended from the mouth of Alexander Creek to the mouth of Portage Creek. Catches of juvenile coho were also recorded at selected fish habitat sites at Indian River and Portage Creek during August and October.

In the Cook Inlet to Talkeetna reach, from June to September, juvenile coho salmon were collected at 25 of the 27 (92.6%) habitat location sites. The incidence of juveniles in catches at habitat location sites ranged from 42.9% in late June to 83.3% in early September. Juvenile coho catches were recorded at all (100%) of the tributary mouth habitat location sites in the Cook Inlet to Talkeetna River reach one or more times during the summer of 1981. The incidence of juvenile coho salmon in catches at tributary mouth habitat location sites ranged from 66.7% in late June to 100% in late August and early September.

Catches of juvenile coho were recorded at 82% of the mainstem and slough habitat location sites in the Cook Inlet to Talkeetna River reach from June to September. The incidence of juvenile coho salmon at mainstem and slough habitat location sites ranged from 11.1% in late June to 62.5% in late September.

Below Talkeetna, the highest catch per unit effort, 41.0 juvenile fish per trap, was recorded at the mouth of Caswell Creek in late August. Relatively high catch rates were also observed from late July to early September at the mouths of Birch Creek, Sheep Creek Slough, Sunshine Creek, and Montana Creek. In the Talkeetna to Devil Canyon reach from June to September, juvenile coho were collected at 13 of the 17 (76.5%) habitat locations.

Two age classes of juvenile coho salmon, 1+ and 2+, from brood years 1978 and 1979 were captured at habitat location sites in the lower Susitna River from November 1980 to May 1981. Age 0+ coho salmon, offspring of brood year 1980, were collected at 12 of the 17 (70.6%) Talkeetna to Devil Canyon habitat locations, while age 1+ were observed at seven of the 17 (41.2%) sites. No juveniles from brood year 1978 (age 2+) were observed in Talkeetna to Devil Canyon habitat location catches during the summer 1981. Age 0+ coho distribution progressively increased from early June through the summer and was most extensive in early September, when the fish were collected at 53.9% of the habitat locations upstream from Talkeetna to Devil Canyon. The incidence of age 1+ coho salmon in catches at habitat locations ranged from 11.8% in late July and late September to 30.8% in early September. Throughout the summer, occurrence of age 0+ fish was more consistent at tributary mouth locations than at mainstem or slough locations. During this same period, age 1+ coho appeared in a lower percentage of both tributary mouth and mainstem-slough habitat locations.

Age 0+ coho were also observed in Indian River and Portage Creek at selected fish habitat sites. Distribution was more extensive, however, in Indian River, where age 0+ coho were collected from Indian River at 4.3, 11.4, and 19.2 km upstream. Age 0+ fish were observed in Portage Creek (7.2 km upstream) only once during the season in October.

The highest age 0+ coho catch per unit effort, 7.0 fish per trap, was recorded at Whiskers Creek in late August. Comparatively high age 0+ catch rates were also recorded at Whiskers Creek mouth during each two-week interval throughout the summer. Relatively high catch rates for age 0+ coho salmon were likewise recorded at Slough 6A and Fourth of July Creek during August and September and at Indian River, 19.2 km upstream, in August.

The highest age 1+ coho catch per unit effort, 0.6 juveniles per trap, was recorded at both Whiskers Creek during early July and at Slough 6A during late August. Consistent catches were recorded throughout the summer at both these sites.

(ii) Other Anadromous Species

- Bering Cisco

Prior to this study, Bering cisco were not known to inhabit the Susitna River. Bering cisco were first captured at river kilometer (rkm) 126 by the lower east bank fishwheel at Sunshine Station on August 25. The fishwheel catch rate on cisco gradually increased until it peaked between 17 and 21 September. At Mainstem Slough and the mouth of Kroto Slough, Bering cisco were taken by gill net on 10 September and again at Mainstem Slough on 14 and 28 September.

Electrofishing conducted 25 September through 15 October demonstrated that Bering cisco were dispersed in the Susitna River from rkm 112 to rkm 161 (measured from the mouth of the

Susitna). Relatively large numbers were located near Sunshine Station, Montana Creek, and the mainstem west bank at rkm 119. One hundred ninety Susitna River Bering cisco were aged. The majority of fish were age 4 (88%), with the remaining age 3 (9%) and age 5 (3%).

Sexually mature Bering cisco were captured from habitat locations over a 112 km reach of the Susitna River. Although spawning sites may generally occur throughout this reach, electrofishing surveys were only able to identify three areas of spawning concentrations. These sites were opposite Sunshine Station, opposite the mouth of Montana Creek, and at rkm 119 to rkm 120 of the mainstem along the west bank.

Susitna River Bering cisco appear to be the anadromous form. The fish captured and identified were evidently undertaking their spawning migration, as no substantiated occurrence of the species was noted prior to 25 August 1981. The fish evidently began their spawning migration up the Susitna River from Cook Inlet in August and arrived at the Sunshine Station fishwheel site over a five-week period from August 25 to September 30. Fish captured by the fishwheel during this time were all bright silver and appeared to be sexually mature; although, with normal handling, they did not produce a discharge of eggs or milt.

From 4 through 7 October, relatively large numbers of Bering cisco, dispersed along gradually sloping gravel bars in the Montana Creek-Sunshine Station area, were located by electrofishing. Random necropsy showed all fish to contain mature sex products, but none had yet spawned.

Electrofishing was again conducted in the Montana-Sunshine area from 13 through 15 October. All fish handled on these dates freely expelled either eggs or milt or were already spent. From these observations, spawning appeared to peak during the second week of October.

- Eulachon

Eulachon are known to utilize the Susitna River system at least as far upstream as the Deshka River-Susitna River confluence. The eulachon is an anadromous member of the smelt family but spends most of its life in the marine environment. Adults are believed to live at moderate ocean depths in the vicinity of the echo-scattering layer and in proximity to shore. In the northern portion of its range, spawning does not occur until May. Upstream migration from the ocean begins when river water temperatures reach approximately 4.4°C and ceases as temperatures exceed 7.8°C. The migration runs usually take place in larger rivers (such as the Susitna mainstem), but spawning grounds may be located in tributary systems. The timing of the Susitna River migration run and the location of spawning grounds have not been determined. A compilation of life history and ecology information by Terrestrial Environmental Specialists, Inc. (APA 1981) contains additional details from available literature on the eulachon.

(b) Resident Species

(i) Impoundment Zones and Vicinity

The following section describes the fisheries resource of the upper Susitna River basin in the proposed impoundment regions. Of greatest significance was the presence of sizeable grayling populations throughout the tributaries. In general, though, information on the Susitna mainstem in this region remains limited.

The numbers of individuals of several species, including burbot, round whitefish, longnose suckers, and cottids, are rather small. It is not known whether this is because of the limited populations of these species, to sampling site locations, or to sampling efficency. As a result, conclusions drawn from the information presented are preliminary.

- Arctic Grayling

During the 1981 studies of the Upper Susitna River, 3,279 adult Arctic grayling over 135 mm fork length were captured. Table 3.53 lists grayling catches by tributary and month. Arctic grayling were collected at 100% of the habitat location sites in the upper Susitna River during the 1981 season.

The population estimate for Arctic grayling in the upper Susitna River study area calculated at the 95% confidence level (4df), is 10,279 with a range of 9,194 to 11,654. This population level would give an average of approximately 501 adult grayling per clearwater tributary mile or 121 per river mile including the main Susitna, to be inundated. Tagged grayling demonstrated interchange between tributaries using the main Susitna as a migratory corridor.

Kosina Creek has the highest estimate for an individual tributary at 2,787 (range 2,228-3,720) followed by the Oshetna River at 2,017 (range 1,525-2,976). Fog Creek had the lowest estimate at 176 (range 115-369). No estimate is listed for Watana Creek, although Watana is included in the study area total estimate, because the low number of tagged fish recovered would have resulted in an estimate with an unacceptably wide range of values.

Three hundred eighty-one upper Susitna River Arctic grayling from hook and line and gill net catches were aged by using scale analysis. These fish ranged from age 1 to age 8; age 5 and age 6 were dominant, comprising 33.9% and 31.5% of the sample, respectively.

Arctic grayling examined during May and early July exhibited spent gonads and frayed dorsal and caudal fins, indicating that they had already spawned. Fish in this condition were collected at the mouths of the tributaries.

In the course of the upper Susitna River study, a total of 2,652 Arctic grayling were tagged and released during 1981. As a result, there is some indication of Arctic grayling intrasystem migration in the upper Susitna River drainage. Preliminary analysis indicates not only a wide range of movement within the individual tributaries but also inter-tributary migration.

- Lake Trout

Lake trout were found only in Sally Lake and Deadman Lake (Figure 3.35, two selected fish habitat sites in the upper Susitna River basin, both of which support a limited sport fishery. Of these two sites, only Sally Lake will be inundated by the proposed Watana impoundment. All lake trout were captured by gill net and rod and reel and all within 39 m of the shoreline in less than 1.8 m of water. Gear was fished at various depths of up to 12 m in Sally Lake. A total of 35 lake trout were captured, 32 in Sally Lake and three in Deadman Lake. All Deadman Lake fish were captured by hook and line, while gill nets produced the greatest results in Sally Lake. Catch per rod and reel hour was highest in Deadman Lake, where it was 0.75/hour.

Scales were taken from 19 lake trout collected in Sally Lake. Only seven scales were readable, and all of these were age 5. During mid-August, both pre-spawning and post-spawning lake trout were captured in Sally Lake.

- Burbot

Burbot were collected at all eight upper Susitna River habitat locations between May and September 1981. The percentage of incidence of burbot in sampling catches ranged from 50% of the locations sampled in May to 100% of the locations sampled in July.

Catch rates for all streams combined varied from 0.53 burbot per trotline day in May to 0.95 in September. The second highest catch rate, 0.73 burbot per trotline day, was recorded in July. Although sampling was also conducted upstream in the tributary study areas, all burbot catches were made in the Susitna mainstem, immediately up- or downstream of the tributary confluences with the Susitna. Jay Creek, with a May to September average catch rate of 1.14 burbot per trotline day and total catch of 32 burbot, was the most consistently productive habitat location, followed closely by Watana and Goose creeks.

Otoliths were removed from 54 burbot and analyzed for age determination. Age classes 4, 5, and 6 made up the majority of burbot caught, comprising 25%, 20%, and 35% of the sample respectively.

- Round Whitefish

Round whitefish were captured at all habitat locations sampled in the upper Susitna River system, except Fog, Deadman, and Goose creeks. Jay and Kosina creeks were the most productive. The percentage of incidence of round whitefish at habitat locations ranged from 33% in July to 7% in September. The capture of 47 juvenile round whitefish (18-52 mm) at Jay Creek was achieved by using seines and electroshockers.

Twenty-two upper Susitna River round whitefish from gill net catches were aged by scale analysis. Ages ranged from 6 to 8, with age 7 encountered most frequently.

- Longnose Sucker

Longnose suckers were found in all habitat locations except Fog and Tsusena creeks. All adult suckers were captured in gill nets set immediately upstream or downstream of the confluence of the tributary streams. A total of 144 suckers were captured from May to September. The mouth of Watana Creek produced consistent catches of suckers for a total of 75. In July suckers were caught in all habitat locations fished. (Kosina and Fog creeks were not fished.) This species was caught in 25% of the habitat locations fished in May and in September.

Scales of 90 upper Susitna River longnose suckers were removed and analyzed. Age classes 7, 8, and 9 made up the majority of longnose suckers and comprised 25%, 36%, and 20% of the sample, respectively. Juvenile longnose suckers (24-105 mm) were captured in sloughs and backwater areas of the Susitna River at Jay, Kosina, and Watana creeks.

- Sculpins

Thirty-eight sculpins were taken during 352 minnow trap days from upper Susitna River reach habitat locations. Habitat locations associated with clear water and other tributaries were most productive. The catch rate from May to September 1982 was 0.11/trap day. The largest numbers of sculpins were recorded for Fog Creek, Tsusena Creek, and the Oshetna River, with total catches of 8, 9, and 10, respectively. Tsusena Creek had the highest catch rate at 0.23/trap day, while no sculpins were captured at Jay Creek during this study. Sally Lake, a selected fish habitat site, was minnow trapped only during May and resulted in the collection of four sculpins.

- Miscellaneous Species

During the course of the 1981 field studies, a single specimen each of humpback whitefish and Dolly Varden was captured. The humpback whitefish was a male, 347 mm fork length taken at the mouth of Kosina Creek on September 24. The single Dolly Varden was taken at the mouth of Fog Creek on 25 August. This fish was also a male, 235 mm fork length. Possible occurrences of the Alaska whitefish and lake whitefish have been reported in the Susitna River drainage (McPhail and Lindsey 1970, Williams 1968). As discussed below, these two species are not readily distinguished from the humpback whitefish. The presently known range of the humpback whitefish in Alaska is restricted to rivers which empty into the Bering, Chukchi, and Beaufort seas (Morrow 1980). Dolly Varden are known to be present in this portion of Alaska (Morrow 1980).

(ii) Downstream (below Devil Canyon)

- Arctic Grayling

Arctic grayling were first captured at rkm 150, 1.6 km southwest of the head of Birch Creek Slough on 19 February 1981. Throughout the winter months, gill netting under the ice infrequently produced grayling. Gill net catches of adult grayling increased sharply from 1 to 15 May at the mouths of the Deshka River and Cache Creek Slough. After 15 May, catches declined at all habitat locations on the Susitna River between Cook Inlet and Devil Canyon. Incidence of Arctic grayling, however, principally juvenile and immature, ranged from 10% to 20% of the 44 habitat location sites sampled during each two-week period throughout the summer months. In September, catches of adult grayling at tributary mouths increased. At that time, relatively large numbers of these fish were located on the Susitna River at Kashwitna River, Montana Creek, Birch Creek Slough, Lane Creek, Indian River, and Portage Creek.

Age determinations were made on 174 Arctic grayling caught on the Susitna River between Alexander Creek and Portage Creek. These fish ranged in age from age 0+ to age 10. The most prevalent age classes captured were age 5 (17.9%) and age 6 (23.4%).

Arctic grayling began their spawning migration in the Susitna River in late April and a substantial increase in grayling catches by gill net was noted at the mouths of the Deshka River and Cache Creek between 1 May and 15 May. Necropsies showed most of the fish were sexually mature, but since manipulation of the fishes' abdominal cavities produced no milt or eggs, the fish were not fully ripe.

No evidence of Arctic grayling spawning was found at any sampling locations between Cook Inlet and Devil Canyon during the 1981 season. It can only be speculated that the adult Arctic grayling from the Susitna River migrate into non-glacial tributaries to spawn some time in late April or May.

- Rainbow Trout

Rainbow trout were collected at seven tributary and four mainstem habitat location sites along the Susitna River from Alexander Creek to Slough 10 (rkm 214) from November 1980 to May 1981. This species did not appear consistently in catches from any of the locations sampled, but low densities of rainbow trout appeared throughout the winter months.

Rainbow trout were captured at a total of 89% of the habitat locations in the Cook Inlet to Devil Canyon reach. The percentage of incidence of catches in the Cook Inlet to Talkeetna and the Talkeetna to Devil Canyon reaches was 81% and 94%, respectively.

In the Cook Inlet to Talkeetna reach, the percentage of incidence of catches at habitat location sites ranged from a low of 7% during the first two weeks of August, to a high of 50% during the first two weeks of September.

The incidence of rainbow trout in habitat locations sampled remained in the 20% to 30% range from the first of June through 30 July and again from 15 August to 30 August. The low percentage of incidence occurring from 1 August to 14 August was probably due to coinciding high water levels and the resulting ineffectiveness of the sampling gear.

Habitat locations associated with tributary streams produced higher catches per unit effort than did the mainstem locations. Consistent catches of rainbow trout were recorded at Anderson Creek, Alexander Creek, and Deshka River habitat location sites.

Catch per gill net at Anderson Creek rose to 9.0 in late September, while during the last two weeks of August, highs of 1.0 and 0.8 fish per trotline were reached at Alexander Creek and the Deshka River, respectively.

In the Talkeetna to Devil Canyon reach, the percentage of incidence of rainbow trout catches at habitat locations ranged from 77% during late June and again in early September, to a low of 18% in early August. The June peak is probably due to the presence and movements of spawning fish, while the high in September reflects movement downstream to winter habitat.

The low percentage of incidence in early August, as in the Cook Inlet to Talkeetna reach, was probably caused by high flood stage waters and associated factors. Rainbow trout were captured at all habitat locations, with the exception of the mainstem site below Portage Creek. The most consistent catches occurred at tributary mouth and slough habitat locations. Catches per gill net ranged from 0.0 to 6.0 per day at tributary and slough locations, with the high of 6.0 rainbows per day recorded at Whiskers Creek Slough during late June. Hook and line catches produced highs of 2.0

and 7.0 rainbows per hour at Portage Creek and Whiskers Slough, respectively. High catches per unit effort at Whiskers Creek and Whiskers Slough in June are attributed to the presence of spawning rainbows.

One hundred eighty-four Susitna River rainbow trout collected from Cook Inlet to Devil Canyon by fishwheel, trotline, electrofishing, and hook and line were aged using scale analysis. Age classes 3, 4, and 5 made up the majority of the fish at 30.8%, 32.0%, and 19.9% of the total sample, respectively. The age class composition was similar for each reporting reach of the lower Susitna River. Rainbow trout in the age sample ranged from age 1 to age 7.

- Burbot

From November 1980 through May 1981, burbot were captured by various sampling gear placed in the Susitna River at a total of 42 habitat locations and selected fish habitat sites beginning at the mouth of Alexander Creek and extending to a mainstem site at rkm 118.

Habitat locations and selected fish habitat sites downstream of Talkeetna, particularly the mouth of the Deshka River, the mouth of Alexander Creek, and four mainstem sites located at rkm 16, 69, 97, and 134, yielded the highest catch rates.

Burbot were occasionally encountered in habitat locations or selected sites located upstream of Talkeetna during the winter and those catches were made exclusively at mainstem sites. The mainstem site opposite Curry recorded the highest catch rate of all sites above Talkeetna.

The distribution of burbot in the Cook Inlet to Talkeetna reach, as indicated by the percentage of habitat location sites recording catches of burbot by any gear type, appeared to increase as the summer progressed. Burbot catch rates generally remained low and varied through June and July at most habitat locations. One location, a large, stable eddy located just upstream of the Parks Highway bridge, recorded the most consistent catches of burbot throughout the year. During August and September, catch rates generally increased, and the percentage of habitat locations recording catches of burbot rose to a maximum of 88% for the first two weeks of September. In addition, burbot were also abundant at the mouths of the Deshka River, Alexander Creek, and the Birch Creek Slough.

The incidence of burbot catches in the Talkeetna to Devil Canyon reach decreased steadily from early June to mid-July when only mainstem sites at rkm 193, 198, and 235 were producing catches. After July 16, the percentage of habitat location sites recording catches sharply increased, while sloughs, creek mouths, and mainstem sites all recorded catches of burbot.

The catch per unit effort from June to September varied from 0.0 to 3.0 burbot per trotline day. Throughout the reach upstream of Talkeetna, the mainstem site 3.2 km below Portage Creek and a mainstem site at rkm 183 were the most productive, while Slough 11 and the mouth of Whiskers Creek recorded the lowest catches.

At no time during this period of sampling did a stream mouth site show any consistent catch per unit effort except for Lane Creek in late August and September. Lane Creek is a clear, cold tributary that, until the last two weeks of August 1981, flowed straight into the Susitna River. At that time, the creek changed course and began flowing into a slough channel of the Susitna River. After this change, the catch per unit effort increased and stayed fairly consistent until the end of September.

Small but consistent catches of juvenile burbot were recorded during late August and September at both the mouth of the Deshka River and the mouth of Alexander Creek. Juvenile burbot were occasionally found at only six other locations from Cook Inlet to Devil Canyon during this study.

Electrofishing surveys conducted during August, September, and October 1981 succeeded in locating burbot in mainstem and slough channels of the Susitna River from rkm 70 to rkm 160. Catch rates varied from 0.0 to 12.8 burbot per hour, but as these surveys were not designed to reflect relative abundance of burbot, the results could only be used to further document the distribution.

Age classes 4, 5, and 8 made up the majority of burbot, and comprised 14%, 11%, and 12.5% of the sample, respectively. Of Of the burbot used for age determination, age 4 averaged 407 mm (range 303-520 mm), age 5 averaged 439 mm (range 365-620 mm), and age 8 averaged 559 mm (range 465-647 mm).

Burbot are known to spawn from mid-December to early April. Female burbot collected in the Susitna River beginning in early Septmber were observed with well-developed eggs. Throughout June and through September, both sexually mature and immature burbot were observed.

- Round Whitefish

Round whitefish were captured at only four habitat locations during winter studies from November 1980 to May 1981; all of these sites were located downstream of Talkeetna. Small numbers of round whitefish were taken in gill nets set at the mouth of Sunshine Creek in March and again in gill nets set during May at the mouths of the Deshka and Kashwitna Rivers as well as in Cache Creek Slough. As indicated by the direction from which they hit the nets, the fish were all captured while moving upstream.

The presence of round whitefish near the mouths of tributary streams in March and May, after no catches were made in these same locations during November through February, indicated a general pattern of movement into these areas and on into these tributaries.

Round whitefish were collected at 30% of the habitat location sites sampled from Cook Inlet to Talkeetna during the first two weeks of June. The mouth of Sunshine Creek recorded the highest catch rate of all gear types, 5.5 fish per gill net night. After June 15, the incidence of round whitefish in habitat location catches downstream of Talkeetna dropped to between 0.0% and 11.1% of location sites sampled until the last two weeks of September, when catch incidence rose to 45% of all sites sampled. During these weeks, round whitefish were collected at three mainstem sites and six tributary mouth sites downstream of Talkeetna.

Round whitefish were more consistent in sampling gear catches above Talkeetna from June through September. The incidence of round whitefish catches ranged from 17.6% to 44.4% during June and July, then dropped to 0.0% in the first two weeks of August. The incidence of round whitefish in catches remained below 10.0% of sites sampled until the last two weeks of September when 35.3% of sites sampled recorded catches of round whitefish. The highest and most consistent catch rates were recorded at sloughs 6A and 10 and at the mouths of both Indian River and Portage Creek.

Forty-five Susitna River round whitefish, from fishwheel, gill net, and electrofishing catches made from Cook Inlet to Devil Canyon, were aged using scale analysis. Round whitefish analyzed for age composition ranged from age 0+ to age 8, with age 4 being encountered most often.

- Humpback Whitefish

(In the discussions pertaining to the resident fish species of the Susitna River Study area, ADF&G has listed three species of whitefish as humpback whitefish. The three species are the humpback whitefish, Alaska whitefish, and lake whitefish. The difficulty in readily distinguishing among these three species necessitated this action.)

The first capture and observation of a humpback whitefish occurred on 12 February, 4.2 km below the mouth of Montana Creek. This fish, caught in an under-ice gill net, was the only one of its kind captured that winter. During June, relatively large numbers of humpback whitefish were also collected at the mouth of Anderson Creek, Sunshine Creek, Slough 6A, and Portage Creek.

From mid-July until September, humpback whitefish were collected at habitat locations on the Susitna River between Cook Inlet and Devil Canyon. Adults were more frequently collected in the

1 to 15 September time period and were more common in the habitats sampled below Talkeetna than in the river reach above Talkeetna.

The ages of 67 Susitna River humpback whitefish were confirmed via scale analysis. The fish ranged in age from age 2 to age 7. Age 4 fish, which made up 31.3% of the aged catch, was the predominant age class encountered. Age 3, age 5, and age 6 fish each composed 19.4% of those fish aged.

Between 1 and 30 June, large gill net catches were made on the Susitna at Anderson Creek, Sunshine Creek, Slough 6A, and Portage Creek. Necropsies indicated that the fish in these catches were sexually mature but not ready to spawn. Between 26 August and 14 September, 170 humpback whitefish were caught at the Sunshine fishwheel. Inspections of fish caught from mid-September to early October showed well-developed gonads, but again, the fish were not yet ripe. No humpback whitefish were caught or observed after 7 October.

During the 1981 season, between Cook Inlet and Devil Canyon, no evidence of spawning among humpback whitefish was collected at any sampling location. Consequently, one could only speculate that humpback whitefish spawn in the Susitna River some time after 7 October.

- Longnose Sucker

Longnose suckers were first captured and observed at the mouths of the Deshka River and Cache Creek Slough on 9 May. By early June, longnose suckers were dispersed on the Susitna River between Kroto Slough and Portage Creek. The percentage of habitat locations at which longnose suckers were captured by gill net was relatively high during the early part of the summer and then decreased during mid-summer. The percentage increased again during September in the lower river, but not above Talkeetna. The highest fall gill net catches were reported at the Deshka River and Sheep Creek Slough. An increased presence of longnose suckers was also found in September in the mainstem Susitna below Talkeetna.

Juvenile longnose suckers were continually present, primarily in the Susitna River below Curry. As the season progressed, however, they shifted farther downriver.

One hundred ninety-seven longnose suckers taken from the Susitna River by fishwheel, gill net, and electrofishing gear were aged by scale analysis. The majority of these fish were age 6 and 7, comprising 33% and 22% percent of the catch, respectively. The oldest fish caught, representing 3% of the catch, were age 9.

- Dolly Varden

November through May sampling within the Susitna River from Cook Inlet to Devil Canyon produced a catch of two Dolly Varden. One was taken by gill net from Little Willow Creek; the other, by trotline at rkm 134.

From June to September 1981, Dolly Varden were collected at a total of 52% of the habitat locations in the Cook Inlet to Talkeetna reach. The occurrence of Dolly Varden in habitat location catches by two-week periods varied from a low of 8% in the last two weeks of August to a high of 29% in the last two weeks of September. Tributary stream mouth habitat locations produced the most consistent catches of Dolly Varden, with the highest catches occurring in late June at the mouth of the Kashwitna River.

In the Talkeetna to Devil Canyon reach, Dolly Varden were collected at a total of 59% of the habitat locations. From June to September, the occurrence of Dolly Varden in habitat location catches varied from a high of 21% in June to a zero catch in July. Catches of Dolly Varden occurred in this reach again, however, in August and September. A total of 17 Dolly Varden were captured in habitat locations at the mouths of Indian River and Portage Creek; a selected fish habitat site at the mouth of Billion Slough produced seven of the 17 fish captured. Other sites in this reach produced only one Dolly Varden.

The higher incidence of Dolly Varden catches during July may be directly related to the migration and spawning at this time of pink, chum, and sockeye salmon, upon whose eggs Dolly Varden feed. The higher catch incidence in September can be attributed to two factors: Dolly Varden had moved into their own spawning areas within the clearwater tributaries, and they had begun outmigration into their wintering habitat.

During helicopter surveys of upper Indian River and upper Portage Creek, a stunted population of Dolly Varden was observed. In the lower Susitna River study, these fish were found only within upper Portage Creek and upper Indian River. Minnow traps produced good catches of these fish: Indian River, 50 fish; Portage Creek, 127 fish.

- Threespine Stickleback

Threespine stickleback were collected at 37 (84%) of the 44 habitat locations in the Cook Inlet to Devil Canyon reach of the Susitna River from Alexander Creek to the mainstem Susitna Island site. Catch per unit effort rates in the Cook Inlet to Talkeetna reach were higher, overall, than those in the Talkeetna to Devil Canyon reach.

The number of habitat locations that produced threespine stickleback was highest in June (84%) and declined steadily to 16% in September. The higher percentage in early summer indicated that fish observed then had been involved in spring spawning movement, activity that had disappeared by September. Except Goose Creek 1, all habitat locations in the Cook Inlet to Talkeetna reach produced stickleback. Twelve of the 17 habitat locations in the Talkeetna to Devil Canyon reach produced catches of this species.

- Cottids

Between November 1980 and October 1981, cottids were captured at 40 (91%) of the 44 habitat locations in the Cook Inlet to Devil Canyon reach of the Susitna River. The percentage of habitat locations producing catches in the Cook Inlet to Talkeetna portion of the reach ranged from a high of 70% in late August to a low of 42% in late July. For the Talkeetna to Devil Canyon reach, there was a high of 76% in early July and a low of 35% in late September.

- Lamprey

Arctic lamprey were captured at 14 habitat location sites between rkm 16 and rkm 162, which were surveyed from November 1980 through September 1981. During the winter surveys, the only habitat location site to produce Arctic lamprey was Rustic Wilderness, where only one lamprey was captured. All other lamprey were collected during the summer surveys.

The highest catch was recorded in early July at Whiskers Creek. These lampreys had an estimated length of 70 mm and were captured in a single trap which had become buried in the silt. The highest catch frequency was recorded during the 1 to 15 September sampling period when 27.8% of all sites surveyed produced lamprey. All productive habitat location site surveys during this period occurred at tributary sites downstream of rkm 81. The lowest incidence of capture for this species, 3.7%, was observed in the 16-31 July sampling period.

- Northern Pike

During the 1950's, northern pike were illegally transplanted by private individuals into the Susitna River drainage. As a result, northerns have been reported in the Yentna River drainage in Bulchitna, Hewitt, and Whiskey Lakes (Kubik, pers. comm.).

A northern pike, measuring 715 mm fork length and aged at nine years, was captured on 11 September 1981 in a gill net set overnight, 150 m upstream of the mouth of Kroto Slough. This fish is the first northern pike recorded in the mainstem Susitna River and is believed to have migrated out of Bulchitna Lake. This migration became possible where a hydraulic barrier washed out, thereby allowing northern pike into the Yentna River.

(c) Aquatic Habitat

(i) Impoundment Zones and Vicinity

In the proposed Devil Canyon impoundment zone, habitat evaluation sites were established at Fog Creek, at the Susitna mainstem near Tsusena Creek, and at Tsusena Creek. Both the mainstem of the Susitna as well as Fog and Tsusena creeks contained highly oxygenated water with pH values near seven or slightly higher. Conductivity values for all sites were moderate in range; turbidity levels were low in the two tributaries, with a moderate increase in the mainstem. Temperatures in both the tributaries and the mainstem were similar, with maximum recorded temperatures usually above 10°C.

Within the proposed Watana impoundment, habitat evaluation sites were located at: Susitna mainstem near Deadman Creek, Deadman Creek, Susitna mainstem near Watana Creek, Watana Creek, Susitna mainstem near Kosina Creek, Kosina Creek, Susitna mainstem near Jay Creek, Jay Creek, Susitna mainstem near Goose Creek, Goose Creek, Susitna mainstem near Oshetna River, and Oshetna River. The same trends in measured parameters discussed for the Devil Canyon impoundment are also present in these locations: well-oxygenated water, usually slightly basic pH, moderate conductivity levels, low turbidity levels in the tributaries compared to those in the mainstem, and similar water temperature ranges.

Watana Creek is located at river kilometer 305 on the north side of the Susitna River and is approximately 13 km upstream from the proposed Watana dam. Watana Creek is a shallow meandering stream. It has a gradual gradient, resulting in a moderate flow with few pools interspersed between the predominant riffle areas. The substrate consists mostly of gravel and rubble. The water is often turbid during the summer because of heavy rains and unstable soils present upstream.

Kosina Creek, located at river kilometer 324 on the south side of the Susitna River, lies approximately 32 km upstream from the proposed Watana dam. Kosina Creek is a deep and turbulent stream, predominantly whitewater interspersed with deep pools and shallower riffle areas. Substrates consist mostly of sand, large cobble, and boulders. The stream channel is stable and is situated in a narrow valley with a moderate gradient. It is often braided, with total widths frequently around 30 m.

Jay Creek is located at river kilometer 328 on the north side of the Susitna River and lies approximately 35 km upstream of the proposed Watana dam. Jay Creek is a relatively narrow, shallow stream, predominantly riffle with a moderate flow. Substrate consists of gravel, cobble, and rubble, often embedded in sand. Although the water is generally clear, unstable soils in upstream areas often result in landslides which can change the water to a turbid condition within minutes.

Located at river kilometer 360 on the south side of the Susitna River approximately 69 km upstream from the proposed Watana dam, Goose Creek is a narrow, shallow stream. The habitat is predominantly riffle with a moderate flow and few pools. Substrate consists of rubble, cobble, and boulders, often embedded in sand. The stream channels and banks are stable; the water usually remains clear even during period of moderate rain.

The Oshetna River, located at river kilometer 363 on the south side of the Susitna River, lies approximately 72 km upstream from the proposed Watana dam. The Oshetna River is a large, meandering stream approximately 30-40 m wide with an average depth of one meter. Streamflow is slow to moderate, with alternating pool and riffle areas. Substrate consists mostly of rubble and cobble, with some large boulders. The stream channel is stable throughout the study area and contains many large gravel bars. This stream is partially under glacial influence, and the water is often turbid even during periods of dry weather.

(ii) Downstream (below Devil Canyon)

Sampling was conducted in various reaches of the Susitna River from Cook Inlet to Devil Canyon. These included the Yentna reach, Sunshine reach, Talkeetna reach, and Gold Creek reach (Figures 3.31, 3.32, 3.33, and 3.34. In addition, five selected habitat evaluation sites in the vicinity of Gold Creek were studied in greater detail (Figure 3.34).

Water quality measurements in the Yentna reach were made at the following locations: Alexander Creek, Anderson Creek, Kroto Slough, Mainstem Slough, Deshka River, Lower Delta Islands, and Little Willow Creek. The tributaries, sloughs, and mainstem sampling localities all exhibited high dissolved oxygen readings. The pH values were generally in the high-six to middle-seven range, except for the Deshka River and Little Willow Creek readings, which were at the lower limits of this range. The most notable difference between tributary and other areas was the much lower turbidity levels recorded in the former. Anderson Creek, the only exception to this pattern, registered high levels.

Areas sampled in the Sunshine reach of the Susitna included: Rustic Wilderness, Kashwitna River, Caswell Creek, Slough West Bank, Sheep Creek Slough, Goose Creek, Mainstem West Bank, Montana Creek, and Rabideux Creek. All waters were well oxygenated, and pH values, typically around 7.0 or less in the tributary areas sampled, were slightly higher at slough and mainstem sites. Conductivity was generally low in the tributaries and moderately high in the mainstem and slough sites. Rabideux Creek showed the highest conductivity readings for any of the tributaries sampled in this region. Turbidity readings were extremely low in most of the tributaries, especially in Caswell and Montana creeks.

Sampling sites in the Talkeetna reach included: Mainstem 1, Sunshine Creek, Birch Creek Slough, Birch Creek, Cache Creek Slough, Cache Creek below Talkeetna and Whiskers Creek Slough, Whiskers Creek, Slough 6A, Lane Creek, and Mainstem 2 above Talkeetna. In general, high dissolved oxygen levels were present in all of the study areas sampled. The exception was Cache Creek, where a low dissolved oxygen reading during the latter part of the salmon run was attributed to low flows during this particular sampling period. The lower ranges of pH readings in this region, for example at Whiskers Creek and Whiskers Creek Slough, may have been due to more acidic flow than was present in the more downstream areas sampled. Conductivity readings were generally moderate, and, when the influence of the mainstem Susitna was negligible, turbidity levels were generally lower in the tributaries and in the sloughs than in the mainstem.

In the Gold Creek reach, the general habitat evaluation sites included: Mainstem Susitna at Curry, Susitna Side Channel, Mainstem Susitna Gravel Bar, Slough 8A, 4th of July Creek, Slough 10, Slough 11, Mainstem Susitna - Inside Bend, Indian River, Mainstem Susitna Island, and Portage Creek. In general, the trends seen in the previously discussed stretch of river were also seen in this stretch.

The ranges for the recorded parameters are shown in Table 3.54. In this table, unless listed differently, the ranges given for the tributary sites include all of the sampling sites from that particular tributary. The only really significant trend seen in the upstream tributary sampling was that turbidity levels were generally higher at the tributary mouths. This characteristic was undoubtedly caused by mainstem Susitna influence.

The five selected habitat evaluation sites studied were sloughs located along the Susitna River from approximately 8 km downstream of Sherman to approximately 6.4 km upstream of Indian River. The sloughs studied were: Sloughs 8A, 9, 16B, 19, and 21.

Slough 8A is approximately 2.9 km in length. The initial .4 km from the mouth upstream is influenced by the mainstem Susitna River and, except during periods of extremely low river flow, a backwater area is created in the slough. Above this area, during the study, the flow was free, obstructed only by beaver dams located within the middle section of the slough. Slough 8A can be characterized as having sloping, 1.8-meter cutbanks and six "heads" which, except during periods of low mainstem discharge, contributed flow from the mainstem. During those periods, flow was generated through groundwater percolation and water release from beaver dams. Sockeye and chum salmon were observed spawning in the lower stretches of the slough, which was the longest of the five sloughs sampled and exhibited the greatest diversity. Because they were so long, sloughs 8 and 9 had transects only at their "heads" and mouths.

Slough 9 is an open water channel approximately 1.9 km long, with sloping, 1.8-meter cutbanks and substrate composed of gravel, rubble, and cobble. The main source of water for the slough consisted of flow from the mainstem Susitna River except during periods of low discharge. Two small tributaries, which were located on the northeast and southeast banks, maintained flow in the slough during low discharge periods. They provided the entire low-flow discharge. The northeast tributary was a known site for coho spawning.

Slough 16B is a free-flowing channel approximately .6 km in length and consisting of steep cutbanks ranging from .3 m to 1.5 m in height along both sides of the entire length of the slough. The substrate observed during the study was fairly homogeneous throughout and consisted primarily of gravel and rubble. The main source of flow was from the mainstem Susitna River, which entered the head of the slough. During periods of low mainstem discharge, as the head of the slough was dewatered, the slough itself became isolated from mainstem influence, and groundwater percolation alone contributed most of the water. Although spawning was not observed during the present surveys, a few chum salmon carcasses were found in dewatered areas within the slough.

Slough 19, which is largely spring-fed, is backed up at its mouth by the Susitna River, forming a pool approximately half the slough's length. At the time of the study, the slough itself was approximately .3 km in length, with sloping, 1.5-meter cutbanks in the upper portion and generally sloping banks throughout the lower portion. The substrate was composed of 100% silt and scant aquatic vegetation from the slough's mouth approximately 60-90 m upstream. Above this distance, the substrate was primarily gravel, with a layer of silt ending with cobble and rubble near the head of the slough. Sockeye were observed spawning in this slough. Redds were located by noting areas where the fish had fanned the silt to gain access to the underlying gravel.

Slough 21 is a forked, open channel stream approximately .8 km long with sloping, 1.5-meter cutbanks. Except during periods of low discharge, the main source of water is the mainstem Susitna River. At low discharge of the mainstem, however, the slough is fed by a small, clearwater tributary entering the northeast channel of the slough. During the study period, this tributary along with ground water percolation, maintained water in the main channel and northeast channel, while the northwest channel was dewatered. From the mouth to approximately 225 m upstream, the substrate was composed primarily of silt sparsely interspersed with gravel and cobble. Above this portion of the main channel and in the northeast channel, the substrate was composed of silt, gravel, and rubble. It was in these channels that all spawning activity was observed.

The northeast channel substrate consisted primarily of rubble and cobble interspersed with gravel. During the sampling period, no fish were observed spawning in this site. This channel was also the first to dewater. The northeast channel, as a result of the contribution of a small tributary, was never found dewatered, nor was the main channel of the slough. The sites along Slough 21 were selected because varied types of habitat, water quality, and fish activities, such as spawning and rearing, were represented.

In general, average water temperature in the sloughs during the June, July, and early September sampling periods was 9.0°C or higher, decreasing significantly in late September, when average water temperature ranged between 1.8°C and 5.6°C. Although data were limited, a comparison between surface and intergravel temperatures indicated that intergravel temperatures remained constant at 3.0°C, and surface water temperatures varied diurnally between 4.5°C and 8.5°C. The intergravel temperatures were consistently 2°C below the lowest recorded surface temperatures.

Dissolved oxygen readings were usually near 100% saturation until a slight decrease occurred in September. Generally, the slough samples showed moderately high conductivity readings; moderate alkalinity levels; pH readings in the middle-six to middle-seven range; and, for the most part, fairly typical cation, anion, heavy and trace metals, and nutrient levels. The most notable metal concentrations were those reported for iron. Turbidity levels in the sloughs were high when sloughs were apparently influenced by mainstem water.

3.4 - Threatened or Endangered Species

(a) Plants

At present, no plant species are officially listed for Alaska by federal or state authorities as endangered or threatened; however, 37 species are currently under review by the U.S. Fish and Wildlife Service (USDI 1980b) for possible protection under the Endangered Species Act of 1973. A recent publication by Murray (1980) discusses the habitat, distribution, and key traits of most of these species. None of these species are known to occur, however, in the upper Susitna River basin.

A list of species (Table 3.55) extracted from Murray (1980) was believed to contain the most likely plants of this category that could potentially occur in the Susitna River drainage and in the landscape to be modified by the construction of the proposed dams and associated facilities. Since the upper reaches of the drainage were expected to be the least affected, however, the major portion of the present survey was devoted to the study of potential habitats in and around the impoundments. The general habitat requirements and occurrence of these plant species were known from previous taxonomic and ecological study in Alaska and from information given by Hulten (1968). For instance, several of the endangered species and the only threatened species, (*Smelowskia pyriformis*), favor well-drained rocky or scree slopes.

Field searches were made in potential habitats in August 1980 and early July 1981. On each field trip, aerial and ground reconnaissance was made by three to four botanists and agronomists with the purpose, thereby, of increasing the probability of finding the pertinent plant species.

Following an assessment of potential habitat, specific field surveys were conducted in the following areas: 1) the upper drainage basin, specifically alpine areas near the Susitna and West Fork Glaciers; 2) the lowlands of the upper drainage basin, Maclaren and Tyone Rivers, ridges, terraces, and periglacial features; 3) the lower drainage, outcrops, and promontories along the Susitna River near Watana Creek, Kosina Creek, and gravel bars in the river bed; 4) alternative access routes; and 5) Borrow Pit A (Figure 9.7).

Calcareous outcrop areas found in 1980 were surveyed again in 1981, but earlier in the season. A prominent light-colored outcrop on the northwest flank of Mt. Watana supported a mat and cushion vegetation type in which many calciphilic species were present. The exposed bench was both well-drained and calcareous, requirements for several of the species being sought.

The Kosina Creek calcareous outcrop area was re-surveyed in 1981 to make observations at an earlier phenological time and to obtain flowering specimens of the *Taraxacum* species collected there in 1980. Several flowering plants of *Taraxacum* were collected in 1981, and the preliminary determination indicated that the species was *T. alaskanum*, a common species in some areas. The aspect of the Kosina Creek outcrops is north-facing, and the dark soil around the calcareous rocks is rather fine-grained. The Kosina Creek outcrops are almost accordant both with the calcareous outcrops on the northwest side of Mt. Watana and with the calcareous lag gravel domes west of Watana Creek. The Taraxacum collections were made in proximity to the calcareous rocks of the outcrop, and none were found in the surrounding vegetation types; one may thus assume that the species has calciphilic tendencies. Saxifraga oppositifolia and Rhododendron lapponicum, two recognized calciphiles, were notably abundant in the Kosina Creek outcrop area.

The northern alternative access route to the proposed dam sites (from the Denali Highway, not the recommended route) was surveyed in July 1981 by the plant ecology team. Two sites were studied on the ground; the rest of the route was observed from low-level helicopter flights.

A sandy, blowout area on the northwest side of Deadman Mountain on this northern access route was chosen for ground study. The well-drained habitat was believed to be a favorable site for several of the endangered and threatened species. Vegetation was a shrubby heath-birch-willow type. A second site on the south side of Deadman Mountain was also studied in connection with the survey of the alternative access route to Watana from the Denali Highway. A series of dry ridges, probably glacial moraines or terraces, was present, and the vegetation on two of these ridges was surveyed. The vegetation was typically a mat and cushion type. A later survey was made of this northern alternative access route and a ground study site was chosen on the east side of Deadman Mountain near the 1200 m elevation. The area was characterized by dry, rocky, windblown ridges vegetated by mat and cushion species, and in the lower and moister sites, by low shrub willow-birch-heath vegetation.

In none of the three survey areas on the alternative access route from the Denali Highway were any of the species in question found. The other access routes were similarly surveyed, but the plants in question were apparently absent there as well.

The vegetation in the vicinity of Borrow Pit A was surveyed in July 1981. The low ridge area was characterized by rocky outcrops intermixed with low areas containing knee-high, shrubby vegetation. In shallow depressions or ravines, the vegetation included both more herbs and grasses and taller shrubs such as alder. No threatened or endangered species were found.

(b) Wildlife

The only endangered wildlife species, listed by either the U.S. Fish and Wildlife Service or the State of Alaska, that could possibly occur in the upper basin study area is the peregrine falcon. No evidence of this species' nesting or even migrating through the study area was discovered during the course of this study. Suitable cliff-nesting habitat was surveyed in both 1980 and 1981 with no peregrine nests found. In addition, despite the following ornithological effort expended during the course of this study no peregrines were seen: 385 party-hours of breeding bird censusing; 53 party-hours of ground censusing of waterbirds; 44 party-hours of ground observations of raptor/raven nest sites; and more than 630 party-hours of general bird surveys. Furthermore, qualified observers performing the other field studies were requested to report any incidental observations of noteworthy species; no confirmed sightings of peregrines were reported.

The only confirmed historical records of peregrines in the upper basin study area are presented by White (1974), who saw two individual peregrines during his June 1974 survey, but found no sign of nesting. One bird was a "single adult male. . . roosting on a cliff about 4 miles upriver from the Devil Canyon dam axis," and the other was a "sub-adult . . about 15 miles upriver from the Devil Canyon dam axis." White (ibid) stated that the Yentna-Chulitna-Susitna-Matanuska drainage basin "seemingly represents an hiatus in the breeding range of breeding peregrines . . .", and Roseneau et al.(1981) stated that "the Susitna and Copper rivers both provide . . . [very few] . . . potential nesting areas for peregrines."

Peregrine falcons are a concern along the transmission line north- ern study area. A nest site is located east of the proposed transmission route crossing of the Tanana River. The nest was not active during 1981 but was used prior to this time. Whether or not it will be used again is unknown.

(c) Fish

The U.S. Department of Interior, Fish and Wildlife Service, does not list any fish species in Alaska as being threatened or endangered (Richard Wilmot, pers. comm. 1981). The State of Alaska Endangered Species Act includes no fish species on its list of endangered species.

3.5 - Anticipated Impacts on Botanical Resources

Potential impacts on vegetation were identified by review of pertinent literature and by discussion with various specialists knowledgeable regarding the problems associated with hydroelectric development. Anticipated impact areas in the upper basin and transmission corridors were identified by overlaying expected activities on vegetation/habitat maps. Calculations of area size were made based on vertical projection. Because of slope, the actual area to be impacted will be somewhat higher than that presented. The general location of proposed facilities is presented in Figure 9.7. Impact analysis for the downstream floodplain consisted of relating the general changes in flow during reservoir filling and operation to plant succession trends.

(a) Watana Dam and Impoundment

(i) Construction

The obvious impact of constructing the dam and of filling the Watana reservoir will be the elimination of portions of different vegetation/habitat types. The hectares of each vegetation/habitat type to be affected are presented in comparison with the total hectares of those types in the entire upper Susitna River basin and in an area within 16 km of the upper river (Table 3.56).

At a maximum pool elevation of 666 m (2185 ft) the Watana impoundment will inundate approximately 14,691 ha. Of those, 12,587 ha are vegetated and represent 0.9% of all the vegetated area of the upper basin. Much of the impoundment area could be classified as wetland (Table 3.7). Primary losses will occur in the woodland and open spruce stands and in the open mixed forests. Birch forests will be substantially affected by the impoundment, relatively more so than any other vegetation/habitat type (Table 3.56). The other types which would experience a relatively major impact are conifer-deciduous forests and balsam poplar forests.

Additional impact on vegetation may occur beyond the impoundment areas, if roads or other activities associated with clearing the woody vegetation from the impoundment zone are not restricted to the impoundment area. As discussed under mitigation (Section 3.9), restriction of disturbance to the impoundment area will limit the extent of this impact.

Construction activities at the dam site, borrow sites, airstrip, construction camp and village sites will result in a loss of additional hectares of vegetation (Table 3.56). Proposed camp and village sites, airstrip site, and borrow areas will be located primarily in woodland black spruce and low shrub stands. Borrow areas D and H also cover large mixed forest stands. Borrow areas may eventually be revegetated and are discussed in more detail in Section 3.5 (c)--Borrow Areas.

All of the aforementioned construction activities will be almost entirely contained within an area designated as a construction zone. This zone (Figure 9.7) represents the maximum area of potential construction disturbance. It is unlikely that this entire zone will be directly affected; however, if all the vegetation is removed from this zone, 13,725 ha will be lost in addition to that in the reservoir area lost by inundation (Table 3.56). This loss represents 0.8% of the entire upper basin. Reclamation of areas that will only be temporarily affected will reduce this loss and is discussed under Section 3.9 (b).

The significance of these losses, aside from the vegetation loss itself, will be the associated loss of habitat for wildlife. The principal losses for big game will be a reduced food supply for black bears and moose. Browse supplies in the impoundment area are marginal and do not represent a late winter reserve for moose. Birch and mixed forest stands, however, provide bears with substantial supplies, which are particularly important in early spring. A more detailed discussion of the impacts on big game is presented in Section 3.6 (a) (i).

(ii) Operation and Maintenance

The pool elevation of the Watana reservoir will vary an average of 27 m (90 ft), with a low of 639 m (2095 ft) in May, and a gradual increase to a full pool elevation of 666 m (2185 ft) during September. The drawdown zone (from full pool to low pool) will be essentially unvegetated. During dry years, however, the full pool target elevation may not be attained and exposed areas that are not flooded may become naturally revegetated for a short period until they are flooded again. The greatest potential for this type of revegetation exists in areas of gentle slope, such as the Watana Creek area.

The Watana reservoir is located in a region of discontinuous permafrost. Consequently, there is potential for large earthflows and slumps, especially on north-facing slopes, as the relatively warm reservoir thaws adjacent permafrost. This type of disturbance will most likely occur on black spruce sites and may lead in places, to their replacement, by alder stands and, possibly, by open paper birch stands. Bank erosion from above the full pool elevation may also result from wave action and altered subsurface drainage.

An impact noted by Baxter and Glaude (1980) for northern reservoirs is the potential for peat masses to float to the surface of the reservoir. This type of impact should not be extensive at the Watana reservoir, since only a small amount of the peat-forming wet sedge-grass vegetation will be inundated. Some potential for such an occurrence does, however, exist in the Watana Creek area.

There are two other minor impacts that may occur during the operation of the Watana facility: the potential modification of local climate and the icing of vegetation around the dam outflow. In general, large bodies of water influence the local climate by acting as cold sinks in winter, thereby delaying the initiation of spring, and as heat sinks in summer, thus extending localized warm weather. It has been estimated that such influence will be restricted to within about 1.6 km of the reservoir shoreline.

Local climatic changes may, in turn, result in minor changes in vegetation phenology. The severity and extent of this potential change in vegetation is difficult to predict. They may, however, include a localized delay in snowmelt and in greening of vegetation in spring and, possibly, a delay in leaf-fall in autumn. Any impact on vegetation in the spring may be moderated somewhat, however, since the pool elevation will be at its lowest point and thus, the distance from the water edge to the vegetation edge will be at its greatest.

At the dam outflow, ice fog will probably occur during winter months when the temperature is in the approximate range of -12°C to -23°C (+10°F to -10°F). This ice fog will freeze on contact with vegetation and may accumulate to create loads sufficient to break twigs. Although this impact will be very localized, birch trees, because of their many small branches, will be the most susceptible to damage.

(b) Devil Canyon Dam and Impoundment

(i) Construction

Construction and filling of the Devil Canyon dam and impoundment will eliminate an estimated 3,214 ha of vegetation/habitat types (Table 3.57). Primary vegetation losses will be of open and closed mixed forests and open spruce forest. Construction activities at the dam, camp, and village sites will further eliminate or modify at least another 223 ha of vegetation, primarily closed mixed forest. An estimated 1,706 ha of wetlands are within these direct impact areas (Table 3.7).

If the entire construction zone (Figure 9.7) is affected, 5,688 ha will be lost in addition to the reservoir area (Table 3.57). It should be noted that the area of the construction zone represents a maximum potential loss; a certain portion of this area will probably not be disturbed and reclamation activities may restore areas temporarily affected. The maximum potential loss, including the construction zone and reservoir area, represents 8,884 ha and 0.5% of the entire upper basin.

Vegetation losses at Devil Canyon will not be significant in terms of moose or caribou, since most of the affected area is situated on steep slopes which are generally inaccessible to these ungulates. These areas do, however, provide a relatively large forage supply for black bears. Big game impacts are detailed in Section 3.6 (b) (i).

(ii) Operation and Maintenance

The pool elevation of the Devil Canyon reservoir will fluctuate an average of 17 m (55 ft) during the year. The drawdown zone created by this fluctuation will essentially be devoid of vegetation. As discussed for the Watana reservoir, vegetation may invade some portions of this zone when the full pool target elevation is not attained. On the other hand, since much of the Devil Canyon reservoir is very steep-sided, this invasion may only occur at the very upper reaches of the reservoir in the Tsusena Creek vicinity.

As discussed for the Watana reservoir, erosion of material from above the pool elevation may occur after filling. The extent of this impact will vary, depending on many factors, but the amount of slumping will probably be less than that at Watana.

Localized climatic changes may also occur around the Devil Canyon reservoir. Because of the long, narrow configuration of the reservoir, however, which leaves relatively smaller surface area exposed to create climatic change, the potential for such change will be less than that expected for the Watana reservoir. Any such changes are, therefore, expected to have a negligible effect on surrounding vegetation.

Finally, the operation of the Devil Canyon reservoir will result in changes in downstream flows, downstream water temperatures, and ice conditions. The impacts of these changes on vegetation are discussed in Section 3.5 (d) - Downstream Floodplain.

(c) Borrow Areas

The complete development of all borrow areas at both Devil Canyon and Watana will destroy an estimated 1,751 ha of vegetation/habitat types (Tables 3.56 and 3.57). Those portions of the borrow areas within the impoundment and those associated with access road construction are not included in this estimate. This estimate does include, however, those borrow areas within the construction zones previously discussed. Woodland and open spruce, low mixed shrub, and birch shrub will be the principal types affected. Borrow Area K, which is a quarry associated with the Devil Canyon dam, is covered primarily by mixed forests.

The total impact from borrow areas will probably be less than the 1,751 ha estimated, since certain areas (possibly A and H) may not be used and others may be only partially developed. Also, reclamation of all these areas is possible [(see Section 3.9 (b)]. Areas that are developed should not, therefore, be permanently destroyed as a terrestrial habitat but may remain changed in terms of the type of habitat for a long period of time.

The development of borrow areas may also influence vegetation in adjacent areas by lowering the water table. This type of impact will probably only occur to any noticeable extent around Borrow Area D, where adjacent land to the north and west may be influenced. This impact will be localized, however, and will probably result in only minor species composition changes in the areas affected.

(d) Downstream Floodplain

(i) Construction

Decreased flows during the period of filling will enable vegetation to move into the upper portions of what is now submerged river bottom. Between the Devil Canyon dam site and 0.5 km above the confluence of the Susitna and Chulitna rivers, the development of vegetation, however, will be relatively negligible, since most of the area to be exposed consists of rocky substrate, rather than smaller particles suitable for the rooting of vegetation. Thus, vegetation will probably be limited to fireweed, horsetails, dryas, sweetvetch, and possibly some other pioneering species. Another hindrance to vegetation development is that plants will be restricted to interstices of the rock-armored river bottom. Moreover, the filling period will not be long enough for sufficient wind-blown soil to accumulate to allow for further vegetation development.

Because of decreased flows, areas that are presently horsetail communities will quickly develop into balsam poplar sapling and willow communities. The rate of this change depends on the synchronization of seed crops with adequate precipitation and suitable temperatures. The areas supporting horsetail are relatively limited, however, most occurring within 11 km upstream of the confluence of the Susitna and Chulitna rivers. During the period of reservoir filling the impact on vegetation below the Susitna-Chulitna confluence is expected to be negligible.

(ii) Operation and Maintenance

At Gold Creek, river flows during the growing season (May to September) will be reduced from an average of about 20,000 cfs to an average of about 10,000 cfs. Seasonal floods will essentially be eliminated. As a result, some of the presently unvegetated bank areas in the reach from Devil Canyon to the Susitna-Chulitna confluence will begin to develop horsetail, dryas, willow, and balsam poplar communities. Barring disturbances by ice jams, willow and balsam poplar saplings will develop within five years of the last disturbing influence on sites presently having sandy or silty substrates.

Establishment of significant cover on rocky sites may require several decades while adequate wind-blown sands and silts accumulate; even then, vegetation will be dwarfed and slow-growing for several more decades. In the downstream Susitna above Talkeetna, the area above the level of the river during 40,000 cfs flows is already vegetated. Below that level, most of this area has a rocky substrate, not conducive to lush growth. Consequently, the overall increase in vegetation cover for this reach of the river will be minimal.

Since the Devil Canyon to Talkeetna reach of the river is expected to remain largely ice-free, a principal environmental force maintaining early successional vegetation will be absent during operation. This gap will allow present early successional vegetation to advance to later forest types. During some winters, however, accumulations of ice fog on vegetation adjacent to the wider sections of the river may break down trees and tall shrubs, creating brush fields of young balsam poplar, willow, and alder. This effect is not expected to proceed beyond bank-side vegetation.

Below Talkeetna, the effects of either reduced or increased flows will be moderated by the contributions of the Chulitna and Talkeetna rivers. While the degree of moderation is uncertain, certain trends in impacts can be expected. For example, the primary impact of decreased summer flow below Talkeetna will be to allow early successional vegetation to move down onto sites that are presently eroded by high summer flows. Thus, until a new equilibrium with the river is reached, new early successional stands will migrate toward the new level of peak flows, while older early successional stands (then less affected by high flows) will advance to alder and immature balsam poplar types.

The time required for transition from early successional stands of willow and balsam poplar to mid-successional stages is roughly equal to that required for establishment of new early successional stands (that is, six to eight years). The total area covered by the new stands is expected to be nearly equal to that lost to mid-successional vegetation.

The above sequence of events may be negated by floods from the Chulitna or Talkeetna rivers or, in rare instances, by flood water passing the Susitna project. Such events may maintain the distribution of vegetation types on the floodplain below Talkeetna similar to the way it is at present.

(e) Access Route

(i) Construction

Construction of the Parks Highway-to-Devil Canyon/Watana access road (including railroad yard and all potential borrow areas) will disturb approximately 900 hectares of vegetation, providing that machinery stays within 30 m (100 feet) of the center line (Table 3.58). Primary losses will be to open and closed conifer-deciduous forests and low shrub types.

The total direct impact of the permanent access road may be somewhat less extensive than the aforementioned estimate, since the roadbed will only be about 14 m (45 feet) wide and all the identified borrow areas may not be used. Between Gold Creek and Devil Canyon, however, the pioneer road will probably cover separate ground from the route of the permanent access road and, therefore, will result in additional temporary impact. Eventual revegetation will restore these areas.

(ii) Operation and Maintenance

During operation of the road, impacts may extend beyond the road base itself. Where the road restricts drainage, woody vegetation types will shift toward sedge-grass tundra and wet sedge-grass conditions. Areas which are presently wet but which will become drier will experience a gradual invasion of shrubs and trees, depending on specific soil/site conditions.

Accumulations of dust on roadside vegetation may cause snow melt to occur two to three weeks earlier for a distance of 30-100 m either side of the road (CRREL 1980). This factor, associated with accumulations of some elements, (particularly calcium), in road dust and changes in photosynthesis, may substantially reduce the density of four-angled Cassiope, stiff clubmoss, sphagnum moss, Cladina, and other mosses and lichens; on the other hand, cottongrass may increase (CRREL 1980). Such shifts in vegetation composition would not be obvious to any but the trained observer and should not cause any soil erosion problems.

The most significant source of impact associated with the access road may be damage caused by unrestricted off-road vehicle traffic (Sparrow et al. 1978). The most extensive impact of such use would be on willow and shrub birch. Sedges would be most resistant to damage. The most significant damage, however, would occur on upland tundra communities, where soils are shallow and rocky. The potential restriction of off-road vehicle traffic is discussed under mitigation (See Section 3.9 (b)).

Considerable potential for fire also exists, especially during the spring. The remoteness of the region increases the time required to reach a site and to bring a fire under control. Thus, while such an event may be localized, it may also extend over vast areas. In any event, fires will cause changes in the vegetation similar to those which have occurred historically from naturally occurring wildfires (that is, vegetation would be set back to early successional stages). Neither the wet areas nor the sparsely vegetated upland tundra communities will support a significant fire. The birch and low mixed shrub, the black and white spruce, and the mixed conifer-deciduous forest habitat types, however, may ignite into substantial fires. Fire could revert these latter types to seral brush communities, highly productive of moose browse.

(f) Transmission Line

(i) Construction

Construction of the transmission line will result in long-term vegetation impacts where tower structures and permanent access roads are placed. In addition, movement of machinery over the ground will temporarily set back brush growth. The major impact of construction will be to reduce the overstory cover of trees. Where spruce trees are cut, spruce bark beetle problems may arise.

The estimated amounts of different vegetation types that will be within the right-of-way are presented in Table 3.59. Additional areas may be affected if access roads are placed outside of this right-of-way.

The transmission line between the dams and the intertie will primarily traverse closed conifer-deciduous forests and the birch shrub type. Utilization of the access road to the dams will help limit the impact in this area. From Healy to Fairbanks the transmission line traverses open spruce forests, open conifer-deciduous forests, and low mixed shrubs. Extensive clearing will be required along this route from the Tanana River to Fairbanks. Within the route segment between Willow to Cook Inlet, the primary vegetation types include open spruce, closed conifer-deciduous forests, and wet sedge-grass types. Clearing will also be required in the forested areas here.

At several places, the transmission lines will cross wetlands. They are especially common in the Tanana Flats region of the northern corridor (from the Nenana crossing to the Tanana River) and along the southern portion of the Willow-to-Cook Inlet corridor. Small wetland areas may be spanned without impact, providing precautions are taken during construction. Larger expanses of wetlands, though, will be adversely affected, but impacts could be minimized if construction time is restricted to winter. Potential impacts include direct disturbance of wetland vegetation (and resultant loss of wildlife habitat) as well as changes in drainage patterns and possible erosion problems.

(ii) Operation and Maintenance

Maintenance of the transmission right-of-way may require the topping or removal of the taller tree species, such as white spruce, birch, aspen, balsam poplar, and tamarack. If these trees are removed, shrubby undergrowth is expected to accelerate growth and to thicken, and the number of individuals of some shade-tolerant species are expected to decrease temporarily until shrubs thicken. Periodic clearing of trees along the transmission right-of-way is expected to benefit wildlife from the standpoint of increased forage production once the animals become accustomed to the sound of the lines [See Section 3.6 (f)].

Impact on vegetation may also occur in the vicinity of the transmission line as a result of increased ATV use. Such use may be especially common where the transmission lines cross roads or other existing access points.

3.6 - Anticipated Impacts on Wildlife Resources

(a) Watana Dam and Impoundment

(i) Big Game

For the purposes of this discussion, the proposed Watana facility includes the dam, spillway, camp, village, airstrip, and impoundment as well as the construction zone around the dam site. Borrow areas associated with the construction of this facility are addressed separately [see Section 3.6(c)(i)].

- Moose

The construction and operation of the Watana dam and impoundment will negatively impact moose in several ways. The most obvious and probably the most important impact of the proposed facility on moose will be the direct loss of habitat. It is anticipated that 26,813 ha of habitat will be either permanently lost or temporarily disturbed. Of this total, 14,691 ha will be inundated and permanently lost, and the remaining 12,122 ha will be lost as a result of other facility components. A portion of this 12,122 will be permanently lost, but at a minimum, 50% may be available for reclamation. Regardless of how much can be restored, the figure of 26,813 ha does represent the immediate loss of moose habitat which will occur.

The severity of the impact of this habitat loss will vary within the moose population. Those moose that have home ranges that fall primarily within the impact zone will be displaced and be forced into adjacent areas where they will suffer high mortality. This is most likely to affect relatively sedentary moose which typically utilize a small area as both summer and winter range. (Within the upper basin, most radio-collared moose which displayed such a sedentary pattern were found west of Watana Creek.) Impacts on moose that utilize the impoundment zone on a limited or seasonal basis will be different and more difficult to predict although it is likely that these moose too will be reduced in number.

The impoundment zone appears to serve two major functions for moose which shift home ranges from summer to winter: (1) as winter habitat and (2) as an area which provides green forage early in the spring. Moose that use the impoundment zone as winter habitat typically spend the summer months at high elevations and then move down to lower elevations, frequently to river bottoms, during winter when deep snow at higher elevations impedes movement and reduces the availability of food. During the course of these studies, however, radio-collared moose did not display this type of movement pattern, probably due to mild winter conditions. It is therefore likely that the movement data on moose do not reflect typical movement patterns of moose during more severe winters. Therefore, the lowlands along the river which will be flooded should still be considered of importance to the moose population as winter habitat.

The level at which this winter habitat could support moose during a severe winter, though, is questionable. In the absence of detailed browse surveys within the impact zone, it is impossible to determine how many moose could be supported there under harsh winter conditions. Cursory and subjective conclusions developed during the course of the Susitna studies suggested that the quantity of browse along the river is low and appears to be virtually completely utilized by December. Based on this preliminary conclusion, on the blood data (which suggested that the condition of Susitna moose had deteriorated over the past few years), and on the apparent lack of any significant fires in the past 30 to 35 years, it appears that the impoundment zone may not presently be of any significant value as a winter food reserve for moose. If a natural fire were to occur in the forested areas along the river sometime in the future, the value of the proposed impoundment zone as a wintering area for moose would be greatly improved. The construction of the Watana facility, of course, would preclude that possibility.

The other manner in which the impoundment zone serves the needs of both sedentary and migratory moose is by providing green forage early in the spring. Such forage is most prevalent on south-facing slopes, which are the first areas to become snow free and allow for the early emergence of herbaceous plants. The availability of these plants is very important to moose, in particular to pregnant and lactating cows which have a very high nutritional demand. A very large proportion of the south-facing slopes in the area will be flooded by the Watana impoundment. What this will mean for the moose population will depend to a large degree on the severity of winter conditions. Following a mild winter, moose may not be nutritionally stressed enough to be impacted by this reduction in early spring forage. Following a more severe winter, however, the early availability of green forage may help to reduce starvation mortality.

The relatively sedentary moose which are displaced from the impoundment zone will aggravate the situation described above, since they will compete for food with moose already inhabiting adjacent areas. This will likely hasten the process of range deterioration that appears to be currently underway. The severity of this situation and the damage which will be done to vegetation will depend on the ability of the surrounding area to support additional moose and on the predation rate of wolves on these moose. If sufficient wolf predation takes place before the habitat is over-utilized, the long term quality of the habitat may not be too severely affected. In this case, the key element will be the degree to which wolves are adversely affected by the project. Being more sensitive to disturbance than moose, it is possible that, at least at first, the wolf population will be reduced to a greater degree than the moose population thus allowing for greater moose survival and consequently greater potentential for habitat damage because of an overabundance of moose.

In addition to direct habitat loss, the moose in the area may be adversely affected by microclimatic changes caused by the impoundment. It is predicted that the Watana impoundment will alter the microclimate in the immediate downwind areas. Temperatures may be reduced sufficiently in some areas to retard the emergence of spring vegetation which, as previously explained, moose utilize for forage in early spring. Although this possibility of microclimatic effects impacting moose through an influence on vegetation does exist, it is not likely to be of major significance due to the distances that will exist in early spring between the permanent shoreline and open water. Because of the projected drawdown schedule, the impoundment should be at its lowest level at or following the breakup of ice. In areas where the impoundment is very wide, such as the Watana Creek drainage, the potential for microclimatic changes are greatest because moving air will pass over a greater distance of water. It is also in such areas, however, that the greatest distances will exist, due to topographic features, between open water at this time of the year and the shoreline: in many areas these distances will exceed the 1.6 km zone of influence predicted for microclimatic changes. In those sections where the impoundment is narrow, such as east of Jay Creek, the potential for microclimatic changes is less because of the reduced surface area of water. In these areas, however, the distance between water and shoreline will be minimal in early spring, again due to topography. In other words, where the potential for microclimatic changes is greatest, the vegetation is far from the water, and where the vegetation is near the water, the possibility for microclimatic changes is less.

The potential for microclimatic changes having an impact on moose is far greater during the winter months when the impoundment is ice-covered. The relatively smooth surface of the ice will reduce the frictional drag of winds, which are from the east and northeast during winter and this will cause the blowing and drifting of snow for several kilometers inland on the downwind (west and southwest) side of the reservoir. It is therefore likely that, in many areas downwind of the impoundment, snow accumulations will be far greater than those that presently occur in the area. This will greatly restrict the use of such areas by moose in the winter. First of all, deep drifts will improve the ability of wolves to kill moose in these areas. There will also be less browse available. Finally, moose weakened by passing through such drifts will be more vulnerable to wolf predation.

In summary, moose will be impacted through the loss of 26,813 ha of habitat and a reduction in usable winter habitat downwind of the impoundment due to snow depths. This loss will cause the direct displacement of those moose whose home ranges are located primarily within the project area. It will also reduce significantly the availability of early spring forage, which is of some importance and, following severe winter conditions, probably critical to many moose in the area. The project will also eliminate a possible wintering area which is presently of questionable value. Although other factors may also affect moose (such as increased difficulty in negotiating ice conditions during breakup and disturbance from human activity around construction and clearing operations), they are all relatively minor in comparison to the direct and indirect loss of habitat. How many moose will be adversely affected and the degree to which the carrying capacity of the area will be reduced are currently unknown. Based on the census data collected and the distribution of moose use, it is possible that 400 moose may be severely impacted as a result of direct displacement or loss of major portions of their home ranges. An additional 800 moose could be impacted to a lesser degree through an overall reduction in the carrying capacity of the region and overcrowding from displaced moose. This is a very rough estimate and the actual numbers could vary as much as 50% (200 to 600 severely impacted and 400 to 1200 moderately impacted). Possible mitigation measures to reduce these impacts are discussed in Section 3.9.

- Caribou

The amount of caribou habitat lost as a result of the inundation of terrain by the Watana impoundment will be insignificant. Less than one percent of caribou habitat in the upper Susitna River basin will be inundated by both the Devil Canyon and Watana impoundments combined. Furthermore, the habitat to be lost is of low quality.

The proposed reservoir, however, does intercept an historically important migration route of the Nelchina caribou herd across the Susitna River between Deadman and Jay creeks. Ice conditions on the shoreline of the impoundment may act as an obstacle to future crossings of the impoundment, and the ice conditions on the impoundment itself may constitute an additional obstacle to migrating caribou.

The annual drawdown of the reservoir in winter will result in the impoundment being at its lowest level at the time of the spring migration, in late April and early May. At this low point, the impoundment will average approximately 27 m (90 ft) lower than when it is full in September. The gradual winter drawdown will result in the formation of ice shelves grounded on the shore. These shelves will fracture into linear strips as the supporting water recedes and strands the ice on the shore. The width of the strips and the difference in height between adjacent shelves will depend upon the thickness of the ice. The thinnest shelves will be lodged highest on the banks in early winter. Where the slopes of the shoreline are gradual, such as along the Watana Creek drainage, the shelves will be wide and flat and more easily traversed. Where the banks are steeper, the shelves will be fractured into smaller blocks and pile up as ice moves up from below and slides down from above; these areas may be more difficult for caribou to cross.

These spring conditions in the impoundment will be significantly different from those occurring at present in spring along the Susitna River in the vicinity of the traditional caribou crossing. The ice shelf area will be wider than the present shelves formed on the river bank. The breakup also will be delayed for several weeks. The risks involved in crossing the impoundment will be different from those associated with the swiftly flowing river carrying river ice floes downstream. During this period, crossing the reservoir would be hazardous to caribou.

In addition, during the winter months, the prevailing winds are from the east and northeast. They will push snow across the smooth ice of the impoundment to pile up and form a deep snow bank along the downwind shore. During the spring breakup, this snow bank will be alternately soft during the warmer days and crusted during the chill nights. It may constitute another obstacle to caribou attempting to climb the south bank.

This migration route was used in the past by a considerable portion of the Nelchina herd when it frequented the northwest portion of its distribution, but has been used by only small numbers of caribou since 1971, with the possible exception of 1976. It is not possible to predict when the herd might return to its former migration patterns, but it is reasonable to expect that it will at some period in the future, especially if the herd population increases dramatically. When the route was utilized, it was used by three distinct migrating groups: (1) pregnant cows and yearlings migrating southward during late April and May across the river to the traditional calving grounds in the Kosina Creek and Oshetna River valleys; (2) cows and calves during the post-calving migration to northern summer ranges in late June and July; and (3) mixed bands of caribou during August and September. The conditions that caribou will face in the impoundment during the later migrations will be much different from those described for the spring migration. During the summer and early autumn, the impoundment will be reaching its full level and will constitute a long, narrow lake averaging approximately 1-2 km wide. It is not expected that the caribou will experience any special difficulties in crossing the reservoir during those periods; caribou are excellent swimmers, and they regularly cross lakes when migrating.

Migrating caribou could respond in a variety of ways to the changed environment which the impoundment will create. The severity of the obstacle caused by the shore ice shelves will vary depending on the stage of breakup and the point at which the caribou reach the impoundment; they may approach at a steep bank or a gradually sloping shoreline.

The possible reactions produce a variety of potential results in the future distribution of the Nelchina herd. In one scenario, the migrating caribou will travel along the shore until they find a safe crossing point, as they do at present. In another, the caribou will attempt to cross a hazardous section of the reservoir and suffer increased injury or mortality. In a third, the caribou will continue eastward along the north shore of the impoundment towards the big bend of the Susitna River and cross the river above the confluence of the river with Goose Creek or the Oshetna River, where the impoundment largely will be drained at this time of year and contain a flowing river. This last action would lead to a delay of a day or two in reaching the calving grounds with unpredictable consequences for the pregnant cows. In a final scenario, the obstacles associated with the impoundment might constitute such a formidable barrier that the caribou will be forced to turn back and to bear their calves on the alpine plateau, between the Susitna and Nenana Rivers. This area is already recognized as a secondary calving ground.

The last scenario described above might cause a temporary separation of the cow and bull groups. The worst possible case is that it would cause the isolation of a sizable portion of the herd in the northwest portion of the range which has been used in the past as both summer and winter habitat. At present, this area supports a small subherd that is estimated to total less than 1,000 animals.

Although it is difficult to predict how caribou will react, based on the present knowledge of caribou behavior the possible reactions of the Nelchina herd to the impoundment have been placed in the following order, starting with the most likely reaction and proceeding to the least likely reaction.

1. The caribou will manage to cross the impoundment safely in the Watana and Kosina creek area.
2. The caribou will travel eastward and cross the Susitna River in the vicinity of the Oshetna and Tyone rivers on ice-covered flats.
3. The caribou will make hazardous crossings with increased mortality.
4. The caribou will refuse to cross the impoundment and return northward.

The number of activities associated with the construction phase of the Watana dam constitute potential short-term impacts on caribou. The clearing of woody material from the impoundment area prior to flooding may disturb migrating caribou for a period of up to five years before filling is complete. Caribou migrating southward in spring or northward in summer may be disturbed by the unnatural cleared area in the impoundment zone. Air traffic in and out of the Watana construction camp, particularly low-level helicopter traffic, also constitutes a potential impact upon the caribou. If low-level flights occur over the nearby traditional calving grounds, a deleterious impact upon the whole Nelchina herd could result. Similarly, any ground travel by workers to the calving grounds could constitute a serious disturbance to the caribou at a particularly sensitive period during their annual cycle. The dam site is a considerable distance from the calving grounds, but work crews clearing the impoundment zone will be much closer. Mitigation measures proposed to deal with this problem are presented in Section 3.9.

- Wolf

The most severe impact of the proposed Watana impoundment on wolves will be a reduction in the abundance of prey, in particular moose and caribou. As previously discussed, the likelihood of a major impact on caribou is not great, and therefore the prime avenue of impact on the local wolf population will be a reduction in the number of moose. There will definitely be fewer moose present in the area; and due to overcrowding by displaced moose, there will likely be some reduction in the total carrying capacity of the area. Since moose are the prime and most dependable food source for wolves, there will also be a parallel reduction in the resident wolf population.

This predicted reduction in wolves represents the long-term impact. For a short time following the filling of the impoundment, there may be an increase in wolf numbers. This possibility is based on the assumption that wolf numbers will not be reduced as a result of some other aspect of the project such as disturbance from human activity. As discussed in the description of impacts on moose, displacement which results in increased population density and competition for food may reduce the vigor of individual moose and improve the ability of wolves to secure food for a few years. Increased ease of obtaining food may result in wolves requiring smaller territories, and thus provide opportunities for the establishment of more packs. Greater food availability may also result in improved reproductive success on the part of resident packs. In addition, as mentioned in the moose section, deep snow drifts downwind of the impoundment during winter may further increase the vulnerability of moose to wolf predation. The change in moose vulnerability will, however, be of short duration; following the overall reduction in the number of moose and the carrying capacity of the adjacent areas, the mechanisms that served to increase the wolf population will be reversed and the net result will be fewer wolves.

If the impact on moose is restricted to the area immediately within and adjacent to the impoundment, at least six or seven resident wolf packs will be affected as described above. The impact of wolves farther removed from the impoundment will depend on how far the impoundment will have an influence on moose.

An associated factor in the long-term impact on wolves concerns the future of the Nelchina caribou herd. Since the impoundment is not expected to have a severe impact on that herd, caribou will still be available to wolves as an alternative to moose. Because of their migratory nature, caribou are less important than moose to the long-term maintenance of wolf numbers. Yet, if the Nelchina herd continues to increase, it is possible that, to some degree, caribou will compensate for the predicted loss of moose. The increase in the size of the caribou herd is not necessarily related to the project but is dependent to some extent on the current management objectives of ADF&G. The number of wolves and, more importantly, the locations of wolf packs that may benefit from an increase in the size of the caribou herd will vary and are impossible to predict.

Another direct manner in which the Watana impoundment may impact wolves is through the loss of den sites. Since not all of the wolf packs that are resident near the impoundment were radio-collared during the course of these studies, it is not known how many den sites may be lost. At least one and perhaps two den sites are very close to the impoundment and may be abandoned because of flooding or project-related disturbance. Based upon the characteristics of den sites examined during these studies and the apparent abundance of such sites in the area, it is not believed that the availability of den sites is a limiting factor for local wolf populations. The loss of some den sites as a result of flooding is therefore considered insignificant in comparison to the reduction in prey. Although it is pure speculation at this point, it should be noted, however, that since most wolf dens are enlarged red fox dens, the long-term status of the fox population may be important to the availability of suitable wolf dens. The fox population is not presently very high, and there are many old fox dens still available; should the Susitna project result in a major reduction in the number of foxes, however, the long-term availability of denning sites for wolves may ultimately be lower.

Increased air traffic and disturbance resulting from the clearing of the Watana impoundment are also sources of potential impacts on wolves. Although observations suggest that denning wolves can adjust to air traffic, they appear to be very intolerant of ground disturbances. Therefore, since at least two known den sites are close to the edge of the Watana impoundment, the clearing activities required to remove woody vegetation, if they are conducted during the denning period (May through July), could result in den abandonment and pup loss. This would most likely be a short-term impact and, assuming that the den sites were used following the disturbance, the overall impact might not be of major consequence.

- <u>Wolverine</u>

The construction and operation of the Watana facility will impact wolverines in basically three ways. The first is the loss of habitat that will result from the impoundment and associated facilities. As mentioned, this loss will total 26,813 ha. This loss of habitat and associated foraging areas will reduce the ability of the area to support wolverines to some unknown degree.

The second impact is related to the expected reduction in the number of moose and the associated reduction in wolves. Although wolverines do directly prey on a variety of animals, they are well known as scavengers which feed on large animals such as moose and caribou that have been killed by wolves. The reduction in moose and wolf numbers will mean that fewer wolf-killed moose will be available for use by wolverines. As discussed in the wolf section, for a few years following inundation, there may be a short-term increase in wolf-killed moose. Therefore, this impact on wolverines may take several years to materialize and will actually occur after the moose and wolf populations become lower.

The third and probably the most critical impact on wolverines will be disturbance by human activity. This species requires expanses of remote, uninhabited area. The development of a highly concentrated center of human activity around the Watana dam site plus the human activity associated with the clearing of the impoundment will most likely render a large portion of the land adjacent to the Watana impoundment unacceptable to wolverines. The disturbance associated with the clearing activities will be of a short term nature and the area adjacent to the impoundment may be suitable for wolverines following inundation; the permanent facilities around the dam site, however, will preclude the presence of wolverines in that portion of the upper Susitna basin.

In summary, the Watana impoundment and associated facilities will result in a reduction in the wolverine population. The mechanisms of impact include habitat loss, reduction in wolf-killed ungulates, and human activity. The core portion of the wolverine study area, which includes the Watana impoundment, was estimated to contain 11 to 21 adult wolverines during the current studies. It is likely, because of the sensitivity of this species to disturbance, that the majority of these wolverines will be displaced during the construction and filling phases of the project. The extent to which wolverines will use the area following the activities associated with construction and filling is unknown, but it is likely that the upper portions of the impoundment area will prove suitable for some wolverine use.

- Brown Bear

As is the case for other big game species, brown bears will be impacted by the Watana facility through a loss of habitat. Because brown bears exhibit very large home ranges which are characterized by major seasonal shifts in usage, the 26,813 ha of habitat that will be lost is used to various degrees by brown bears. The use of the impoundment area represents only a portion of the total area covered by this species over the course of a year. Based on radio-telemetry data and knowledge of brown bear habits, it has been determined that it is unlikely that the Watana facility will cause the loss of any individual brown bear's home range. As can be seen from Table 3.60, the highest percentage of overlap of a radio-collared brown bear's home range and the Watana impoundment was 25.1% (for bear number 281). Bears number 280 and 340 had home ranges that overlapped the impoundment area by 11.3% and 10.1%, respectively. The remaining bears had home ranges that each overlapped the impoundment area by less than 10%.

Although brown bears appeared to use the impoundment zone throughout the non-denning season, the greatest use probably occurred in early spring following their emergence from winter dens. There is a pronounced tendency for brown bears to move from the high elevations where dens are located to the lower elevations along the river at this time of the year. The reason for this movement is felt to be the attractiveness of areas along the south-facing slopes near the Susitna River which are the first to become snow free and thus make available overwintering berries and early herbaceous growth. It is also possible that bears are attracted to these areas because of the increased likelihood of finding winter-killed moose there.

The importance of these early snow-free areas to brown bears is not known. Regardless, for the purpose of impact prediction, it is assumed that the south-facing slopes that will be flooded (which represent a large proportion of the south-facing slopes in the area) are of some importance to brown bears, and that their loss will reduce, to some unknown degree, the ability of the upper basin to support a brown bear population comparable in numbers to the current one.

The Watana impoundment may also function as a barrer to seasonal movements of brown bears. Several radio-collared bears moved long distances to utilize the salmon in Prairie Creek. Brown bears also concentrated in the calving area of the Nelchina caribou herd where they were suspected of preying on calves. The bears may or may not find the impoundment an insurmountable barrier. That bears are able to cross the Susitna River under high flow conditions suggests that a relatively placid reservoir, especially at constricted points, should not be a barrier. If portions of the impoundment were to prove a barrier to brown bears, the tendency for bears to travel long distances should enable them to locate acceptable crossing points or even circumnavigate the impoundment.

As in the case of the nutritional importance of early snow-free slopes, it is not known how important the salmon and caribou calves are to bears. Obviously, many bears in the upper Susitna and Nelchina basins exist without salmon as a food source. Yet, it is crucial to note that the greater the number of these seasonal foraging areas that are lost, the greater will be the reduction in carrying capacity for brown bears. The relatively large home ranges of brown bears in the project area could be the result of widely dispersed food sources. Thus, the loss of any food source, either directly through flooding or indirectly through blocked access, could be significant to the bear population. This is especially true if more than one type of food is eliminated. It is likely that the brown bear population will be lowered due to the direct loss of habitat. The loss of additional food sources (such as Prairie Creek salmon) could greatly increase that loss.

Another impact on brown bear will be disturbance caused by human activity. Brown bears are fairly intolerant of human presence and will either withdraw from the zone of disturbance, in effect causing a further loss of usable habitat, or possibly come into direct conflict with humans. Any direct confrontation between bears and humans, such as would be caused by improperly disposed food refuse, would likely result in the need to destroy or remove the bear.

The one aspect of brown bear biology that will not be influenced by the Watana impoundment is denning. Brown bears den at high elevations which will be far removed from both the impoundment and disturbing human activity at Watana. Air traffic, however, could be a source of disturbance. No known brown bear dens will be inundated by the Watana impoundment, and it is unlikely that any undiscovered dens will be flooded.

In summary, the Watana impoundment and associated facilities will negatively affect brown bears. The mechanisms of impact will include: (1) direct habitat loss (especially that of probably significant early spring habitat), (2) possible blockage of the movement of bears to seasonally important foraging areas, and (3) potential indirect habitat loss resulting from disturbance by and conflicts with humans. In the absence of accurate population estimates, it is impossible to predict how many bears will be impacted. Because of the far-ranging movement patterns displayed by Susitna brown bears, the loss of any seasonal foraging areas will be a major impact on this population, however, and could cause a significant reduction in the number of bears that inhabit the area.

- <u>Black Bear</u>

Of all the big game species which inhabit the area, the black bear will be the most severely impacted by the Watana impoundment. Because of the association between black bears and forested habitats, the loss of 26,813 ha, most of which is suitable black bear habitat, will result in a drastic reduction in the number of black bears upstream from the Watana dam. The vast majority of the suitable black bear habitat east of the Watana dam site is within the area of the proposed impoundment.

Black bears are more sedentary than brown bears and spend a greater proportion of their time in these habitat types. As indicated on Tables 3.60 and 3.61, a far greater percentage of black bear than brown bear home ranges will be lost. In three cases, more than 40% of an individual radio-collared black bear's home range will be lost. The types of areas that will be lost are very important for black bears during spring, summer, and winter. Early fall is the only time when black bears tend to leave the forested areas in order to feed on ripening berries in shrub habitats located at slightly higher elevations. The construction zone around the Watana dam site will also eliminate a large area of such shrub communities.

Unlike brown bears, which den at higher elevations, black bears den on the slopes along the Susitna River and nearby tributaries and will thus be severely impacted by flooding. Proceeding upstream through the study area, the band of acceptable denning habitat becomes progressively narrower and more confined to the immediate vicinity of the Susitna River. Therefore, the impact of den loss will also become more pronounced farther upstream from the Watana dam. Typically, black bears in the study area denned at elevations between 457 m (1,500 ft) and 762 m (2,500 ft). Of the 13 den sites found in the vicinity of the Watana impoundment, 9 would be flooded by a pool elevation of 666 m (2,185 ft).

Black bears in the Susitna basin also differ from brown bears in regard to their reuse of den sites. None of the radio-collared brown bears that were tracked for two years reused the same den. Of the located black bear dens, all of the natural cavity dens examined and one of the dug dens examined had been previously utilized. This suggests that the availability of suitable den sites is limited and therefore increases the significance of the predicted den loss.

Along the Susitna River, upstream from the Watana dam site, the best black bear habitat is found on the steep slopes (especially the south-facing slopes) and the habitat becomes less suitable farther from the edge of these slopes where the density of trees becomes lower. Therefore, not only will the impoundment eliminate a large amount of black bear habitat, it will eliminate virtually all of the prime habitat, leaving only marginal habitat unflooded. Thus, the simple quantification of hectares of habitat lost does not accurately reflect the magnitude of that loss. The habitat which will remain is of marginal value to black bears not only for foraging and denning but also as protective cover from brown bears.

In summary, although the Watana impoundment will impact black bears in a variety of ways, they are all insignificant and moot in comparison to the direct loss of critical, prime habitat: there will be a major reduction in the number of black bears inhabiting the project area. East of Jay Creek, because of the constricted nature of the forested habitat in that area, it is likely that virtually all resident black bears will be lost. The degree of loss will be gradually less as on proceeds west from Jay Creek to the Watana dam site. In the absence of accurate density estimates, in addition to the many unknowns concerning the response of both black bears and brown bears which influence the abundance of black bears, it is difficult to accurately predict the magnitude of the loss that will occur between Jay Creek and the Watana dam. Based on the data available, however, it would be reasonable to assume that between 70% and 90% of the bears resident in this area will be eliminated. The percentage of loss will probably be lower as one approaches the Watana dam from the east.

- Dall Sheep

Of the three sheep herds identified in the upper Susitna basin during these studies (Portage-Tsusena Creek, Watana-Grebe Mountain, and Watana Hills), only the Watana Hills herd will be impacted by the Watana impoundment. This herd occupies the mountainous region north of the Susitna River and east of Watana Creek. The 1980 count of the Watana Hills herd indicated that 209 sheep were present. The Watana impoundment will inundate a portion of the Jay Creek mineral lick and none of the rest of the area used by the herd.

As described in Section 3.2(a)(viii), this mineral lick is located on cliffs along Jay Creek very close to its confluence with the Susitna River. Preliminary observations indicate that sheep use much of the cliff area, from the river bottom up to and beyond the upper rim. Sheep use appears to be concentrated during the months of May and June. Observations of numerous sheep using the lick at the same time and experience with mineral licks in other parts of Alaska indicate that it is likely that a large proportion of the Watana Hills herd visits the lick during spring.

It is difficult to determine to what extent this herd will be negatively impacted, if at all, by the loss of a portion of the lick. There are several other known licks within the range of this herd, but there is insufficient data available to ascertain the relative importance of each lick to the herd. Also, it is not known if sheep will continue to use the Jay Creek lick following flooding. Although a portion of the lick will be flooded, as a result of the proposed drawdown schedule, the greatest proportion of the lick will be exposed during May and June when sheep use it. It is not known whether or not sheep will continue to use any part of the lick once the project is operating. It is even more difficult to predict if sheep will use that portion of the lick that will be exposed during May and June and under water during the rest of the year.

Because of the high degree of use that the sheep make of it and their willingness to expose themselves to possible wolf predation in order to reach the lick, it should be assumed that the Jay Creek mineral lick is of major significance to the Watana Hills herd. The impact on the herd if flooding renders the lick unacceptable is a matter for speculation. If inadequate alternative mineral sources are available at other licks within the range of these sheep, the possible loss of the Jay Creek lick may result in a reduced ability of the area to support sheep.

In summary, the Jay Creek mineral lick will be affected by the Watana impoundment. The degree to which sheep will use the remaining portions of the lick following inundation and the significance of the lick to the Watana Hills sheep herd are unknown. The total loss or abandonment of the lick, however, could have a possible negative impact on the Watana Hills sheep herd and lower the carrying capacity of that area for sheep.

(ii) Furbearers

The flooding of the Watana reservoir will eliminate 15,320 ha of furbearer habitat, the majority of which is terrestrial habitat. Because of the annual fluctuations of water levels, the draw-down zone and the aquatic habitat created will be of limited value to otters, mink, muskrats, and beavers.

As a result of their great dependence upon forested habitats along the Susitna River and its tributaries, the species most severely affected by the inundation of terrestrial habitat will be pine marten. During summer and autumn, foxes utilize riparian zones along the Susitna River and its tributaries. Flooding of these areas may, therefore, reduce the carrying capacity of the region for foxes. None of the fox dens found during these studies will be flooded. Due to the nature of fox den sites it is likely that only a few, if any, undiscovered dens will be flooded.

At the present time, lynx appear to be restricted to habitats along the lower reaches of some tributaries and adjacent to the Susitna River between Vee Canyon and the Tyone River. Flooding of these sites may, therefore, totally eliminate lynx from the immediate vicinity of the Watana impoundment. Because lynx are dependent on snowshoe hares for food and since hares appear to be restricted currently to areas within the upper reaches of the Watana impoundment, the future of lynx in the area will depend on the status of hares in areas adjacent to the impoundment. Some form of habitat alteration, either through natural or artificial means, will have to occur if hares, and thus lynx, are to become abundant in the project area.

Development and maintenance of the construction camps and village associated with the Watana impoundment will displace a limited number of furbearers. The presence of the camps will probably result in the abandonment of a fox den located west of Deadman Creek. Although this den was not used for rearing pups during the study, indications were noted of past natal use and winter resting use. Foxes may experience additional negative consequences if domestic dogs, with the potential for introducing rabies into the fox population, are housed at the village or camp.

Foxes will also be negatively affected if project personnel, by storing garbage or disposing it in a manner that leaves food available, deliberately or unwittingly provide food for them. Such a practice may leave the animals dependent upon this food source and may also result in artificially high fox populations.

Humans may also experience negative effects of their proximity to traditional wildlife habitats. Property could be damaged and workers exposed to bites and to wildlife-transmitted diseases if foxes, marten, or weasels are attracted to the camps by workers who feed them directly or who establish feeding stations.

In summary, the Watana impoundment and its associated facilities will result in a loss of furbearer habitat. Pine marten will be most severely impacted by these facilities with foxes being impacted to a lesser degree. The result will be the direct loss, through mortality, of those animals that will be displaced, and a subsequent reduction in the carrying capacity of the area for furbearers.

(iii) Birds and Non-game Mammals

- Dam and Impoundment

The general types of impact on raptors that can result from development activities have been well described by Roseneau et al. (1981), and Tables 3.62 and 3.63, which summarize disturbance factors, are taken from their report. Inundation is an additional potential impact from hydroelectric projects. The Watana impoundment will flood 15.1 km of the better quality raptor cliffs (type "A"), leaving only 0.9 km of Type "A" cliff not inundated (Table 3.64). Four active and four inactive golden eagle nest sites, two active and one inactive bald eagle sites, and two inactive raven sites will be destroyed by inundation (Table 3.65). Loss of this nesting habitat will force these birds to other sites, either along the remaining cliffs of the Susitna River and its tributaries, in the nearby cliff/tor habitat (cliffs and high, craggy hills) of the uplands, or in the case of bald eagles, to other nest trees. Unflooded cliff habitat in the surrounding area (for example, along Fog and Tsusena creeks) may increase in importance to these birds. If fish became available in the impoundment, large trees surrounding the impoundment might be used for nesting by bald eagles.

The impoundment will inundate 70 km^2 of forest habitat, which generally includes the most productive avian habitats of the study area (Table 3.36). A number of bird species are restricted to forest habitats for breeding (see Table 3.37). Most of these species are short-lived (except goshawks and great horned owls), and healthy populations occur in adjacent regions. Red squirrels and porcupines are also forest species and also occur commonly in adjacent regions.

Flooding of the fluviatile shorelines and alluvia, both in the main Susitna River and up the mouths of tributary creeks, will destroy breeding habitat of a few bird species (harlequin duck, common merganser, semipalmated plover, spotted sandpiper, wandering tattler, Arctic tern, dipper), some of which are considered uncommon, but none rare, in the region. Impact on wintering habitat of the dipper (open water along fast-running tributaries and in the Susitna River channel) may be the most serious impact in this category because local alternative sites of open water might not be available. Flooding will also deprive early migrant waterfowl of one of the first sources of open water in the region--the rapidly flowing waters of the Susitna River. It is expected, however, that the project will result in open water year round below Devil Canyon, at least as far as Talkeetna [see Section 3.6(d)(vi)].

The large impoundment that will be formed may provide habitat for waterbirds, but the degree of utilization will depend upon the rate and kind of development of food resources in the new lake. Because of the late spring thaw, the lake will be available only for the late-migrating diving ducks, loons, and grebes; in fall, however, it may remain open long enough to be used by late-migrating swans. As with the other large lakes of the region, a low level of use by breeding waterfowl can be anticipated (provided food resources are available). The anticipated draw-down zone will impede use of the reservoir edge by nesting loons and grebes, which usually nest at the edge of sedge shorelines or on small low-lying islands. Migrant shorebirds, who primarily move through central Alaska during the last three weeks of May, will probably use exposed areas of the drawdown zone for resting and feeding. This zone will be of little use to small mammals.

- Camp/Village Sites

The impacts of camp/village sites will be of two main types: 1) habitat destruction and alteration and 2) disturbance to animals themselves, by various types of human activities during and after construction. The latter impact applies more to birds than to small mammals. The amount and types of habitat that will be directly damaged appear inconsequential to the bird and small mammal populations of the area, primarily because these upland habitats are widespread in the region. Ground squirrels can be expected to increase and become tame, especially if fed by workers, and would probably become pests about the camp and village sites. Some birds, too, such as ravens, magpies, and mew gulls, will be attracted to any open refuse dumps. The present plan, however, is to cover the landfill with soil daily to prevent this and other problems associated with birds and mammals using dumps as food sources. If this plan is carried out, the problem will diminish.

Perhaps more important, there could be significant effects on sensitive bird species and habitats in nearby areas, primarily on raptors and waterbirds that use wetlands. Increased air traffic over the Fog Lakes wetlands as a result of activities about the dam site or over the Stephan Lake area as a result of trips between Watana and Devil Canyon camps/villages/dam sites could adversely affect the waterfowl populations. Although some species may, to a certain degree, acclimate to such disturbance, the net result will be a reduction in the suitability of these areas for raptors and waterfowl.

A few waterbirds use the small, scattered ponds between Deadman and Tsusena creeks, but because their numbers are small, potential losses through human influence will be minor compared to their overall population levels in the region.

The Watana camp site is in the general vicinity of raptor/raven cliff habitat along lower Deadman Creek. An active raven nest and territorial merlins were observed here in 1981. The habitat in this location will be flooded by the impoundment, however, so the major impact here will be the habitat's proximity to the reservoir and not to the camp. Depending on its exact location, the village site could be within 1.5 km of a bald eagle nest that was active in both 1980 and 1981, or within 2 km of two raven nest sites, one active and one inactive, along Tsusena Creek.

(b) Devil Canyon Dam and Impoundment

(i) Big Game

A total of 8,736 ha of habitat will be lost as a result of the construction of the Devil Canyon facility. This total includes the impoundment, dam, spillway, and camp and also the construction zone around the dam site. Impacts of borrow areas associated with the construction of the Devil Canyon dam are addressed in Section 3.6 (c). Of this total, 3,196 ha will be permanently lost through flooding, and the remaining 5,540 ha lost as a result of other facility components. Some of the 5,540 ha will be reclaimed following use, and will probably, to some degree, serve as habitat for big game in the future.

- Moose

The Devil Canyon impoundment and associated project facilities will impact moose in the same manner as described for the proposed Watana impoundment [see Section 3.6(a)(i)]. Because fewer moose were found in the vicinity of the Devil Canyon impoundment, the impacts of the facility should be less than those predicted for Watana.

The primary reason for the difference in moose abundance (depicted on Figure 3.12) is that moose in the Devil Canyon area are more sedentary than those in the Watana area, especially the easternmost portion of the Watana impoundment. Moose were tallied during March 1980 in areas that abutted the Watana and Devil Canyon impoundments. Of the total 636 moose counted, only 106 were in the vicinity of the Devil Canyon impoundment, and only two were actually in the impoundment zone. During an intensive survey of the impoundment zones during March 1981, 30 moose were estimated to be present in the proposed Devil Canyon impoundment zone. The difference between the two years is probably a result of the level of intensity employed in the survey effort. Thirty is probably a more typical number of moose than two. Yet, it is likely, because of the mild winter conditions that prevailed during these surveys, that this reported extent of use of the impoundment zone does not represent the situation as it would exist during more harsh winter conditions, when more moose would be expected near the river.

Another difference between the two impoundments is the difference in their expected impacts on microclimatic conditions. The same type of changes described for Watana will probably occur around the Devil Canyon impoundment, but, because of the smaller size and narrower configuration of the Devil Canyon impoundment, the degree to which microclimatic conditions will change and affect vegetation will probably be less than at Watana. Although there will be less of an exposed drawdown zone in Devil Canyon and thus the open water will be close to shoreline vegetation, the distances that air will move over open water will be less than in many portions of the Watana impoundment, and so the net impact will be less. The same principle holds true for blowing and drifting snow during winter. Blowing snow will be deposited over land areas on the downwind side of the impoundment, but because of the size and orientation of the impoundment, the impact of such snow drifts will probably be more localized and less severe than at Watana.

In summary, moose will be impacted through habitat loss, and the number of moose present in the Devil Canyon impoundment zone and adjacent areas will be reduced. The mechanisms described for impacting moose in the Watana impoundment area also will function to impact moose in the vicinity of the Devil Canyon impoundment. The total loss of moose will be less than at Watana as fewer moose are present, less habitat will be lost, and there will be reduced impacts from changes in microclimatic conditions. Based on the moose census and distribution data, approximately 100 moose may be severely impacted as a result of direct displacement or the loss of major portions of their home ranges. An additional 200 moose could be moderately impacted as the result of an overall reduction in the carrying capacity of the region. This is a very rough estimate, and the actual number of moose impacted could differ by as much as 50% (50 to 150 severely impacted and 100 to 300 moderately impacted).

- Caribou

The construction of the Devil Canyon dam and impoundment will have an insignificant impact on the Nelchina caribou herd. The terrain to be flooded contains low quality caribou habitat. The scarcity of caribou trails crossing the valley in this area indicates little caribou traffic. The Chunilna Hills subherd, which occupies the plateau south of the Susitna River, consists of fewer than 350 animals. This subherd is relatively sedentary.

- Wolf

The same mechanisms that will function to impact wolves in the vicinity of the Watana impoundment [see Section 3.6(a)(i)] will also serve to impact wolves residing near the Devil Canyon impoundment. In general, the predicted reduction in the number of moose inhabiting the area will result in the presence of fewer wolves. Three or four resident wolf packs are suspected to inhabit the area adjacent to or just west of the Devil Canyon dam and impoundment (see Figure 3.16) and could be impacted by a reduction in the number of moose available in that general area. As discussed for the Watana impoundment, impacts on moose will represent a short-term benefit, but a long-term detriment, to the wolves in the area.

Despite the similarity of impacts on wolves in the two impoundment zones, there is one major difference which could increase the relative magnitude of the predicted impacts on wolf packs in the Devil Canyon area. Wolves in the vicinity of the Watana impoundment frequently have access to caribou as alternative prey. Because of the migration patterns of the Nelchina herd, there is and has historically been comparatively little use of the area west of Devil Creek by Nelchina caribou. Therefore, the wolf packs that will be affected by the Devil Canyon facility are probably totally dependent on moose for their winter food supply, and a reduction in the number of moose available to these packs may represent a more severe impact than that suffered by wolves residing east of the Watana dam site.

- Wolverine

Because of the lack of accurate census data on wolverines, it is impossible to predict exactly how many wolverines will be negatively impacted by the Devil Canyon impoundment. As described in the discussion of the Watana impoundment [Section 3.6(a)(i)], wolverines will be impacted by habitat loss, a reduction in the availability of wolf-killed moose, and disturbance by human activity. Since wolverines are typically a low density species even under ideal habitat conditions, the number of wolverines that will be impacted by the Devil Canyon facility will be low.

Following the clearing of the Watana impoundment, it is expected that there will be relatively little human activity in the upper reaches of the impoundment; this situation might allow for wolverines to use the area again sometime in the future. The disturbance of wolverines around the proposed Devil Canyon impoundment will be more permanent. The presence of an access road and transmission lines between the two dam sites as well as a center of human activity at each dam site may preclude the existence of any resident wolverines on the north side of the Devil Canyon impoundment. If there is no additional development, the land area south of the Devil Canyon impoundment could be utilized by wolverines following the clearing and filling operations.

- Brown Bear

Because there is less open country adjacent to the Devil Canyon impoundment than to the Watana impoundment, there are fewer brown bears in the vicinity. As can be seen on Table 3.60, only five of the radio-collared brown bears had home ranges that overlapped the Devil Canyon impoundment zone, and in all cases the percentage of overlap was relatively small. Therefore, although the Devil Canyon impoundment will be detrimental to brown bears in the same fashion as will the Watana impoundment [see Section 3.6(a)(i)] there will be fewer brown bears impacted by the Devil Canyon facility.

The severity of the predicted impacts will be less because of differences in the proportion of spring foraging habitat lost. In the Watana impoundment, a large proportion of the south-facing slopes will be lost. Because of differences in pool level and associated topography, a far greater proportion of spring foraging areas will be left in the Devil Canyon impoundment area than at Watana.

The Devil Canyon impoundment also will be a potential barrier to the movement of brown bears to Prairie Creek to feed on salmon. Although the Devil Canyon impoundment will be narrower than that at Watana and, therefore, brown bears might find crossing the impoundment less of an obstacle, it will be more difficult for brown bears in this area to move around it because of other project components that will be present at each end. It is possible, however, that the placid reservoir will be more easily crossed than the flowing waters of the river.

- Black Bear

The proposed Devil Canyon impoundment will have less severe impacts on local black bear populations than will the Watana impoundment [see Section 3.6(a)(i)], but impacts will be marked regardless. Table 3.61 presents the percentage of overlap between the Devil Canyon impoundment and the home ranges of radio-collared black bears.

The average elevation of black bear dens in the vicinity of the Devil Canyon impoundment was 664 m (2,178 ft) with a range of 454 m (1,490 ft) to 1,323 m (4,340 ft). Of 16 black bear dens found in the vicinity of the Devil Canyon impoundment, only one would be flooded by a maximum pool elevation of 444 m (1,455 ft). There will also be a large area of suitable foraging habitat left adjacent to the impoundment. There will be a reduction in the number of black bears in the area, but, unlike the impact at the Watana impoundment (where the vast majority of the suitable black bear habitat in that portion of the upper basin will be lost), the relative magnitude of the impact of the loss of habitat at Devil Canyon will be reduced by the proximity of large areas of suitable habitat.

- Dall Sheep

None of the three sheep herds identified in the upper Susitna basin during these studies (Portage-Tsusena Creek, Watana-Grebe Mountain, and Watana Hills) will be affected by the proposed Devil Canyon impoundment. The herd closest to the impoundment is the Portage-Tsusena Creek herd; a total of 72 sheep were counted in this herd during July 1980. This herd occupies the mountainous area northwest of the Devil Canyon impoundment and should not be affected in any manner by the impoundment.

(ii) Furbearers

The proposed Devil Canyon impoundment will eliminate approximately 2,834 ha of furbearer habitat, the majority of which would be terrestrial habitat. The greatest impact of this flooding would be on pine marten and, to a lesser degree, red foxes. None of the fox dens found during this study would be flooded by the Devil Canyon impoundment. Due to the nature of fox den sites, it is likely that only a few, if any, undiscovered dens would be flooded. The elimination of some riverine aquatic habitat would also result in a reduction of the number of mink and river otters that the area can support. Since beavers and muskrats utilize the area within the Devil Canyon impoundment zone very little at this time, there will be relatively less impact on these species.

Because of the drawdown schedule, the aquatic habitat created by this reservoir will be of limited value to otters, mink, beavers, and muskrats. For example, Murray (1961) indicated that the annual rise and fall from the normal water level should be no more than 0.6 m for beavers to utilize an area. The unvegetated drawdown zone will also reduce the suitability of the newly created aquatic habitat for species such as mink and otters.

The construction camp and village associated with the Devil Canyon impoundment will displace a limited number of furbearers. At Devil Canyon, problems are expected to be similar to but not as serious as those in the Watana impoundment zone because furbearer numbers are generally lower near Devil Canyon.

(iii) Birds and Non-game Mammals

- Impoundment

The Devil Canyon impoundment will involve many of the same consequences to birds and non-game mammals as the Watana impoundment will create. Inundation, which will flood 27.4 km of type "A" raptor cliffs and leave 24.9 km not inundated (Table 3.64), will destroy one active and two inactive golden eagle nest sites and two raven sites, one active and one inactive (Table 3.65).

For some reason, in spite of the presence of cliffs with good structural characteristics, Devil Canyon itself is little used for raptor nesting. Possibly, the deep, narrow canyon with its often strong and buffeting winds makes this area undesirable for raptors. With the filling of the deeper, narrow portions of the canyon upstream of the Devil Canyon dam, the environmental conditions along the remaining type "A" cliffs may conceivably be altered enough to attract nesting raptors and ravens. That is, the remaining canyon will be wider and shallower and perhaps have less violent winds and, thus, be more hospitable to nesting birds.

Finally, cliffs along Portage and Devil creeks and others draining into the south side of the proposed Devil Canyon impoundment may become more important to birds displaced by inundation. Moreover, if the reservoir supports fish, then bald eagles may nest in large trees around the impoundment.

In addition to cliff habitat, the Devil Canyon impoundment will destroy 25 km^2 of forest habitat, which a number of bird species as well as red squirrels and porcupines rely on for breeding sites (see Tables 3.36 and 3.37).

Flooding associated with Devil Canyon will destroy the breeding habitats of the same few unusual bird species as those affected by the Watana inundation. Likewise, early migrant waterfowl may lose sections of the Susitna River that represent some of the region's first sources of open water. This loss of early open water may be compensated for by the availability of open water throughout the winter and spring below the proposed Devil Canyon dam at least as far downstream as Talkeetna.

Like Watana, the Devil Canyon reservoir may offer habitat in the spring to some late-migrating diving ducks, loons, and grebes and, in fall, to late-migrating swans. In addition, if food is available, it may also be used to a limited extent by breeding waterfowl. On the other hand, the changed shoreline at the Devil Canyon site probably will not create the level of impact that Watana will exert. The steep slope of the shoreline will limit waterbird nesting habitat around the impoundment. Moreover, the steeper and smaller drawdown area will be less attractive to migrant shorebirds than the Watana drawdown zone will be.

- Dam Site

Cheechako Creek, the tributary canyon 1.0 km southeast of Devil Canyon dam site and south-southeast of Borrow Area G, contains raptor cliff habitat. A gyrfalcon nested here in 1974 (White 1974), and in 1981 a goshawk nested in birch woods on the east bank. The dam project itself may avoid damage to this tributary above the impoundment level. Depending upon the proximity and degree of human activity associated with a proposed recreation facility, raptors that may be driven away by construction activities may return to nest on the cliffs after construction activities subside.

- Camp/Village Sites

The impact of the Devil Canyon camp/village sites will generally be the same as those at the Watana sites, that is, habitat destruction and alteration compounded by disruption from human activities during and after construction. Habitat loss will consist of 75 ha of closed conifer-deciduous forest.

An active golden eagle nest site along the north side of the Susitna River, below the dam site, is 1.5 km from the camp site and 1.6 km from the village site. In 1974, a gyrfalcon nested (White 1974) in the canyon (Cheechako Creek) 2.2 km east of the village site. This nest site was active in 1980 (species unknown) and was inactive in 1981.

No wetlands significant to waterfowl occur in this area, but air traffic between Devil Canyon and Watana camp/village/dam sites could adversely impact the relatively important Stephan Lake wetlands. Although some duck species may acclimate to the air traffic, it is unlikely that swans will successfully make the adjustment.

(c) Borrow Areas

(i) Big Game

The major impact that the borrow areas for dam construction will have on big game species is the loss of habitat: a total of 1,751 ha will be disturbed (excluding those borrow areas that will eventually be inundated) and thus lost as habitat. The specific plant community types and corresponding quantities affected can be found on Tables 3.56 and 3.57. The cover types that comprise most of the area to be disturbed are woodland spruce (black and white), mixed low shrub, birch shrub, and closed mixed forest. To some extent, the habitat loss will be temporary. With reclamation efforts, many of the borrow areas will be restored to a level that will permit some use by big game.

This loss of habitat will affect big game species to various degrees. Moose and black bears will incur the greatest impact. All of the land area encompassed by the proposed borrow sites is used by moose; the greatest use probably occurs in borrow areas D, E, F, and H (see Figures 3.11 and 3.12). Since most of the moose in the vicinity of the Watana dam site are relatively sedentary, the borrow areas there will probably result in the loss of such a large portion of the annual home range of these moose that they will be displaced. Displaced moose will incur high mortality and for a short time period could compete for food with moose in adjacent areas. The net impact will be fewer moose in the area of the borrow sites and, as a result of overcrowding, a possible long-term reduction in the carrying capacity of adjacent areas.

Black bears in the borrow areas will be impacted in several ways, all of which are similar to those described in Sections 3.6(a)(i) and 3.6(b)(i). With the exception of 70 ha of mat and cushion tundra in Borrow Area A, the area to be lost is all suitable black bear habitat. All of the forested portion is good habitat during winter (when bears den), spring, and summer. The shrub types (mixed low and birch) serve as early fall foraging areas for black bears when berries are available. The greatest loss of forest types will be in Borrow Areas A, E, H, I, and K. Fall habitat areas (shrub) that will be lost are found primarily in borrow areas D and F and, to a lesser extent, in Borrow Area A.

Most of the borrow sites will be located at elevations within the acceptable range of denning elevations for black bears in the area (457 m - 762 m). Due to relatively flat topography, Borrow Areas A and D are probably not good denning areas, and thus their loss will represent only a loss of foraging sites. Borrow Area F is probably too far north of the forested zone along the river to be used for denning by black bears. The greatest potential for the loss of denning sites as a result of borrow activities is in Borrow Areas E, H, I, and K. Borrow Area E, located along the lower reaches of Tsusena Creek, is probably good denning habitat; because of its proximity to the Watana construction area, however, it is likely that this area and any denning potential it offers, will be disturbed in many ways other than through borrow activities. Borrow Area I will be almost entirely within the Devil Canyon impoundment with the exception of 34 ha. This 34 ha, however is composed of closed mixed forest and open black spruce situated along the slopes adjacent to the Devil Canyon impoundment zone and is therefore probably good denning habitat. Borrow Areas H and K are also situated in suitable bear denning areas; both of these borrow areas are south of the Susitna River, however, and, since the data collected on black bears suggests that there is less black bear activity south of the river than north of the river, the loss of denning sites from Borrow Areas H and K many not be too extensive.

Brown bears, wolverines, and wolves will also be impacted by the borrow areas, but probably to a lesser degree than moose and black bears. The primary impact on these species will be a reduction in numbers of prey. This impact will primarily affect wolves, and to a lesser degree, brown bears and wolverines. Brown bears will also lose some spring foraging habitat. A more detailed discussion of these two types of impact was presented in Section 3.6(a)(i). In addition to habitat loss, wolves, wolverines, and brown bears will be impacted through disturbance by the human activity associated with the borrow activities. Blasting and the movement of large vehicles in these areas will most likely cause these species to totally avoid the areas while they are being used.

Caribou will also be impacted by the borrow areas but not to the degree described for other big game species. There is relatively little caribou use of the areas identified for borrow sites. Most of the use that does occur is attributable to summer use by bulls. It is unlikely that the cow/calf segment of the Nelchina herd will come close to the borrow areas during annual movements. As a result, the borrow areas will represent primarily a loss of summer bull habitat. Since bull caribou appear to be less sensitive than other portions of the herd to human activity and disturbance, they may continue to use adjacent areas. Considering the intensity and magnitude of disturbance that will be associated with the borrow areas, however, they will probably avoid the immediate vicinity of each borrow area (possibly by more than 2 kilometers). Borrow Areas A, D, and F are the areas most likely to result in this limited loss of caribou habitat.

Due to the location of the borrow areas, there should be no impact on Dall sheep. The closest known sheep usage is on Mt. Watana, which is approximately 10 to 16 km east of proposed Borrow Area A. The herd that used Mt. Watana (Watana-Grebe Mountain herd) was not noted in the vicinity of Mt. Watana during the 1980 survey. They were located in the southern extreme of the survey area, well away from the proposed Watana impoundment area.

Although the borrow areas may affect big game in other ways (such as through the creation of dust which could reduce the productivity of vegetation in adjacent downwind areas), the prime impacts will be habitat loss and disturbance by human activity. The habitat loss is likely to affect moose and black bears more than other big game species. Disturbance, on the other hand, will probably be more significant for wolves, brown bears, and wolverines.

(ii) Furbearers

Excavation of borrow sites would have negative effects upon furbearers using the area. Borrow Areas A,D,E,H, and K (Figure 9.7) would primarily impact pine marten, red fox, and short-tailed weasels. Because of the relatively large area of land involved, developing Borrow Areas E and F, along Tsusena Creek, would negatively affect red foxes, pine marten, mink, otters, and short-tailed weasels throughout a sizable portion of the drainage of that creek.

If left unvegetated following excavation, the borrow areas would have little long-term value to furbearers. The extent of vegetation restoration measures would determine the future suitability of restored habitats for various furbearer species. The creation of herbaceous and shrub vegetation may be attractive to small mammals and birds and could provide valuable foraging habitat for foxes, short-tailed weasels, least weasels, and coyotes, especially if vegetative heterogeneity is established. Because of the dependence of pine marten on conifer forests and, specifically, on red squirrel middens, it is highly unlikely that marten would use revegetated borrow areas in less than 100 years.

(iii) Birds and Non-game Mammals

Mining of borrow areas will cause two main types of impact: 1) habitat destruction and alteration and 2) direct disturbances resulting from human activities. The amount and types of habitat to be affected by possible borrow areas appear insignificant to the total bird and small mammal populations of the area, primarily because these habitats are widespread in the region. Some borrow areas will eventually be flooded, anyway, and the others will be recontoured and revegetated.

The specific effects of borrow mining will vary somewhat at each site, depending on the types of habitats destroyed and the types remaining after construction and reclamation activities. While birds and small mammals dependent on the destroyed or altered habitats will disappear, those species favoring the newly created habitats will increase their populations. Replacement shrub and forest habitats will be slow in forming because of the harsh environment.

Overall, the impact of borrow areas will be greater on forest habitats than on shrub habitats, partly because forest areas are considerably less abundant in the region. In addition, a high proportion of these already less extensive forest habitats will be inundated by the proposed reservoirs. Thus, the additional loss of forest habitats to borrow areas will have more impact on the avifauna than will the destruction of relatively prevalent shrub habitats.

The activity and noise surrounding the mining operations might disturb breeding raptors and ravens at nearby cliffs. Table 3.66 is a list of the nest sites within about 1.6 km of the proposed borrow areas and thus those potentially subject to disturbance. Any nest sites not in use by 1 June in any year may be considered inactive in that year (Roseaneau et al. 1981) and not subject to the impact of construction noises and the movement of equipment.

(d) Downstream Impacts

(i) Moose

Moose that use the Susitna River area downstream of Devil Canyon may be impacted by the project. The manner in which moose could be impacted relates to changes in the quantity of browse available for winter forage. As discussed in Section 3.2(a)(i), moose congregate along the Susitna River during severe winters and subsist on browse that is associated with the early successional vegetation in the riparian zone. As a result, the riparian zone of the Susitna River downstream of Devil Canyon is a critical factor in maintaining a healthy moose population over a very large area.

The browse species upon which moose rely are typically found growing abundantly on newly disturbed islands or sand bars: such islands are constantly being created and removed by the action of the river. The mechanism of creating new sites suitable for the invasion of browse species which serve the winter food needs of moose is complicated and includes a variety of factors such as flooding, ice scouring, and silt deposition. Since the creation of such sites is dependent to a large extent upon the flow regime of the river including the timing and duration of floods, the volume of ice moving in the river, and the silt load of the water, the flow regulation and changes in other aspects of the river that will result from the Susitna project may possibly alter these mechanisms. [Details of the plant succession process that is operative in this area are presented in Section 3.1(b), and information concerning the availability and utilization of browse along the lower river appears in Section 3.2(a)(i)].

The possible degree of alteration of the present flow regime varies substantially between that portion of the river upstream of Talkeetna and that portion downstream from Talkeetna. Since tributaries between Devil Canyon and Talkeetna contribute relatively little flow, the project will result in major changes in the hydrologic characteristics of this part of the river. The situation downstream from Talkeetna is considerably different. At Talkeetna, water is added to the Susitna from both the Chulitna and Talkeetna rivers. In addition, downstream from Talkeetna numerous tributaries and eventually the Yentna River continue to add water to the Susitna. In other words, at and below Talkeetna the changes in the hydrologic characteristics of the river as a result of the project will be considerably less. Since there is such a marked difference between these two reaches of the river, the discussion of impacts on moose is most appropriately presented in two sections.

- Devil Canyon to Talkeetna

In this reach of the river, it is anticipated that the project will have very little negative impact on moose. The moose that use this area appear to be relatively sedentary, and, therefore, any impact will be confined to those moose that are resident in the area immediately adjacent to the river. In the absence of census data, it is impossible to present the number of moose that are associated with this area.

A detailed description of the vegetation changes that may occur along this part of the Susitna River is presented in Section 3.5 (d). Between Devil Canyon and Talkeetna, the Susitna River is well channelized with comparatively few islands and sand bars. Therefore, the quantity of available browse is probably less than what can be found along the more braided reaches of the river south of Talkeetna.

Since it is predicted that seasonal floods will be totally eliminated in this area some of the currently unvegetated areas along the river will begin to develop some early successional vegetation. Due to the very rocky substrate in the river bottom, however, it is unlikely that any significant increase in vegetative development will take place.

In general, there will be a trend for the development of more mature vegetation on some of the islands. This process will occur because the project will result in less ice formation along this part of the river. Flowing ice is a very powerful force in the disturbance of streamside vegetation.

This trend towards more mature vegetation could be offset, however, by an increase in the frequency and duration of ice fog along the river. In the absence of ice cover during the winter, the difference in temperature between the water and the air will generate ice fog which will in turn accumulate on streamside vegetation. Although the ice fog is not expected to be very damaging, it will probably result in broken branches on tall shrubs and trees. An increase in young balsam poplar, willow, and alder would result. Two of these species, balsam poplar and willow, are important browse species, and, therefore, moose would probably benefit from this aspect of the project.

In summary, there should be little negative impact on moose residing along that portion of the Susitna River between Talkeetna and Devil Canyon. Although changes in the flow regime of the river will be greatest in this area, there should be little reduction in the amount of available moose browse along the river. An increase in the duration and frequency of ice fog may serve to increase the quantity of browse available along the river, thus either negating any minor loss or possibly even resulting in more available browse than currently exists.

- Talkeetna to Cook Inlet

That portion of the Susitna downstream from Talkeetna differs from the upstream portion (Talkeetna to Devil Canyon) in many respects, three of which are important for moose. First, as one proceeds downstream from Talkeetna, the river becomes progressively wider and more braided with a corresponding increase in the number of islands. These islands are less stable than those above Talkeetna; a considerable amount of land is washed away each year, and new bars and islands are created. Second, the extent of moose use is greater south of Talkeetna. The winter forage along the lower Susitna is utilized by moose from a large geographic range extending to the Talkeetna Mountains to the east and across the extensive flat marshy area lying to the west of the river. The third major difference is the fact that the changes brought about by the Susitna project will be considerably less south of than north of Talkeetna. This is because, as previously mentioned, water from several other major sources is added to the Susitna at and below Talkeetna and will reduce the project's effects there. Thus, any changes in available moose browse are not expected to be major.

If the Susitna project does cause some slowing of the rate at which islands are developed and removed, the moose population that uses the area will be subject to two successive changes. First, there will be a short-term increase in the amount of browse as a result of the increased stability of the substrate which will allow early succession vegetation to move down onto the sites that are presently eroded by high summer flows. This increase in early successional vegetation and associated moose browse is likely to prevail for 10 to 20 years. High rates of use would retard the rate of succession and prolong the situation. Ultimately, however plant succession will proceed to the point where plants no longer serve as suitable browse, and the ability of the area to support moose under severe winter conditions will be reduced. A general although unknown decrease in the moose population would therefore follow. The timing of such a reduction will probably be determined by the occurrence of harsh winter conditions.

A more indirect impact on the moose population in this area is related to the status of the beaver population. Beavers are a factor in determining the composition of vegetation in the areas they inhabit. Should the beaver population along the lower river be negatively impacted by the project there could be a corresponding negative impact on moose. It is possible, however, that increased winter flows may in fact allow for greater beaver abundance downstream of Talkeetna. Should this occur, the increase in beavers in the long run might assist in negating any negative impacts on the moose population. The impacts on beaver are discussed in Section 3.6(d)(iii).

In summary, the changes in hydrologic parameters brought about by the project downstream from Talkeetna may be sufficiently diluted to have little if any impact on moose. Should a change result, however, it is expected to be minor in magnitude and to result first in a short-term increase in the amount of browse available to moose and then in a long-term decrease in browse. Any impact on the beaver population could also have an impact on moose: a positive impact on beavers would have corresponding positive impact on moose; a negative impact on beavers would have negative consequences for moose.

(ii) Bears

Both black and brown bears have been reported to utilize the Susitna River downstream from Devil Canyon for fishing. The majority of the bears noted feeding on salmon in this reach of the river were black bears, and the feeding activity was concentrated during August and early September coinciding with salmon spawning. Since changes in the flow regime of the river are expected to drastically reduce salmon spawning in the side channels and sloughs of the river between Talkeetna and Devil Canyon, the opportunity for bears to feed on salmon in these areas will be correspondingly reduced, unless mitigative actions for the fish habitat are undertaken [see Section 3.9(d)]. The loss of this salmon resource will likely affect bears in two different areas.

The primary impact will be on bears that reside in relatively close proximity to the river. The food supply represented by salmon spawning in tributaries is not expected to be directly affected by project flows, so competition among bears for this resource will likely increase. The overall result will likely be a general reduction in the number of bears inhabiting the area, especially in the number of black bears, which are more likely to be permanent residents in the locally available forested habitats.

Bear populations in more distant regions will also be impacted. It appears that in addition to the resident bears which feed on salmon, some bears travel long distances to take advantage of this resource. During 1981, when a total failure of the berry crop in the upper basin was noted, two radio-collared black bears moved from the vicinity of the Devil Canyon impoundment downstream to Gold Creek. Based on the numerous bears noted along the river during 1981, it is thought that bears probably traveled to the river from many areas to take advantage of this alternative food source. Therefore, the loss of this food source would impact bear populations, both black and brown, over a very large area.

Salmon probably represent the most dependable source of pre-denning food. Therefore, during years when other pre-denning food items are not available, the lack of an abundant salmon resource could result in many bears entering dens later than normal and probably in less than optimal condition. Under such conditions, populations could decline as a result of starvation during the winter and higher cub losses due to lactation failure.

The overall impact of the loss of salmon habitat downstream from Devil Canyon will be a long-term reduction in the number of bears that inhabit the region, especially north, east, and west of that portion of the Susitna River between Talkeetna and Devil Canyon.

(iii) Aquatic Furbearers

Projected changes in the flow of the Susitna River downstream from the Devil Canyon dam could result in marked changes in aquatic furbearer habitat. The nature and the degree of change will vary for various portions of the river below Devil Canyon. The greatest change in flow regime will occur between Devil Canyon and Talkeetna. At present, this area is relatively poor habitat for beavers (Table 3.28), and, therefore, any negative impact on beavers will be relatively minor. Since the likelihood of a reduction in fish populations is greatest in this area, however, there could be a corresponding negative impact on river otters and mink. Changes in water turbidity are also likely in this portion of the river but should not affect either aquatic (beaver and muskrat) or semiaquatic (river otter and mink) furbearers since they are not known to select habitats on the basis of water turbidity.

The situation between Talkeetna and Cook Inlet is different in two respects from that in the stretch between Talkeetna and Devil Canyon. First, as one progresses farther downstream from Talkeetna, the suitability of the river for use by beavers increases (Table 3.28). On the other hand, the changes in flow regimes caused by the project become continually diluted and, thus, less likely to result in an impact on beavers. It is difficult to determine the extent or even the direction of any impact associated with these changes. If a change in subclimax, riparian vegetation results, it could mean a reduced food supply for beavers; however, since beavers are themselves a force in creating such subclimax vegetation, this situation may not negatively affect current beaver populations.

Reduced summer flows could also cause a decrease in the areas usable for beavers at that time of the year, either directly or by allowing for a long-term reduction in the number of available sloughs. The latter are highly useful areas for beavers. Increased winter flow, however, may provide greater opportunities for overwintering beavers. Since it is unknown whether summer or winter habitat components are prime factors in controlling the density of beavers in this area, it is difficult to predict exactly what changes will result. At the present time, however, some general speculations can be advanced. First, those portions of the river that contain the greatest numbers of beavers are also those areas that will be least affected by changes in flow regimes, that is, those areas farther downstream from the Devil Canyon dam. Second, any changes in riparian vegetation may be negated by the activity of beavers themselves. And third, increased winter flows may result in improved overwintering opportunities. In summary, that portion of the river that has the fewest beavers will be most affected, while that portion that has high numbers of beavers will experience the least impact.

(iv) Marine Mammals

Several hundred beluga whales concentrate in the upper Cook Inlet area to feed on anadromous fish. Whales have even been reported to enter the lower reaches of the Susitna River during times when salmon and other anadromous fish are present. Little is known concerning these whales and the extent to which they are dependent on any one of the many food sources available in the Cook Inlet region.

The potential for the Susitna Hydroelectric Project having an impact on beluga whales that inhabit Cook Inlet is dependent upon the net effect of the project on Cook Inlet salmon, and is tempered by the availability of alternative food sources. Based on the current predictions of the effect of the project on Cook Inlet salmon populations, and with the possible alternative food sources, it appears unlikely that the Susitna project will have any significant effect on the total food source available to these whales.

(v) Bald Eagles

The survey of nesting bald eagles conducted in 1981 resulted in an estimate of 15 to 20 active nests between Cook Inlet and Portage Creek. This estimate could be converted to an estimate of one nest per 15.8 km of river (based on 15 nests) or one nest per 11.9 km of river (based on 20 nests). The nesting eagle population along the Susitna River could be affected by the proposed project in two ways. First, the availability of suitable nesting trees could be altered. Along the lower river, eagles appear to prefer to erect nests in decadent balsam poplar trees. It is unlikely, because of the abundance of such nesting sites, that changes in river flow could appreciably reduce the number of such nesting sites. In fact, if reduced flows result in any changes in the plant succession trends, such changes would likely favor conditions that permit the development of older, more mature, and thus more suitable balsam poplars.

The second avenue of potential impact is related to changes in the food supply for eagles, in particular, salmon. The potential for a reduction in available salmon appears to be greatest between Talkeetna and Devil Canyon, and thus, any corresponding impact on eagles would most likely occur in this vicinity. Considering the density of nesting eagles along the river, however, and the likelihood of salmon's continuing to be generally abundant, especially south of Talkeetna, there should be little, if any, negative impact on the number of eagles nesting here. If any such impact on bald eagles occurs it would be in the area between Talkeetna and Devil Canyon, which had relatively few nests active during 1981. In fact, any stranding of fish as a result of lower water levels could temporarily increase the food supply for eagles in such locations.

(vi) Waterfowl

Based on the data collected during a survey of river use by migrating spring waterfowl (Table 3.42), it does not appear that the Susitna River is heavily used by these birds. The proposed action may possibly affect this limited use by reducing the area of calm water, such as sloughs, available to migrants. Although such a reduction is possible between Talkeetna and Devil Canyon, this area was found to be the least used portion of the river (Table 3.42) . The project is expected to result in open water year round below Devil Canyon, at least as far as Talkeetna. In the spring, early migrants may use this new source of open water.

In contrast to the mainstem Susitna River, waterfowl do make considerable use of the estuary portion of Cook Inlet near the mouth of the Susitna. The suitability of the tidal flats used by waterfowl in this area could be endangered by a reduction in water levels. Because of the extensive tidal influence, however, it is unlikely that a small change in the Susitna will sufficiently alter the coastal marshes of Cook Inlet as to make them unattractive to migrating and nesting waterfowl.

(e) Access Route

(i) Big Game

The proposed access road will impact big game in two ways: through loss of habitat and by enabling greater access by people into the area. The first source of impact, habitat loss, will be relatively minor in comparison to the increase in access that will take place. A total of 614 ha will be lost to the access road right-of-way [assuming a right-of-way 61 m (200 ft) wide] with an additional 267 ha lost for access road borrow areas and 22 ha lost for a railroad yard. All access road components combined total 903 ha. Closed mixed forest (313 ha) and birch shrub (140 ha) are the most common community types that will be impacted. The other community types involved with the access road are each represented by less than 75 ha. This loss of habitat will affect big game species in the same fashion as previously discussed [see Sections 3.6(a)(i), 3.6(b)(i), and 3.6(c)(i)].

The improved access that will be available as a result of the construction of a road from Gold Creek to Watana will have a definite impact on the big game resource. At the present time, there is very little human activity in the upper Susitna basin. With the exception of a few cabins and the seasonal presence of hunters, the big game animals in the upper basin are basically free of disturbance by humans. The construction and operation of the Susitna project will change this situation dramatically. Some species will tolerate additional human presence, while others will either totally avoid areas of human activity or temporarily come in conflict with humans. Improved access will also increase and change the distribution of hunting pressure in the upper basin, exposing to hunting some subpopulations which have been previously unaffected by that activity. Although regulated hunting is not considered to be generically detrimental to game species, there will be resulting change in the abundance, distribution, and sex and age composition of certain species and subpopulations.

The greatest changes will most likely occur along that portion of the access road between Devil Canyon and Watana. Presently, this area is one of the more remote portions of the upper Susitna basin. Between Devil Canyon and Gold Creek, some level of ground access already exists and the addition of a major construction road in that area will not result in as major a change as will the Devil Canyon to Watana segment. Although the access road will unquestionably have a negative impact on the big game resource, the magnitude and distribution of that impact will depend to a large extent on the manner, if any, in which access and hunting are regulated by appropriate state agencies following construction.

If unregulated access is permitted, the zone of impact essentially will be defined by the ability of people to travel distances off the road with ATVs. If, on the other hand, ATV use is prohibited or regulated, the zone of impact will be greatly reduced and probably limited to within a few kilometers of the road. The types of impacts that could result are many and vary among the species concerned. If hunting is permitted from the road, all big game species will gradually adjust to this situation and either avoid the road or become far more secretive in its vicinity. If hunting is not permitted from the road, it is likely that moose, bull caribou, and black bears will not react negatively to the presence of either the road or human activities along it. Wolves, wolverines, and brown bears are big game species that will most likely avoid the road, especially during the construction period when numerous large vehicles will be present.

Impact of the road on the Nelchina caribou herd will probably be minimal; any effects will be greatest during the construction phase. That portion of the road west of Devil Canyon dam traverses an area of low-quality caribou habitat that is seldom visited by caribou. The construction of this section will have negligible impacts on caribou. The proposed route between Devil Canyon and Watana, on the other hand, traverses an area of shrub land and tundra that consists of fairly good summer range. At present this area is marginally occupied by caribou; these are predominantly scattered groups of bulls. No major pathways of migration are located west of Deadman Creek. The road will not provide easy access to presently critical and remote caribou habitat such as the calving area. Caribou mortality resulting from collisions with vehicles will probably be minimal. It is expected that caribou generally will avoid the vicinity of the road, although bulls are known to be more tolerant of traffic than cows and calves (Cameron and Whitton 1978). It is possible that the road may influence the success of predator attacks on caribou, but since caribou use of the area traversed by the road is low, the significance of this possibility is not great.

Brown bears could be impacted as a reault of a change in the hunting pressure, a disruption of current movement patterns, or both. If hunting is permitted from the road, there will be an increase in the harvest of brown bears in this region. Available data suggest that this increased hunting effort is unlikely to significantly impact brown bear populations, although a combination of improved access and the liberalization of seasons and bag limits could result in local overharvests of brown bear subpopulations. Most likely any such overharvest would result in a reduction in bear density and a lowering of age structure rather than in an elimination of subpopulations.

The access road, in particular that portion between Devil Canyon and Watana, could also function as a deterrent to brown bears moving to Prairie Creek in late summer to feed on salmon. This type of impact and its ramifications have been discussed in Sections 3.6(a)(i) and 3.6(b)(i). The possibility of this happening is greatest during the construction period when large volumes of heavy vehicles will be using the road. The possibility would also be high following construction if the Devil Canyon impoundment acts as a further deterrent, but especially if hunting is permitted from the road. If bears are allowed to encounter the road without being harassed, there is a greater chance that they will find crossing the road acceptable. The major problem is thus during the construction period. Since it is likely that the movement to Prairie Creek is a learned behavior passed on from adult females to cubs and yearlings, the disruption of this behavior for 5 to 10 years could lead to the extinction of this behavior. This would result in a lower capacity for the area, in total, to support the brown bear numbers that presently exist, although it is possible that at some time in the future, following construction, bears would again locate the Prairie Creek salmon resource and reestablish this behavior pattern.

Due to their wilderness characteristics and intolerance of human presence, the access road will probably result in wolverines abandoning the area, especially during the construction period. Following construction, they may again inhabit areas nearby, but they will probably never regain complete use of the area traversed by the road.

There will be little, if any, impact of the road on Dall sheep. The only possibility of any influence would be on the Portage-Tsusena Creek herd if hunting from the road were permitted and sheep hunters using ATVs would be able to gain access to the southern portion of the area presently utilized by these sheep. But again, regulated hunting is not considered a negative source of impact any may simply allow for the utilization of a resource that has up to this point been unavailable.

(ii) Furbearers

If care is taken to avoid wetland areas, the physical disturbance and habitat loss from road construction will be relatively minor because of the small amount of land involved. The segment of the proposed access route between Parks Highway and Gold Creek poses the greatest potential for impact on aquatic furbearers. The long-term negative effects of borrow site development for fill for roads will depend upon the extent of restoration measures. Borrow sites or extended sections of roadways in or adjacent to wetland areas or stands of white spruce or near fox dens could be harmful.

The most serious impact from road construction will arise from improved human access. The effects of public use of roads will consist primarily of increased harvest and human disturbance of furbearers in the study area. Roads will provide convenient access to areas which are now and have historically been remote. The severity of this impact will depend upon regulatory measures imposed.

Red foxes and, to a lesser degree, marten will be most affected by road use. The greatest impact to foxes as a result of increased human activity will occur along the northern portion of the access road between Devil Canyon and Watana. Foxes presently use this area for denning. The impact on marten will not be great along this stretch of the road, but marten populations between Gold Creek and Devil Canyon will probably be reduced by additional trapping pressure that could be associated with the access road.

Vehicle-wildlife collisions will be another source of impact to furbearers. The severity of this impact is difficult to predict because of the paucity of relevant published information. Indications are, however, that losses of furbearers as a result of collisions with vehicles will be relatively low.

(iii) Birds and Non-game Mammals

Construction, maintenance, and use of the access route would have three main types of impacts: 1) destruction of habitat for the roadbed itself and alteration of habitat adjacent to the road and in borrow areas, 2) disturbances, such as noise and moving equipment, along the road, and 3) increased access to the region, and, therefore increased use by humans. The effect of this last impact on birds and small mammals is undetermined at this time, but would be greatest on the larger birds, including waterfowl and raptors.

Birds and small mammals dependent on the habitats destroyed or altered by construction would disappear from the immediate area of the road and borrow areas. On the other hand, after construction, populations of species that favor the newly created habitats will increase. Retarded plant successional development, such as that found adjacent to roads and railroads, will provide habitat for several species of shrubland sparrows and for small mammals generally restricted to open plant communities dominated by herbaceous species--Arctic ground squirrel, tundra vole, and meadow vole. Although borrow areas will be revegetated, recovery of shrub and forest habitats at borrow areas will be slow because of the harsh environment at the elevations of much of the access route.

Recovery rates of forested areas may be faster along Indian River because these areas are at lower elevations and are somewhat more protected than other forested sites. Known raptor and raven nest sites within 1.6 km (1 mile) of the access route or access route borrow areas are as follows:

- Bald eagle nest in balsam poplar near the junction of the Indian and Susitna rivers is only 500 m from the access road and 100 m from Borrow Area 1.

- Gyrfalcon nest (1974) and goshawk nest (1981) in a canyon just east of Devil Canyon dam site are about 1.6 km from the road.

- Two raven nest sites are within 0.5 km of the access road along Tsusena Creek.

Wetlands likely to be adversely affected by the access route are primarily those along Indian River and in the Chulitna Pass area. The degree to which these wetlands will be impacted will depend upon the exact alignment of the road. These wetlands have been viewed only cursorily from the air, so specific effects or levels thereof cannot be predicted. One lake, a productive alpine lake east of upper Devil Creek, appears close enough to be seriously influenced by the segment of the access route between the two dam sites. The route, however, could be "fine-tuned" to avoid serious impact to this waterbody.

(f) Transmission Line

(i) Big Game

- Central Study Area (Dams to Intertie)

In the central study area, the construction and operation of the transmission facility will impact big game species through disturbance and habitat alteration. Little habitat will actually be lost due to the transmission line; in most cases a change in habitat will occur rather than an actual loss. The right-of-way will encompass approximately 927 ha (see Table 3.59). The five most common vegetation types within this 927 ha area are closed mixed forest (347 ha), birch shrub (109 ha), open mixed forest (95 ha), mixed low shrub (82 ha), and woodland white spruce (82 ha). Because of the relatively low height of the dominant plant species, there should be little disturbance of the two shrub types. The three forested communities plus other less abundant forested communities, however, will require the removal of tall vegetation. This will result in a change from forested types to vegetation types dominated by low shrubs or young trees.

Moose and black bears are the two big game species most likely to be impacted by this type of habitat alteration. The impact on black bears will probably be insignificant and may actually be beneficial since it will result in an increased diversity of vegetation types within the affected area. In spite of disturbance during construction and maintenance operations, moose will probably be benefited by the clearing of forested areas. This will allow for the development of early successional community types which will provide an increase in the quantity of browse. Thus, it can be predicted that the carrying capacity of the area traversed by much of the transmission corridor will be increased for moose.

The disturbance of big game species as a result of the transmission line will be greatest during the construction period. The proximity of the transmission line to the access road will greatly reduce the significance of any disturbing activities, however, since disturbance from the access road will be far greater. As discussed in previous sections, the magnitude of this type of impact will vary among the big game species: moose and black bears are the most tolerant of disturbance; wolves, wolverines, and brown bears are the least tolerant. Caribou may also suffer some from construction activities, but, since there is presently very little caribou use of the area, it is anticipated that only a few summering bulls will be bothered by construction activities.

The same relationship of the transmission line with the access road applies to the possibly blocking of movement patterns. Although the transmission line construction activities do have the potential to interfere with the movement of some species (brown bears in particular), the access road is more likely to result in this impact prior to the construction of the transmission line. During operation, however, noise from the conductors (especially in bad weather) may repel animals even at times when there is little traffic on the road. The issue of possible improvement in human access that could result from a transmission line is moot, since the access road represents a far greater potential for this type of impact.

The likelihood of some level of synergistic effect occurring as a result of the proximity of the transmission line to the access road should not be ignored. This effect may be especially significant during the operation phase. Although the major disturbance from the construction phase of the access road will no longer be operative, it is possible that animals will find it more difficult to cross two corridors that will be in close proximity than it would be to cross two more widely separated, especially at times when both traffic is frequent and the conductors are particularly noisy.

In summary, the transmission line in the central study area will have little negative impact on big game species over most of its length. In forested areas, there will probably be an improvement in moose habitat. Disturbance and access impacts associated with the transmission line in most areas will be overshadowed by similar and more severe impacts emanating from the adjacent access road. During operation, however, more sensitive big game species, such as brown bears, could be disturbed to a greater extent due to the close proximity of the transmission line to the access road.

- Northern Study area (Healy to Fairbanks)

The primary type of impact that can be expected to occur in the northern study area is habitat alteration. The transmission line right-of-way in this area will utilize approximately 1,923 ha (see Table 3.59). The four most common vegetation types in the proposed right-of-way are open spruce (685 ha), mixed low shrub (294 ha), open mixed forest (251 ha), and open deciduous forest (150 ha). A variety of other community types are represented by lesser amounts, in all cases less than 100 ha each. The greatest change will be in the forested areas, which represent three of the four most common types.

The clearing of forested communities is expected to be of benefit to moose, since it will result in the creation of early successional vegetation stages which typically provide much more browse than the mature types that presently exist. In all cases, community types that will be so affected are very widespread and abundant in the area, so the change of these community types will not represent a significant negative impact on any big game species. In addition to moose, it is likely that black bears will also benefit from the increased plant community diversity that will occur. Predatory species, such as wolf, where they occur, will benefit indirectly from the increase in moose.

As described for the central study area, most of the disturbance will occur during the construction period and will be minimal following construction. Improved access will result from the establishment of a transmission corridor. The magnitude of the impacts of the increase in both disturbance and access will vary along portions of the proposed line and will be least detrimental in areas where the line will be in close proximity to already existing road or transmission corridors and greatest in areas where the line deviates from existing corridors. The two species most likely to be associated with the line (moose and black bears) are, however, relatively insensitive to disturbance resulting from human activity and should not be severely impacted.

- Southern Study Area (Willow to Cook Inlet)

A total of 866 ha will be affected by that portion of the proposed transmission line between Willow and Cook Inlet (see Table 3.59). The four most common vegetation types traversed by this segment of the line are closed mixed forest (307 ha), closed birch forest (115 ha), open mixed forest (112 ha), and wet sedge grass (101 ha). Other community types, the majority of which are forest types, are also present in lesser amounts. Based on these figures, it is obvious that the greatest impact on big game will result from habitat alteration. As explained previously, this will entail a change from forested communities to shrub-dominated communities. The two big game species that will be primarily associated with this segment of the transmission line are moose and black bear. These species, and moose in particular, should benefit from the habitat alteration that will result.

The disturbance and improved access that will result from this line will represent a potential for negative impacts on these species. Significant disturbance will be, however, of a temporary nature and confined primarily to the construction phase, although maintenance of the facilities and right-of-way will also cause occasional disturbance. In the case of both disturbance and improved access, the net impact will be relatively minor; the area between Willow and Cook Inlet is already heavily subject to human activity, and it is likely that these two species have already adjusted to existing in close proximity to humans.

(ii) Furbearers

The construction and operation of the transmission line will likely affect furbearer species in two ways. First, the creation of a cleared corridor will probably result in some level of additional access for trappers. Increased trapping attributable solely to the transmission line is most likely to occur along portions of the northern and southern study area, where access into certain areas will be improved by the right-of-way. Although some additional trapping pressure will result, it is unlikely that there will be long-term detrimental impact on furbearers. Within the central study area, on the other hand, the proximity of the access road will represent a far greater avenue of human access than the transmission line.

The second manner in which the transmission line will affect furbearers is in those portions where forested vegetation will be cleared. The clearing of vegetation and the operation and maintenance procedures will result in the creation of early successional plant communities, which will most likely be of value as habitat for a variety of small mammals, nesting birds, and snowshoe hares. These prey species will then be utilized by predators such as foxes, marten, short-tailed weasels, and coyotes. In those areas where vegetation clearing will not be required, especially between Devil Canyon and Watana dams, there should be negligible impact on furbearers.

(iii) Birds and Non-game Mammals

In the central and southern study areas, the major impact on avian and small mammal species resulting from the construction and operation of the transmission line will be the alteration of habitat. In areas where vegetation clearing will not be required, the impacts on these species will be negligible. Where clearing is necessitated, there will be some impact, but it will be in the form of a change in species composition and not necessarily a reduction in the number of birds and small mammals using the corridor. This change will entail a reduction in those species that inhabit forested communities and an increase in those species that require plant communities in an earlier stage of succession, such as shrub or grassland type communities.

In the northern study area, the same changes can be expected where clearing is required. In addition, there are several other issues of concern regarding birds along the proposed route. Of prime interest is the proximity of a peregrine falcon nesting site located along the Tanana River east of the proposed transmission route. The nest was inactive during 1981 but was used prior to this time. Whether or not it will be used again is unknown. If the nest is active during the construction of the line, the birds may abandon it as a result of the disturbance. If the nest remains inactive during the line construction, however, it will most likely be acceptable for later use during the operational phase of the line. If necessary, the transmission line in this area could be constructed during a time period that would reduce the liklihood of disturbing nesting peregrines. Furthermore, a Section 7 consultation, as required by the Endangered Species Act, will be conducted with the U.S. Fish and Wildlife Service to help insure that the peregrine nest is not impacted.

Another concern along the northern study area is the proximity of several trumpeter swan nesting areas. North of the Tanana River, the center line of the transmission route passes within 0.4 km of a swan nesting area. South of the Tanana, the center line is approximately 1.6 km from two other nesting areas. All other identified swan nesting sites are farther than 1.6 km from the center line. As in the case of the peregrine falcon, construction activities, especially blasting, might result in the temporary abandonment of that nest located 0.4 km from the line. No long-term impacts on swans are anticipated, however. The only other manner in which swans might be affected by the line is through collisions with wires, an event most likely to occur under poor visibility conditions.

3.7 - Anticipated Impacts on Fish Resources

(a) Watana Dam and Impoundment

The impacts associated with the development of the impoundments of the Susitna Hydroelectric Project are divided into construction impacts, including those connected with filling time, and operation impacts. Table 3.67 identifies potential impact issues associated with the various project stages of hydroelectric facilities.

(i) Construction

Construction impacts can be subdivided into impacts resulting from construction of the cofferdams and those arising from construction of the main dam. The impacts associated with cofferdam construction are relatively brief, however, and the major dam's construction will begin soon after the cofferdams are complete. The effects of the major dam will essentially be a continuation of those created by the cofferdam, so both types will be treated as one for this section of the report.

An obvious impact that has occurred on other hydroelectric projects and will also occur on this project concerns changes in water quality. These changes can be expected when a lentic environment replaces a lotic system. Physical changes, such as temperature and turbidity, as well as chemical changes associated with such factors as leaching of nutrients and minerals from the reservoir area soils will impact the aquatic organisms that currently inhabit the reservoir area. Inundation of the mainstem and tributaries will eliminate present habitat in those areas.

The construction of the Watana dam and the subsequent development of the impoundment will affect the mainstem resident fish species by eliminating approximately 85 km of mainstem riverine habitat. The mainstem has populations of burbot and round whitefish, which are often associated with the mouths of clear water tributaries. In addition, sculpins, longnose sucker, Dolly Varden and Arctic grayling have been found in this section of the drainage. The grayling, however, has been primarily associated with the clear water tributaries.

Inundation of the mainstem, although it will cause a loss of riverine habitat, is not expected to affect adversely the fish populations that are present. It is expected that the reservoir will provide the habitat necessary for the existing populations of burbot, longnose sucker, and whitefish to sustain themselves and possibly even to increase. In addition, studies show that 85-95% of the incoming sediment will be trapped and will settle out in the Watana reservoir. Thus clear or almost clear water may be present in the upper Watana reservoir waters during the winter. As a result, additional or improved overwintering sites may be available.

Moreover, overwintering areas that are associated with the clear water flows of the area's tributaries will probably also increase. While the drawdown during the winter months reduces this area, the remainder is still many times the pre-project stream area. The flooded tributary areas will be much deeper and should continue to have clear water entering them from the tributaries. These areas could provide additional overwintering areas for such tributary fish as grayling. It is not known, however, whether overwintering habitat availability is a population-limiting factor in this region. These areas may possibly become productive habitat for other life stages of the fish populations.

Many tributaries enter the mainstem Susitna in the area that will be affected by both construction of the dam and inundation by impounded waters. The impacts associated with construction of both the cofferdam and the Watana dam will be concentrated in the tributaries closest to the actual dam site, namely, Tsusena and Deadman creeks. These both contain grayling. Deadman Creek will also be affected by inundation, but Tsusena Creek is downstream of the Watana dam and, thus, will not be flooded by the Watana impoundment. It will, however, be affected by other project facilities [Section 3.7 (c)]. It is expected that Tsusena and Deadman creeks will be further affected during construction, primarily by additional sport fishing pressure exerted by construction personnel.

During dam construction, Tsusena Creek will be additionally affected by the planned removal of gravel. This process will affect the stream habitat of Tsusena Creek (see Section 3.7 (c), Borrow Areas). In addition, a water supply dam to be constructed on Tsusena Creek will eliminate migratory movement of resident species through this area. The impoundment behind the water supply dam may, however, provide additional over- wintering habitat.

Deadman Creek lies approximately 1.6 km upstream from the proposed Watana dam. A large waterfall, which is presently a barrier to fish migration, is located about 1.6 km upstream from the creek's mouth. Approximately 3.7 stream kilometers would be inundated by the proposed impoundment, which would also inundate the waterfall and allow fish migration between Deadman Lake, about 10 km upstream, and the Susitna River.

In addition to Tsusena and Deadman creeks, which are in the immediate vicinity of the proposed Watana dam, other Susitna tributaries will be affected by the creation of the Watana impoundment. These include Watana, Kosina, Jay, and Goose creeks, and the Oshetna River, all of which are upstream of the dam site. At Watana Creek, about 14 stream kilometers will be inundated by the proposed impoundment; at Kosina, approximately 6.4 stream kilometers; at Jay Creek, about 5.0; at Goose, approximately 2.4; and at the Oshetna River, about 3.2 stream kilometers.

A primary concern in regard to fisheries is the impact of the Watana impoundment upon the Arctic grayling populations in the region. ADF&G (1981) has estimated that 10,000 $\pm$ grayling inhabit the areas of the streams and mainstem that will be inundated, and most of the impact will be felt in those streams in the vicinity of the Watana impoundment. Grayling in all the streams mentioned are not presently subject to heavy sport fishing pressure. Thus, although a moderate amount of increased sport fishing pressure may occur on the streams distant from the dam site, it is not expected to be a significant consequence.

Grayling populations in the tributaries are probably near their maximum, with some natural limiting factor controlling any increases. The limiting factors could be the number of spawning sites or overwintering areas, the amount of available food, or a combination of several factors. If overwintering areas are the limiting factor, then grayling could be moving downstream during the winter to find suitable sites. If they move through Devil Canyon, they would not be able to ascend the canyon in the spring. It is evident, however, that a large portion of the suitable stream habitat currently used by the grayling in the clearwater tributary areas within the Watana impoundment zone will be lost to the inundating waters. There is also a possible loss of some spawning areas associated with the mainstem that are fed by clear water. Overwintering habitat presently available in the Susitna mainstem will be lost, but replaced by impoundment lake waters. Clearwater rearing habitat that support this population in the tributaries will be lost by inundation. Sally Lake (Figure 3.35), an 18-hectare clearwater lake with a population of both grayling and lake trout, would be eliminated.

(ii) Operation and Maintenance

Operation of the Watana power development will necessitate an annual fluctuation in the reservoir surface water elevation. At full capacity, the reservoir maximum surface elevation will be 666 m (2185 ft. m.s.l.). During an average year, the reservoir will be drawn down 27 m (90 feet). During a succession of dry years, however, the reservoir may be drawn down 43 m (140 feet) from the maximum surface elevation. Drawdowns of this magnitude will eliminate shallow shoreline environments which are necessary for the reproduction, shelter, and food requirements of many fish species.

The annual fluctuation, a characteristic of all hydroelectric power developments except run-of-river, will create a broad, barren shoreline that, at the end of the winter season, will be exposed. During the summer, water being stored in the Watana impoundment will cover this shoreline. During filling and in the early years of operation, mud slides will occur as the soils in the reservoir become saturated and the water levels fluctuate.

During winter months, as the reservoir waters are drawn down to provide power, ice shelving is also expected. Ice formation in the impoundment will be different from the formation of ice that currently takes place in the same reach of the Susitna River. A fairly uniform thickness of approximately 80 cm can be expected throughout the reservoir. The timing of ice formation, however, is expected to be consistent with present patterns. The reservoir ice is expected to begin forming along the shore about the middle of October, the same time as it presently begins.

Ice jamming may occur in Watana Creek and in the Susitna River near the Oshetna River and Goose Creek. Another ice-related impact has to do with ice jamming. Winding channels with steep banks and the possible supply of large quantities of ice from upstream are indicators for jamming. Ice will only affect the fish populations, though, if it limits access either to tributaries in the spring for spawning or access to the reservoir for overwintering. Such restriction is not expected to happen, however. Any ice formations that block the stream will be quickly eroded by the high flows from the tributaries in the spring.

The Watana reservoir with a storage volume of 9,625,000 acre-feet has a ratio of capacity to inflow of approximately 1.82. Preliminary estimates indicate that from 85-95% of incoming sediment will be trapped in the reservoir, with particles smaller than two microns possibly passing through. The sediment-laden streamflow from the Susitna mainstem will initially spread through the reservoir as either surface flow, interflow, or underflow, depending on the relative densities of the reservoir waters and the Susitna waters. Increased winter turbidity levels are expected to be the impact associated with the reservoir sedimentation process. The fish that currently inhabit the mainstem are presently subjected to glacial stream conditions much more severe than they will be during the operation of the project. Reservoir turbidity should not be a negative impact on longnose suckers, round whitefish, or burbot -- the species most likely to inhabit the reservoir.

Temperature conditions in the Watana reservoir will be different from those that now occur in the mainstem and tributaries, although the reservoir will not actually stratify. A gradual temperature decrease with depth will occur in summer until water temperature is 4°C. In winter the temperature will increase with depth from 0°C to 4°C, with the top 5+ meters predicted to be colder than 4°C. This temperature structure is not expected to cause an adverse impact on reservoir fish.

(b) Devil Canyon Dam and Impoundment

(i) Construction

Construction impacts for the Devil Canyon development are expected to be similar to the Watana impacts. Construction of the cofferdam is expected to increase temporarily the downstream load of suspended solids. The two micron and smaller fraction of the sediments may remain in suspension and pass through the Watana reservoir to Devil Canyon. If this happens, construction of the cofferdam during low water periods of the year, when water is normally clear, will result in slightly more turbid conditions downstream. Turbidity from construction during high water flows would be far less noticeable. In addition, during the period when the Watana development comes on line and the Devil Canyon project begins, increased flows for power generation will be discharged downstream. The increased flow of water will have the effect of diluting any additional sediments caused by cofferdam construction. No other direct impact of actual construction of the Devil Canyon dam is expected.

An indirect impact of construction that can be expected, however, is increased fishing pressure on the sport fish in the tributaries near the construction site. With the possible exception of salmon fishing on Portage Creek, these tributary areas are not currently subject to high fishing pressure. In fact, the grayling populations in the impoundment tributaries are probably at their maximum density levels. Increased fishing pressure will alter these population levels as well as fish populations in Portage Creek and Indian River.

Impoundment of the Susitna waters will provide the major impact in the Devil Canyon development. Inundation of the mainstem and tributaries will alter the present habitat of resident fish in this reach. These streams will be flooded to the 443.5 m (1455 ft) msl elevation.

The tributaries in the Devil Canyon impoundment area, however, are characterized as having steep slopes with occasional barriers, such as waterfalls. Cheechako, Devil and Tsusena creeks, three creeks entering the Devil Canyon impoundment, all contain waterfalls. These falls will not be inundated by the creation of the impoundment and will still function as effective barriers to fish passage.

Because of the glacial input, the mainstem is very turbid during the summer months and is not, therefore, considered to be prime fishery habitat. Resident species have, however, been collected in the mainstem. Longnose suckers, round whitefish, and burbot are the major contributors to the mainstem fishery. Impoundment of waters is not expected to adversely affect these fish populations.

On the other hand, grayling populations, which inhabit portions of the tributaries, will be affected by the habitat change. Loss of spawning areas near the stream mouths could be a negative impact. In addition, the impoundment will surely increase overwintering area. In conjunction with the loss of the riverine environment will be the creation of a lake environment. The change from a lotic to lentic environment will probably be accompanied by a shift in species composition. For example, burbot, longnose suckers, and possibly whitefish would be present as opposed to grayling.

Finally, in addition to the other tributaries mentioned above, Fog Creek, located at river kilometer 278 on the south side of the Susitna River, and approximately 37 km upstream from the proposed Devil Canyon dam, would be inundated by the proposed impoundment to a point approximately 1 km upstream of its mouth.

(ii) Operation and Maintenance

The Devil Canyon development will be operated in conjunction with the Watana dam, located just upstream of the Devil Canyon impoundment. Annual drawdown at Devil Canyon will be about 17 m (55 ft). As in the Watana impoundment, drawdowns of such magnitude will eliminate shallow shoreline environments in the reservoir, which are necessary for the reproduction, shelter, and food requirements of many fish species.

The Devil Canyon impoundment will have a capacity to inflow ratio of .16, making it much more reactive to upstream influences than the Watana project will be. The outflow from the Watana project, however, will provide water with chemical characteristics different from those currently prevailing in the Susitna River.. In addition, leaching of minerals and nutrients from the reservoir soils will further change the chemistry of the water. Until the banks stabilize, mud slides from the steep slopes into the reservoir will increase the rate of input of minerals from the soils. The extent of this impact on both the Devil Canyon and Watana development cannot be fully assessed, however, on the basis of current information; at present, little is known about the zone of mineralization or about the soil nutrients. A decrease in the suspended sediment load entering the Devil Canyon reservoir, which results from the Watana operation, should permit an increase in light penetration and a corresponding increase in primary productivity.

(c) Borrow Areas

Impacts associated with the construction phase of the project in regard to borrow and quarry areas would result from direct excavation of stream bed material and sedimentation problems caused by runoff or meltoff entering nearby aquatic habitats. Heavy metals which could degrade the existing water quality of these aquatic habitats, could also be an impact associated with runoff and meltoff from excavated areas. It should be noted that borrow or quarry areas not located near any streams or lakes would not have any impact on fish resources.

The most significant and long-term impacts could result from Areas E and F (Figure 9.7). Area E is situated near the mouth of Tsusena Creek, an area which would be inundated; area F would be along sections of the creek that would not be inundated by the impoundment. Persistent siltation problems could occur and affect the remaining resident fish populations, especially grayling. A similar situation could exist at Area H in regard to Fog Creek and Area D with respect to Deadman Creek.

Those areas which would eventually be inundated by the impoundments could cause a temporary impact which could be either fairly significant or rather minimal, depending upon the size and/or location of the borrow area in question.

For example, Area L would be inundated by the Watana impoundment, and any impact directly associated with this area would be temporary and insignificant in comparison to inundation of the region. The same also can be said of Area J, although the Susitna stream bed excavation would certainly hasten the destruction of resident fish habitat in the Susitna mainstem.

Most of Area I, located in the mainstem Susitna River, will be inundated by the Devil Canyon impoundment. Its impact upon the fish habitat in this section of the Susitna would, therefore, normally be termed insignificant. The extent of this area, however, and the fact that siltation could occur well downstream and possibly affect resident and perhaps anadromous species' reproductive habitat in the Susitna River make the potential impact from Area I of some significance. As this situation points out, areas that will only be partially inundated by the Devil Canyon reservoir could be a persistent source of siltation as water levels in the impoundment rise and fall. On the other hand, while this increase in siltation could reduce primary productivity in the reservoir, it would probably not create any significant impact on the fishery.

Excavation at Area G could have a similar impact if siltation is permitted downstream of the Devil Canyon dam site. Even though this area is closer to portions of the river utilized by salmon, the much smaller size of Area G in comparison to Area I could limit its impact. Area G would not be of any impact following inundation.

(d) Downstream Impacts

(i) Construction

- River Mouth to Talkeetna

Construction-related impacts on downstream resident fisheries are related to changes in discharge, water quality, water temperature, ice formation, and geomorphological changes in the river. These changes are caused by the re-routing of the Susitna flow through diversion structures during the construction of the dams, disturbances of the river or its tributaries during construction, and reduction in flows during the filling of the reservoirs.

During the immediate construction period, water will be diverted around the dam construction site by means of a bypass tunnel. This structure should pass the run-of-river discharge until the dams are to be filled. Discharge changes from the pre-project conditions during this initial diversion period will probably be minor and not significantly affect downstream fisheries.

During the filling period, a net loss of downstream water to the fisheries will occur over several years. The monthly mean and annual frequency duration curves for the Sunshine Station project decreases in the monthly discharges for June, July, and August. Increases in discharge occur in October through May. There is no significant change in discharge during the month of September.

An analysis of the natural variability of flows has been prepared for data collected at gaging stations located at Gold Creek and Susitna Station on the Susitna River and from the Chulitna and Talkeetna rivers. A comparison of the pre- and post-project discharges at the Sunshine Station indicate the post-project monthly average discharge would be approximately 69% of the pre-project discharge during June, 77% during July, 85% during August, and 94% during September. The flow variability data were not available for the Sunshine site, but patterns were very similar for the four sites evaluated, with Talkeetna the most variable and Susitna Station the least. Gold Creek and the Chulitna Station data were similar and intermediate between the other two sites.

For purposes of comparison of natural variability with the post-project changes, the Gold Creek data were used as representative of the lower river conditions. The data analysis indicated that post-project average monthly flows resemble the annual average low flows that occur over one day during June and July and are slightly below the three-day occurrence. The post-project August flows are similar to those that normally occur over a 14-day period, while the September flows are not significantly different from the natural flow. October post-project flows are higher than those which occur normally but are within the natural variability that occurs over a 14-day period at Sunshine Station. Winter flows during this filling period should not deviate from the natural conditions.

Post-project water quality changes have been presented only for sediment with regard to the trap efficiency of the reservoirs. Trap efficiency was estimated to be between 85% and 97%, with particle sizes of less than two microns remaining in suspension. A general statement that the turbidity of the river water below Devil Canyon will decrease during the summer and increase in the winter appears to be appropriate. The winter increase in turbidity may even be noticeable below Talkeetna. Turbidity values in the winter are currently less than 5 NTU's.

Examination of other water quality parameters measured throughout the year does not indicate any abnormally high concentrations that may be limiting to aquatic life. Increases in nutrient concentrations should result from the flooding of vegetation within the impoundments. Phosphorous concentrations are often associated with increases in productivity. Increases in nutrients in glacial systems that are light-limiting, however, do not necessarily cause increases in production. Downstream nutrient increases are a likely consequence of the construction of the project, although predictions of these concentrations have not been made.

Below the confluence of the Susitna and Chulitna rivers, summer changes in water quality should not be perceptible because of the influence of the Chulitna on the mainstem river and the natural variability of water quality within the system.

Temperature changes have only been projected for the portion of the Susitna above Talkeetna. During dam construction, no effect on river temperature should occur. During the filling period, warmer winter temperatures are projected. The temperature changes in the river below Talkeetna have not been analyzed, but they would appear to be minor. During the filling of the reservoirs, the small winter flows are projected to have only minor influence at the three-river confluence area near Talkeetna. The filling flow will be similar to normal winter flows, allowing the river to cool between Devil Canyon and Talkeetna at a rate more rapid than that which will occur during operation.

The few effects on temperature during the summer period should not be discernible below Talkeetna because of the reduced flow contribution of the upper Susitna on the main channel during this period.

Ice conditions will change somewhat in post-project conditions during operation. During filling and construction, however, the normal winter flows should not create any significant changes in ice formation below the Chulitna river confluence.

During the filling period, flood peaks from the Susitna will be eliminated while the flood waters contributed by the other tributaries will continue. This change should provide more channel stability than that which now occurs, but the differences will probably not have perceptible changes on any of the fish habitat in the lower river.

o <u>Anadromous Species</u>

The Susitna hydroelectric project's effect on the runs of anadromous fish in the lower Susitna River from the mouth to the confluence of the Talkeetna River - a distance of about 157 km has not been fully established at this time. This portion of the river flows through a broad floodplain with some shifting (or instability) of the channels, and in places, the channel is divided into numerous channels. Only about 20% of the total flow in the lower Susitna originates from the river and its tributaries above the confluence of the Talkeetna River. Thus, any effect of the hydroelectric dams would, in general, be masked by the discharge of water from the tributaries flowing into the lower Susitna.

At the same time, however, the lower Susitna River provides the sole migratory route for the very large runs of salmon that enter the various tributaries below the Talkeetna to spawn and for the young returning to the sea. The effect on migration of salmon of any change in the flow regime of the Susitna, though small and whether beneficial or detrimental, would be magnified in importance accordingly.

The extent to which various species of salmon spawn in the main channels of the lower Susitna River and its adjacent sloughs is not known at this time, nor is the extent to which the main channel may serve as a nursery area for the juvenile coho, chinook, and possibly sockeye salmon.

In addition to these general effects upon the salmon population that are attributable to the Susitna project, other impacts will occur and will vary with the project activity in question. That is, the impact associated with dam construction, for example, will differ from the effects of filling the reservoir, and these will vary from the impact of operating and maintaining the facility.

During the construction and filling period, minimal flows ranging from 900 cfs in the winter to 6,000 cfs in the summer will be discharged from the dam. As the reservoirs gradually fill, there will be no provision for adjustment of water temperature to satisfy the needs of early development of salmon eggs. It should be noted that during filling, the temperature of the water is expected to reach the near ambient level by the time it reaches Gold Creek in both summer and winter and should have little effect on the spawning or migrating salmon in the lower Susitna River.

Also, during the filling of the reservoir, a gradual decrease in turbidity in the summer and an increase in level of chemical constituents of the water as a result of leaching from the soils can be expected. Turbidity will be slightly less in the summer months of glacial melt but will be overshadowed by the turbidity load of the Chulitna River.

Any addition of nutrients will tend to increase the biological productivity of the stream; exceptions would be concentrations of toxic chemicals (for example, copper and iron), but whether such concentrations will exist is not presently known.

It is not expected that the reduced flows that will occur in late spring and summer will be sufficient to cause any physical block to salmon migration. On the contrary, those flows should improve the migratory conditions for salmon ascending the lower Susitna River by reducing the water velocities and thus requiring the salmon to expend less energy during their migration upstream. Conditions for access to the small sloughs and tributaries used by salmon for spawning could be affected with an expected lowering of the water level by from .3-.6 m in the vicinity of Susitna Station. The reduced flows would have minimal effect on the mainstem spawning if it occurs.

o Resident Species

The resident fish probably spawn primarily in clearwater tributaries of the Susitna, with possible spawning in the mainstem by burbot, longnose sucker, and whitefish. During the winter months, many of the tributary residents outmigrate from the tributaries and overwinter in the mainstem. This movement has been inferred from capture data gathered during the fall and spring near tributary mouths. Information on the distribution of juvenile residents by season is minimal. Based on existing data, no major impacts are projected for the resident species below the Susitna and Chulitna confluences during construction and filling.

- Talkeetna to Devil Canyon

There are two periods to be considered when describing potential impact issues in the Susitna River downstream of Devil Canyon during the construction phase. The first period is the construction time. The river area affected during this period will be minor and will be contained within the cofferdams. At most, there may be some minor modification of turbidity levels from time to time during the construction of the cofferdams and diversion tunnel and during the road-building activities. This modification is not expected to be significant, however. During the cofferdam stage of construction, the cofferdams must not be overtopped. The river flows will be passed as the river runs through the discharge ports. Discharge will not change appreciably during the dams' construction period; except at the start of diversion, there will be no modification of flow.

One concern during the construction period is the accidental spill of chemicals and petroleum products in the impoundment area. Such accidents would primarily affect local fisheries in the impoundment area and, depending of course on the magnitude of the spill, should have minor consequences on downstream areas.

The second period of the construction phase that is expected to affect fish populations in the Susitna River downstream of Devil Canyon is the filling time, when water in the reservoirs will be brought to a usable level. This filling is expected to begin before the main dams are completed. There will be a subtraction of flow and minimal, if any, change in river bed morphology. The filling period will also mark the beginning of any changes that may occur in the deltas of incoming streams.

The main interference to flow will occur during the short period of time needed to bring the pool levels behind the cofferdam to an operating head in order for the diversion works to function.

Since Watana dam will be fully developed before Devil Canyon dam is started, there will be two short interruptions of flow as the two reservoirs are filled.

As the dams get higher, the water levels of the lakes forming behind them will also rise. The incoming flows will be modified to the extent that storage will permit, and a safety freeboard level will be provided to prevent overtopping of the works during an unusual flood. Particularly during summer, there will probably be some modification of flow, which will equal the volume of stored water behind the uncompleted structure.

As the reservoirs approach their lower operating levels, conditions closely approaching operating conditions will exist. This situation will provide some benefits from lowered flood flows but will not contribute additional flows for the summer period unless these are allowed for in the filling schedule. Thus, substantial changes in the summer flows will occur, which will, in turn, considerably reduce the flow in the side channels and sloughs in this reach to only local run-off and spring-fed flow. With normal flood peaks that occur during summer eliminated during the filling period, a more stable channel will be created and the bedload movement that occurs during this time will be reduced.

With the summer flows well below the natural variability of the river under pre-project conditions, it is expected that the sloughs from below Devil Canyon to Talkeetna will be affected in that adequate water will not be made available to them. The sloughs in question will be those that fish have been found to use either for spawning or for spawning and rearing. Approximately 40 such slough areas have been identified in this stretch of the Susitna River.

At some time during the filling period, density water layers will form in the impoundment. Firm control of temperature will probably not be possible until the reservoirs have reached their lower operating levels. Temperature modification caused by the Watana reservoir will probably equilibrate by the time the water reaches Portage Creek.

Present monthly average temperature changes have been recorded, and post-project temperature changes expected to occur during the filling of the reservoir have been projected for this reach at the Gold Creek site and near the mouth of the river at the Chulitna confluence. Depending upon the summer flow level provided, there will be modifications of natural temperatures in the spilled water after the stratification resulting from the formation of density water layers occurs. In general, temperatures will decrease slightly in the summer and increase more markedly in the spring and fall. This temperature pattern is likely to delay formation of winter ice cover over the Susitna River above Talkeetna and, with substantial increases in temperatures during April and May, to accelerate breakup in the spring.

Apart from temperatures, there may be some other modifications of water quality. These alterations would primarily be at the beginning of the storage of silt in the reservoir areas or at the beginning of discharge of less silt-ladened water below the projects. In addition, if the diversion tunnels are installed in the winter, the sediment level may be significant unless proper mitigative actions are taken to prevent any sediment additions to the river. If, on the other hand, the by-pass tunnels are installed in the summer, the increase in sediment levels will be only minor.

Nutrient levels (phosphorous and nitrogen compounds) will probably also increase in the impoundments during the filling period as vegetation within the impoundment becomes inundated. The consequences of these increases on downstream water quality have not been determined, however. Besides the phosphorous and nitrogen compounds, no other chemical parameters have exhibited abnormal levels that might be detrimental to aquatic life under pre-project conditions. It should be noted that there are presently no data to suggest any adverse effects on water quality related to these other chemical parameters during reservoir construction and filling. Furthermore, there are only limited data on mineralization levels with the reservoir areas, and as a result, no forecast can be made as to the effect on downstream fishery of alterations in mineralization levels.

During the winter months, very little change in usable habitat is likely, either during construction or filling of the reservoirs. Unlike summer flows, winter flows should be very similar to those occurring before construction begins. The only major difference between winter and summer impacts is that, as noted above, if diversion tunnels are installed in winter, they could result in significant additions of sediment to the river.

o Anadromous Species

Estimates of the number of each salmon species to be affected in this reach of the river are discussed in section (iii) below. One change in the habitat that will result from the Susitna project is that the low summer flows will dewater the side sloughs along the river.

The low summer flows will be due, in part, to the planned diversion tunnels. Although the water drop may be rather sudden, the river should quickly recover as the narrow segment is filled upstream from the cofferdam. Thus, the effect on salmon populations is expected to be minor.

o Resident Species

During the summer, resident fish in this reach of the mainstem are primarily burbot and longnose suckers. During the filling period, most other residents are associated with the mouths of clear water tributaries. During the early spring and late fall sampling periods, adults were more often associated with the mainstem than they were during the summer. This difference probably reflects migratory movements between the clear water tributaries.

During the late summer months, whitefish, grayling, and rainbow trout fry have been found to use the slough habitats, pointing up the relative importance of these areas to the rearing of juveniles. Very little information on winter distribution is available.

Geomorphological changes, in general, should not adversely affect the resident fish in that, with a decreased variability in discharge, a more stable channel should result. More specifically, however, as described above, dewatering of the side slough habitats will occur during the summer months, with water from springs being the only contribution to these areas. Even though the effects of reduced Susitna flows on the recharge of these springs is not known, the portion of the resident fisheries using these areas should be reduced. On the other hand, most of the resident fish are dependent on clear water tributaries, and these are not likely to be affected by the project. The significance to the overall population size of the rearing fish using these areas is not known.

The decrease in scouring floods during the summer should make the mainstem more hospitable to resident fish than under pre-project conditions. Sufficient information is lacking, however, as to whether the post-project conditions will be a sufficient enough improvement in habitat to enhance the current, almost non-existent use of this type of habitat. The decreased flows during the spring and fall should not significantly affect the inter-system migration that occurs at this time. One reason is that no fish passage problems are anticipated; moreover, no other changes in water quality are expected which may cause any adverse impacts.

The temperature changes described above are well within the range of tolerance of the resident species, so no direct effect is anticipated. If temperature changes trigger migratory movements of overwintering fish, however, premature migration may occur. The delay in ice formation and the earlier spring breakup that is likely to occur during reservoir filling also as a result of temperature modifications will probably have a minor impact on the resident fisheries. The full effect of either of these change on the resident species is not known, however.

Geomorphological changes, in general, should not adversely affect the resident fish, in that with a decreased variability in discharge, a more stable channel should result.

(ii) Operation and Maintenance

- Estuary

The proposed Susitna hydroelectric project will alter the monthly and seasonal discharge patterns of the Susitna River. Based on a simulated 30-year average, flow increases over existing conditions will occur during the October through April period, with monthly average flows increasing from approximately 50% to 120% in the Susitna Station region. The greatest increases will occur during the December through March period. Summer discharge levels will be decreased slightly, with the maximum monthly average decrease in discharge being approximately 15% at Susitna Station. This maximum decrease will occur during June.

The effect on the upper Cook Inlet estuary of altered discharge patterns will be of much smaller magnitude than those which may possibly occur in the Susitna River between Talkeetna and Devil Canyon. The difference in importance is mainly because the upper Susitna River contributes roughly only 20% of the total Susitna River discharge entering Cook Inlet.

The Susitna does contribute a significant portion of the total volume of fresh water entering Cook Inlet annually. It has been estimated that the Susitna and the other rivers entering the Knik Arm contribute nearly 80% of this volume. The Susitna River alone is responsible for approximately 60% of the annual freshwater contribution to the inlet. During the operation, first, of Watana and, then, of Watana and Devil Canyon as well as during the filling of the Watana impoundment, however, changes in the annual freshwater contribution entering Cook Inlet from the Susitna will be negligible.

Increased winter discharges will increase the volume of fresh water entering the estuary during the winter and may lower salinity levels in the vicinity of the river mouth. Strong tidal action in this region is likely to result in water's being mixed fairly rapidly through the water column. Such mixing will further reduce the possibility of the formation of a well-defined surface layer characterized by significantly lower salinities. Air temperatures are low enough during November and December, however, to cause the rapid onset of freezing, despite minor variations near the Susitna River mouth in either the salinity or water temperature. The ice breakup pattern in the spring could be altered slightly by the decrease in the volume of the annual freshet.

In general, substantial decreases in turbidity levels in an estuary could influence productivity and result in an increase in predation upon larval and juvenile fishes, particularly pink salmon. Studies have shown that predation on juvenile pink salmon in estuarine environments can be exceedingly high. Since much of this predation is based upon visibility, lower turbidity levels can increase predation considerably. Decreased turbidity levels in the estuarine plume, however, could increase primary productivity levels. This decreased turbidity could result in a corresponding drop in the extinction coefficient which indicates a greater amount of light penetration into the water column.

Increased winter flows could shift the region of maximum productivity in the upper estuary farther from the river mouth region. Effects upon estuarine ecological conditions will probably be minor.

As mentioned previously, however, the maximum decreases during the May through August period in the lower Susitna near Cook Inlet will be, on the average, approximately 15% and will occur during June. Decreases of around 10% are anticipated during May, July, and August. These changes are not thought to be of significance, especially when compared to the mean monthly fluctuations on a year-to-year basis. These have been estimated to be over 50% in July and over 100% during June and August. It would appear that predicted post-project changes in summer discharge levels will not affect smolt outmigration or adult spawning migration patterns in the vicinity of the upper Cook Inlet estuary.

As discussed in Section 3.6 (d), the impacts to the various marine mammals and birds utilizing the upper Cook Inlet estuary should be minimal. Among these are the belugas, or white whales, which frequent the area between Anchorage and the mouth of the Beluga River. Some changes in the sedimentation processes within the estuary, may occur, however, especially in the delta regions.

- <u>River Mouth to Talkeetna</u>

The operation period for the dams is assumed to begin at the time when power generation starts. At that time, there will be a gradual shift from the previous 900 cfs winter flow discharge during the filling period to an average 9,000 cfs flow during full operation. The projected summer flow will range from 5,000 to 17,000 cfs, with some periods of spill resulting from heavy summer rain and glacial melt.

The operation and maintenance of the proposed Susitna Hydro Project will alter the physical and chemical parameters at the lower river in the same way that these characteristics will change during the filling period in the summer. During the winter, however, additional water will be discharged from the reservoir pool, increasing downstream flows and providing conditions that do not normally occur under the natural flow regime.

During the operation and maintenance of this project, discharge in the lower river will decrease somewhat during the summer months and increase substantially during the winter. For the Sunshine Station, the monthly mean and annual frequency duration curves project decreases in the average monthly discharge for June, July, and August. Increases in discharge will occur in October through May. No significant change in discharge is projected for September.

Data analysis indicates that post-project operation average monthly flows will resemble the historic average low flows that occur over one day during said month and are slightly below the average low flow three-day occurrence of June and July. The post-project August flows will be similar to those that normally occur over a 14-day period, while the September flows will not differ significantly from the natural flow. October post-project flows will be higher than those which occur normally but will be within the natural variability that occurs over a 14-day period. Post-project flows at Sunshine Station during November, December, January, February, March, and April will be well above the normal variability. The largest departure from the normal conditions will occur in December when normal winter flows of 4,200 cfs at Sunshine will be increased three-fold to 12,000 cfs. This change will increase the stage at the Sunshine station about one meter. The channel at this station is much narrower than at other portions of the lower river, so this stage change should project a maximum that could be expected to occur. During this winter period the total wetted surface area of the Susitna River below Talkeetna will increase above the normally wetted area of pre-project conditions.

As in the construction phase, an increase in turbidity levels during the winter should be noticeable below Talkeetna in that the Susitna under post-project water conditions will be the dominant flow contributor during these months. On the other hand, during the summer months, the turbidity below Talkeetna should not change appreciably because of the minor contribution of the Susitna in this reach to the suspended sediment load.

Examination of other water quality parameters measured throughout the year does not indicate any abnormal concentrations that may be limiting to aquatic life. Increases in nutrient concentrations should result from the flooding of vegetation within the impoundments. Phosphorous concentrations are often associated with increases in productivity. Increases in nutrients in glacial systems, however, which are already light limiting, do not necessarily cause increases in production. Downstream nutrient increases are a likely consequence of the construction of the project, although predictions of these concentrations have not been made.

Below the confluence of the Susitna and Chulitna rivers, summer changes in water quality should not be perceptible, both because of the influence of the Chulitna on the mainstem river and because of the natural variability of water quality within the system.

Temperature changes have been projected for the portion of the Susitna above Talkeetna only. By the time the water in the lower Susitna reaches the confluence of the Talkeetna, there is likely to be no difference in the water temperatures of the two rivers. During operation of the reservoirs, the larger winter flows, which will also be warmer than present winter flows, are projected to have only minor influences at the three-river confluence area near Talkeetna.

In the confluence area near Talkeetna, ice conditions will be substantially altered during the operation of the project. Under normal year temperature conditions, the increased winter water temperatures are not expected to allow an ice cover to form above the confluence. Consequently, a delay in ice formation will probably occur in the river as far down as the Parks Highway bridge. If ice is formed in November, the discharge is projected to increase by approximately one-third during the month of December. Ice jams and aufeis formation should occur at increased rates in this reach, creating high backwaters in the vicinity of Talkeetna. This ice should not have adverse effects on resident fisheries habitat but may cause flooding under normal conditions.

During the operation of the dam, flood peaks from the Susitna will be reduced, but the flood contributed by the other tributaries will continue. The flood events that currently occur every two years at Sunshine bridge will occur every 10 years during operation. The five-year peak flood that will occur under post-project conditions is predicted to be the same as the present 25-year flood. These changes are likely to provide more channel stability than that which now occurs.

o Anadromous Species

The decreased summer flows that are projected may inhibit or prevent salmon from entering some of the spawning sloughs.

Bering cisco enter the river in mid-September and spawn in the mainstem in the area between Montana Creek and Talkeetna during the first week of October. They apparently outmigrate to the ocean immediately after spawning. The times of emergence of the young and outmigration of the juveniles to the estuary have not been established. Based on the available data, however, no impacts are currently foreseen for any of the project phases.

Little is presently known about the use of the Susitna River by the eulachon. It would be expected that this species would spawn in some tributaries or in the Susitna mainstem. Eulachon upstream migration runs are temperature triggered. Since temperature in the river mouth region will not be altered, migrational runs will not be affected. On the basis of available information, it thus appears that there will probably be no impacts during any of the project phases.

o Resident Species

The species investigated by ADF&G during the summer of 1981 (with reconnaissance investigations during the winter of 1980-81) included rainbow trout, Arctic grayling, burbot, round whitefish, humpback whitefish, longnose sucker, Dolly Varden, threespine stickleback, cottids, Arctic lamprey, and northern pike.

These resident species probably spawn primarily in clear water tributaries to the Susitna with possible spawning in the mainstem by burbot, longnose suckers, and whitefish. During the winter months, many of the tributary residents outmigrate from the tributaries and overwinter in the mainstem. This movement has been inferred from capture data during the fall and spring near tributary mouths. Information on the seasonal distribution of juvenile residents is minimal.

Although very small changes in temperature regime are projected below Talkeetna, those that do take place will occur primarily during the winter months. These changes will all be well within the tolerance ranges of the resident species.

In post-project conditions, geomorphological changes in the system should be very minor in terms of their effects upon resident fisheries habitat. Because of reduced flows during the summer, there is a potential for aggradation near the confluence of the Susitna and Chulitna rivers but these changes should not affect fisheries habitat of the resident species. Ice processes will change in the confluence area but are not anticipated to create problems for resident fishery habitat.

- Talkeetna to Devil Canyon

o Anadromous Species

The third period of concern when assessing the impact of the Susitna project on local fisheries is the start of the operation, when varying flows either will be discharged through the power units or will be spilled. The following impact discussion is based on the current proposed operation of the facilities for maximum power production. The desired flows will be supplied, in part, through Cone valves. With the jets dispersing the outflow, there should be no penetration to carry air below a .6 m depth in the plunge pool. The only exception would be a major flood occurring at 50-year or longer intervals. There is now supersaturation of dissolved gas (oxygen and nitrogen) at high flows in the Devil Canyon area, but these levels are below critical levels [Figure 3.36 (APA 1981)].

It is evident that this stream becomes more turbulent and entrains more air at higher flows. It is possible that with the reduction of flow in the canyons even a small increase of saturated gas in the plunge pool will not increase present natural levels below Devil Canyon.

As mentioned above, the period of filling is the time when possible changes will begin in the deltas of the incoming streams because at that time there will be a loss of support level. This change will continue until stability is reached. The period of existing minimum flow in the river will be altered to become the period of the maximum discharge through the power units. This flow, however, is below that which would be needed to wet the sloughs, between Devil Canyon and Talkeetna which are presently used by salmon for spawning or rearing. Thus, approximately 40 sloughs, and, in particular, important chum salmon spawning habitat will be lost by the proposed project flows.

Various studies have been undertaken to indicate the temperatures that may be expected below Watana dam and below both Watana and Devil Canyon dams, when both are in operation. It is expected that as a result of river modifications caused by the project, the entire winter flow pattern will be changed at least to Talkeetna. With this change in winter flow and temperature pattern, ice production would be altered. While this alteration poses no problem above Talkeetna, it represents a potential problem to both fish and fish habitat below Talkeetna.

The clear water sources, or the aquifers, that supply the sloughs in the winter are presently unknown. In some cases, this water is apparently supplied from bank storage, and it is speculated that, in some cases the flow has an origin in the main river channel, with the water being clarified by passing through the gravels of an island. In the absence of this information, it cannot be predicted whether or not these areas will remain as salmon producers.

Recent studies have indicated that there will be significant storage of river-borne particles in the Watana reservoir. Below the two dams there will be clarification of flow during summer. This clarity, in turn, can alter the food production and the usefulness of the river for improved salmon production. Increased predation on young salmon, however, is also a possibility.

Under the maximum power production scheduled, there still will be periodic spills from Watana reservoir, which must be passed through Devil Canyon into the natural river bed. The level of these flows will be important with respect to their effect upon the morphology of the river downstream to Talkeetna, particularly their effect upon the morphology of the side sloughs or side channels where fish may now be produced.

o Resident Species

During the operation of the Susitna hydro project, physical habitat in the reach of river between Talkeetna and Devil Canyon will be changed the most. For example, during the operation phase of the program, substantial changes in the summer flows will occur. These flows will considerably alter the flow in the side channels and sloughs in this reach, reducing it to local run-off and spring flow.

During operation, sediment will probably decrease in the lower river during the summer months and increase during the winter.

Like the increases expected during filling, nutrient levels (phosphorous and nitrogen compounds) are also likely to increase during the operational period as vegetation within the impoundment becomes inundated. The consequences of these increases on downstream water quality, however, have not been determined. The limited data base does not indicate that, under pre-project conditions, any other chemicals are present at enough levels to be detrimental to aquatic life. Similarly, current available data suggest no adverse effects of reservoir operation on water quality in relation to these other chemical parameters.

The normal flood peaks that occur during the summer will be substantially reduced during the operation of the project, creating a more stable channel and reducing the bedload movement that occurs. The fall spills, whenever, they occur, however, may disrupt the newly stabilized stream bed.

The resident fish found throughout the year in this reach of the river are primarily burbot and longnose suckers. Other residents are chiefly associated with the mouths of clear water tributaries. During the early spring and late fall sampling periods, adults were found associated more often with the mainstem than they were during the summer. This probably reflects migratory movements between the clear water tributaries and the mainstem. Very little information on winter distribution is available. Friese (1975) found whitefish, grayling, and rainbow trout fry using the slough habitats during the late summer months, a reflection of the relative importance of these areas to rearing juveniles.

During the winter months, a significant increase in the wetted area of the main channel should occur. Dewatering of the side slough habitats will occur during the summer months, when water from springs will be the only contribution to these areas. The effects of reduced Susitna flows on the recharge of these springs is not known. While the portion of the resident fisheries using these areas will probably be reduced, most of the resident fish are dependent on clear water tributaries, and these areas will not be affected by the project. The significance of the rearing fish using these areas to the overall population is not known.

The decrease in scouring floods during the summer should make the mainstem more hospitable to resident fish during the summer than it is under pre-project conditions. However, insufficient information is available as to whether the post-project conditions will result in sufficient improvement in habitat to enhance the current, almost non-existent use of this type of habitat. The decreased flows during the spring, when inter-system migration of resident fish occurs, should not significantly affect this activity. No fish passage problems are anticipated, nor are there any changes in water quality anticipated which suggest adverse impacts.

Temperature effects on the river above Talkeetna will be most noticeable during the winter months. These temperatures will be well within the tolerance range of the resident species, so no direct effect will be expected.

(iii) Overview of Impacts on Salmon - Talkeetna to Devil Canyon

The following discussion is an estimate of the magnitude of the Susitna Hydroelectric Project's impact upon the five salmon species utilizing the Talkeetna to Devil Canyon reach of the Susitna River. As stated earlier, between 1% and 2% of the Susitna escapement use this reach of the river.

It is believed that the primary spawning sites for chinook salmon in this reach of the river are located in the tributaries, particularly Indian River and Portage Creek. Although the use of this stretch as a migrational route will not likely be hampered by project flow, potential loss of rearing habitat here may be an adverse impact on the chinook.

As a result of the impacts in the Talkeetna to Devil Canyon reach of the Susitna, approximately 14,000 of the annual sockeye salmon harvest in the Cook Inlet could be lost. All of the sockeye salmon in the Susitna River reach above Talkeetna were found only in the slough habitats. Yet to be defined for this reach of the river, however, is the location of rearing habitat for the sockeye. There are no lakes in this area to which they have access. If it is assumed that, at this time, the sockeye have contributed on an equal basis with sockeye from other portions of the Susitna with known rearing habitats, then the impact will be a loss of all or most of the slough spawning habitat in the Talkeetna to Devil Canyon reach. This loss will alter the Susitna escapement by approximately 1% and the Cook Inlet run by about .05%

It is expected that practically the entire adverse impact on pink salmon will occur in the reach of river above Talkeetna. Based on 1981 escapement data, if all spawning habitat were lost above Talkeetna, it would impact approximately 2% of the Cook Inlet harvest or approximately 9,000 to 10,000 odd-year run pink salmon. Since the odd-year pink salmon were found spawning primarily in the tributaries in this reach of the river and not in the side channels of the mainstem, what impact upon them that occurs is not expected to be extensive. Even-year pink salmon must, by virtue of their numbers, be less selective about the choice of spawning sites. It is, therefore, anticipated that even-year pink salmon will be found in all available habitat; however, 1982 information is needed to address this impact in detail.

Seventy percent of the Cook Inlet harvest run of coho salmon are estimated to originate from the Susitna River drainage. The Cook Inlet annual harvest for 20 years of record is 231,000 coho salmon. Preliminary sources have indicated that the 1981 Cook Inlet coho salmon harvest was a record catch of nearly 500,000 fish. An excessive harvest may have occurred and could be responsible for the low escapement of coho into the Susitna in 1981. Twenty-two percent of the Cook Inlet run returns to the Susitna River for reproduction. In 1981 this was estimated to be approximately 33,000 to 34,000 fish by the ADF&G. Coho escapement was thought to be rather weak during 1981 and the coho population is thought to be somewhat depressed. As a result, the 1981 figure is probably below the long-term average.

Most of the coho salmon that go above Talkeetna use tributaries for spawning, although some mainstem spawning has been observed. Thus, impact of power flows on the coho salmon in this reach is not expected to be severe.

It is anticipated that the flows associated with power production will all but eliminate access to essentially all of the sloughs in the Talkeetna to Devil Canyon reach of the Susitna River. The sloughs are used extensively by chum salmon for spawning. This lack of access will adversely affect the chum salmon causing a severe reduction in their population in this section of the Susitna River. On the other hand, at least 80% of the chum salmon in the Susitna River use other areas for spawning.

The percentage of all five Pacific salmon species that use the Susitna River above Talkeetna is low. In some cases, the impact associated with the power project will be minimal, as with the chinook. In other cases, such as with the chum salmon, consequences will be more severe. With regard to the useful habitats of the Pacific salmon, the remainder of the Susitna drainage, including the major tributaries and the Yentna, Chulitna, and Talkeetna rivers, will not be affected.

(e) Access Route

(i) Construction

Impacts on fish resources from access road construction could effect both anadromous and resident fish species. With proper mitigation procedures, however, these effects are not expected to be severe. Stream bank and stream bed disturbances during construction could disturb spawning, rearing, or shelter habitat in the immediate construction zone or could result in the siltation of these habitats downstream. Failure to remove fallen trees and other debris resulting from construction activities could prevent fish passage in both an upstream or downstream direction. Such obstructions would most likely be a problem in the smaller streams.

Oil residue and bacterial as well as nutrient contamination resulting from the presence of construction vehicles, facilities, and the construction work force and families could degrade the water quality of any nearby aquatic habitats. This contamination would be of greatest impact in smaller tributaries or lakes where the potential dilution of any contaminants would be limited.

The proposed access plan includes a road from the Parks Highway at Hurricane to Gold Creek, a road to Devil Canyon on the south side of the Susitna, and a north-side connection between the two dams. If this plan is implemented, the anadromous fish populations of Indian River, in particular, and the Susitna River generally could be affected during the construction phase. The construction of a bridge across the Indian River and the access road along the Indian River could both create siltation problems for spawning salmon species, in particular, king, chum, and coho salmon. Resident species could also be affected.

The construction of two bridges across the Susitna (near Gold Creek and at Devil Canyon) could also cause siltation problems downstream of both construction sites. This siltation could be detrimental to salmon utilizing the mainstem Susitna for spawning; both chum and coho salmon spawning sites have been identified in this general region of the mainstem.

The access road segment between Gold Creek and the Devil Canyon dam site would cross several small tributaries located south of the Susitna River. Most or all of these streams contain grayling populations, which may be affected during road construction.

More significant grayling populations could be affected along the Devil Canyon to Watana portion of the access road. Devil and Tsusena creeks, which would be crossed, have fairly sizable grayling populations. Since the areas of these creeks that will be crossed by the access road will not be inundated by the Devil Canyon impoundment, these crossings must be considered possible additional impacts.

Increases in angling pressure from the presence of a larger number of construction workers and their families could affect the salmon and resident fish populations throughout the regions where satellite and large construction camps and villages are located. Specifically, the presence of a construction camp at Hurricane could increase fishing pressure upon the Indian River salmon stocks. The Gold Creek camp could increase the pressure on both the Indian and the Susitna rivers. Salmon stocks in Portage Creek could be influenced by the camp location at Devil Canyon. The fish to be affected by the Watana camp population are most likely to be grayling in the Watana and possibly Tsusena creeks.

The same type of construction-related impacts noted above are possible during pioneer road construction. The same area between the Devil Canyon and the Watana dam sites that could be affected by access road building may also experience changes from pioneer road building. The segment between Gold Creek and Devil Canyon will affect areas additional to those to be affected by the permanent road. On the other hand, because of the smaller workforce, the contamination and pollution impacts would be fewer and the angling pressure far less during pioneer road construction.

Sedimentation problems may also be an impact associated with borrow pits used for access road construction. These problems would be minimal, however, compared to those created by the borrow and quarry areas used for dam construction.

(ii) Operation and Maintenance

The most significant potential impacts associated with the operation and maintenance of the access road will arise from two different sources. First, a lack of maintenance of the stream crossings could result in a degeneration of those areas, which could, in turn, affect the fish populations. The second major impact on fisheries could be triggered by the failure of the stream crossings themselves or the failure of any road design or construction methods that may have been implemented, in fact, to limit or to eliminate siltation or blockages to fish passage. General road maintenance and repair could have the same types of effects as those associated with construction, but the levels of these impacts would be lower than those of their construction period counterparts. With proper design and adequate maintenance of stream crossings these significant potential impacts can virtually be eliminated.

(iii) Public Access

The presence of the access road and any allowance of permanent access on the pioneer road could have a significant impact upon the fish resource within the vicinity of these routes. Increased public access could result in a corresponding increase in angling pressure. In contrast to a more temporary increase in angling pressure associated with the presence of the construction population, public access would create a long-term or permanent impact. An example of such a long-term consequence is the possible creation of a permanent village near the Watana dam site. The regions of greatest access would be the entire stretch of the Indian River, with its salmon fishery, and the grayling and lake trout populations in the upper basin.

Resident fish species may be particularly vulnerable to excessive fishing pressure because of their late maturity and slow growth rate. In the case of the grayling, the ease with which they may be caught by hook and line makes this species particularly vulnerable to angling pressure.

(f) Transmission Line

(i) Construction

Transmission line construction could affect fish habitat through direct streambed disturbance or by causing siltation problems downstream. This siltation would occur during the movement of construction equipment or materials through streams that need to be crossed. If stream crossings are constructed, the same impacts could occur, and problems with fish passage could arise if these structures should fail. In general, however, impacts associated with tranmission line construction should be minimal.

Impacts associated with construction camps used during transmission line construction would be similar to those associated with construction camps for access road building. The same camp sites will be used for both construction projects. Thus, the same possibility of contamination and angling pressure impacts discussed in relation to access road construction will exist for transmission line construction.

(ii) Operation and Maintenance

In terms of fisheries, impacts associated with the operation and maintenance of transmission lines should also be minimal. Streambed disturbances during routine maintenance and operation should be insignificant. Any stream crossings erected during the transmission line construction phase, if not properly maintained, could result in fish passage blockage. In the northern corridor, stream crossings over the Tanana and Nenana Rivers could be significant. Indian River and Susitna River crossings, in the central area, are also important crossing sites. In the southern corridor, critical stream crossings will be made over Willow Creek and the Little Susitna River.

3.8 - Anticipated Impacts on Threatened or Endangered Species

(a) Plants

None of the plant species under review for possible protection under the Endangered Species Act of 1973 are known to occur in the vicinity of any proposed project facilities, nor were any of these species found during searches of potential habitat [Section 3.4(a)]. Although some potential habitat does exist in the upper basin, it is distant from any proposed facilities. As a result, it is not anticipated that any of these species will be adversely affected by any project activity.

(b) Wildlife

No endangered wildlife species are presently known to occur in the project area in the upper basin [see Section 3.4(b)]. As previously noted, the peregrine falcon is the only species that could occur in the project area and no peregrines were documented during the present study. This does not, however, mean that peregrines will not, sometime in the future, attempt to use the cliff habitat along the Susitna River or adjacent tributaries for nesting purposes. Some of the cliff habitat will have been inundated, but some will remain [Section 3.6(a) and (b)]. One may speculate that if peregrines attempt to breed in the project area following construction of the hydroelectric facilities they would stand a good chance of being successful. Due to construction activity, the possibility of successful breeding during the construction phase might be considerably less, depending upon the proximity of the selected nest site to the construction sites.

There is a possibility that future use of the peregrine nest site located near the Tanana River may be affected by the transmission line. The nest was not active during 1981 but could conceivably be used at some time in the future. If the nest is active during the construction of the line, the birds may abandon it as a result of the disturbance. If the nest remains inactive during the line construction, however, it may be acceptable for later use during the operational phase of the line.

(c) Fish

Since there are no threatened or endangered fish species listed for the State of Alaska, there can be no impact in regard to this topic.

3.9 - Mitigation of Impacts on Fish, Wildlife, and Botanical Resources

(a) Mitigation Policy and Approach

The mitigation policy and approach was developed by TES in cooperation with Acres American and the Alaska Power Authority. The text was released by the Power Authority for agency review and comment. The following text is a revision of the original, incorporating agency comments.

1 - INTRODUCTION

The fish and wildlife mitigation aspects of the Susitna project have been addressed through a Fisheries Mitigation Core Group, a Wildlife Mitigation Core Group, and a Fish and Wildlife Mitigation Review Group. The two core groups consist of staff members of Terrestrial Environmental Specialists, Inc., consultants with expertise in special areas (caribou, furbearers, anadromous fish, etc.), and a representative of the Alaska Department of Fish and Game. The purpose of the two core groups is to develop the technical specifics of the mitigation policy and plans.

The purpose of the Review Group is to review and comment on the results of the core groups. Agencies represented on the Mitigation Review Group are:

Alaska Department of Natural Resources
Alaska Department of Fish and Game
U.S. Fish and Wildlife Service
U.S. Environmental Protection Agency
U.S. Bureau of Land Management
National Marine Fisheries Service

A mandate of the APA charter is to develop supplies of electrical energy to meet the present and future needs of the state of Alaska. APA also recognizes the value of our natural resources and accepts the responsibility of ensuring that the development of any new projects is as compatible as possible with the fish and wildlife resources of the state and that the overall effects of any such projects will be beneficial to the state as a whole. In this regard APA has prepared a Fisheries and Wildlife Mitigation Policy for the Susitna Hydroelectric Project as contained herein.

2 - LEGAL MANDATES

There are numerous state and federal laws and regulations that specifically require mitigation planning. The mitigation policy and plans contained within this document are designed to comply with the collective and specific intent of these legal mandates. Following are the major laws or regulations that require the consideration and eventual implementation of mitigation efforts.

Protection of Fish and Game (AS 16.05.870)

The Alaska state laws pertaining to the disturbance of streams important to anadromous fish address the need to mitigate impacts on fish and game that may result from such action. The pertinent portion of item (c) from Section 16.05.870 reads as follows:

"If the Commissioner determines to do so, he shall, in the letter of acknowledgement, require the person or governmental agency to submit to him full plans and specifications of the proposed construction or work, complete plans and specifications for the proper protection of fish and game in connection with the construction or work, or in connection with the use, and the approximate date the construction, work, or use will begin, and shall require the person or governmental agency to obtain written approval from him as to the sufficiency of the plans or specifications before the proposed construction or use is begun."

National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 USC 4321-4347) was designed to encourage the consideration of environmental concerns in the planning of federally controlled projects. Regulations pertaining to the implementation of NEPA have been issued by the Council on Environmental Quality (40 CFR 1500-1508; 43 FR 55990; corrected by 44 FR 873 Title 40, Chapter V, Part 1500). Items (e) and (f) under Section 1500.2 (Policy) of these regulations describe the responsibilities of federal agencies in regard to mitigation.

Federal agencies shall to the fullest extent possible:

"(e) Use the NEPA process to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment.

(f) Use all practicable means, consistent with the requirements of the Act and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions upon the quality of the human environment."

Federal Energy Regulatory Commission

Federal Energy Regulatory Commission (FERC) regulations also refer directly to the need for mitigation actions on the part of the developers of hydroelectric projects (18 CFR Part 4). The following reference is quoted from Section 4.41 of the Notice of Final Rule as it appeared in the November 13, 1981, issue of the Federal Register (46 FR 55926-55954) and was adopted. Exhibit E of a FERC license application should include, among other information,

". . . a description of any measures or facilities recommended by state or Federal agencies for the mitigation of impacts on fish, wildlife, and botanical resources, or for the protection or enhancement of these resources. . . ."

The regulations go on to require details concerning mitigation including a description of measures and facilities, schedule, costs, and funding sources.

Fish and Wildlife Coordination Act (915 USC 661-667)

Item (a) of Section 662 of the Fish and Wildlife Coordination Act describes the role of the federal agencies in reviewing federally licensed water projects.

". . . such department or agency first shall consult with the United States Fish and Wildlife Service, Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular State wherein the impoundment, diversion, or other control facility is to be constructed, with view to conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for the development and improvement thereof in connection with such water-resource development."

FERC will comply with the consultation provisions of the Fish and Wildlife Coordination Act.

3 - GENERAL POLICIES TO BE CARRIED OUT BY THE APPLICANT

3.1 - Basic Intent of the Applicant

In fulfilling its mandate, an objective of the Alaska Power Authority (APA) is to mitigate the negative impacts of the Susitna Project on the fish and wildlife resources. This goal will be achieved through comprehensive planning during the early stages of project development and through a program of ongoing consultation with the appropriate resource agencies. Since the APA realizes that highly coordinated planning will be necessary to achieve this goal, a decision-making methodology has been developed to provide a framework for addressing each impact and the mitigation options available. This methodology outline also identifies the process for resolving conflicts that may develop between APA and the resource agencies. The FERC will resolve any disputes which the agencies and APA cannot resolve.

The mitigation plan will be submitted by the APA to the FERC as a component of the license application. Prior to this, any draft mitigation plans will be submitted to resource agencies for formal review and comment. The final mitigation plan to be implemented will be stipulated by the FERC. The ultimate responsibility for insuring implementation of the plan will be that of the APA and will be carried out by the APA or any other organization charged with managing the project as stipulated by the FERC.

3.2 - Consultation with Natural Resources Agencies and the Public

In order to achieve the above-mentioned goals, it will be necessary to provide opportunities for the review and evaluation of concerns and recommendations from the public as well as federal and state agencies. During the early stages of planning, representatives of state and federal agencies will be encouraged to consult with the applicant and the applicant's representatives, as members of the Fish and Wildlife Mitigation Review Group. Additional review and evaluation of the mitigation plan will be provided through formal agency comments in response to state and/or federally administered licensing and permitting programs.

APA will consider all concerns expressed by members of the general public and regulatory agencies regarding the mitigation plan. Input from the public will be given appropriate consideration in the decision-making process as it pertains to the direction of the mitigation effort and the selection of mitigation options.

3.3 - Implementation of the Mitigation Plan

The ultimate responsiblity for insuring implementation of the mitigation plan rests with APA. Prior to implementing the plan, an agreement will be reached as to the most efficient manner in which to execute the plan. The agreement will determine which organization will serve to carry out various portions of the plan and will include stipulations to insure adherence to the accepted plan.

Realizing that a mitigation monitoring team will be necessary to insure the proper and successful execution of the mitigation plan, part of the plan will detail the structure and responsibilities of such a monitoring body. The successful organization and operation of a monitoring team will require both funding and commitments. These matters will be resolved through negotiation leading to mutual agreement among the various involved parties after the mitigation plan is complete and the necessary level of resources can be more accurately defined.

3.4 - Modification of the Mitigation Plan

As part of the mitigation plan, a monitoring plan will be established, the purpose of which will be to monitor fish and wildlife populations during the construction and operation of the project to determine the effectiveness of the plan as well as to identify problems that were not anticipated during the initial preparation of the plan.

The mitigation plan will be sufficiently flexible so that if data secured during the monitoring of fish and wildlife populations indicate that the mitigation effort should be modified, the mitigation plan can be adjusted accordingly. This may involve an increased effort in some areas where the original plan has proven ineffective, as well as a reduction of effort where impacts failed to materialize as predicted. Any modifications to the mitigation plan proposed by the monitoring team will not be implemented without consultation with appropriate state and federal agencies and approval of APA and FERC. The need for continuing this monitoring will be reviewed periodically. The monitoring program will be terminated when the need for further mitigation is considered unnecessary, subject to FERC approval.

4 - APPROACH TO DEVELOPING THE FISH AND WILDLIFE MITIGATION PLANS

The development of the Susitna Fish and Wildlife Mitigation Plans will follow a logical step-by-step process. Figure 1 [Figure 3.37] illustrates this process and identifies the major components of the process. Also identified in Figure 1 [Figure 3.37] are the organizations responsible for each step. The following discussion is based on Figure 1 [Figure 3.37] and uses the numbers in the lower right corner of each block of that figure for reference purposes.

The first step in the approach (Step 1) entails the identification of impacts that will occur as a result of the project. Each impacted resource and the nature and extent of the impact will be defined. The fish and wildlife resources will vary in definition and may include a population, subpopulation, habitat type, or geographic area. The nature and degree of impact on each respective resource will be predicted to the greatest extent possible. This step will be the responsibility of the Core Group of the Mitigation Task Force.

Following the identification of impact issues, the Core Group will agree upon a logical order of priority for addressing the impact issues. This will include ranking resources in order of their importance. The ranking will take into consideration a variety of factors such as ecological value, consumptive value, and nonconsumptive value. Other factors may be considered in the ranking if deemed necessary. The impact issues will also be considered in regard to the confidence associated with the impact prediction. In other words, those resources that will most certainly be impacted will be given priority over impact issues where there is less confidence in the impact's actually occurring. The result of this dual prioritization will be the application of mitigation planning efforts in a logical and effective manner. The results of the prioritization process will be reviewed by the Fish and Wildlife Mitigation Review Group.

Step 2 is the option analysis procedure to be performed by the Core Group. The intent of this procedure is to consider each impact issue, starting with high priority issues, and reviewing all practicable mitigation options.

Mitigation for each impact issue will be considered according to the types and sequence identified by the CEQ (Figure 2 [Figure 3.38]). If a proposed form of mitigation is technically infeasible, only partially effective, or in conflict with other project objectives, additional options will be evaluated. All options considered will be evaluated and documented. The result of this process will be an identification and evaluation of feasible mitigation options for each impact issue and a description of residual impacts.

Additional items that may be addressed by the Core Group include an identification of organizations qualified to execute the mitigation plan and recommendations concerning the staffing, funding and responsibilities of the mitigation monitoring team.

Step 3 concerns the development of an acceptable mitigation plan. The feasible mitigation options identified through Step 2 will be forwarded to the mitigation review group for informal agency review and comment. Any recommendations received from the review group will be considered by APA and the Core Group, prior to the preparation of draft fisheries and wildlife mitigation plans. These draft plans will be sent to the Fish and Wildlife Mitigation Review Group for comment and then, following revision, to the FERC as a component of the license application. The final fish and wildlife mitigation plans to be implemented will be stipulated by the FERC following discussions with APA and appropriate natural resource agencies.

Step 4 will be the implementation of the plan as agreed to during Step 3. This will commence, as appropriate, following the reaching of an agreement by all parties.

During the implementation of the plan, which will include both the construction and operation phases of the project until further mitigation is deemed unnecessary, the mitigation monitoring team will review the work and evaluate the effectiveness of the plan (Step 5). To accomplish this goal, the monitoring team will have the responsibility of assuring that the agreed upon plan is properly executed by the designated organizations. The team will be provided with the results of ongoing monitoring efforts. This will enable the team to determine in which cases the mitigation plan is effective, where it has proven to be less than effective, and also in which cases the predicted impact did not materialize and the proposed mitigation efforts are unnecessary. The monitoring team will submit regularly scheduled reports concerning the mitigation effort, and where appropriate, propose modifications to the plan. If stipulated in the FERC license, such reports would be distributed to FERC and State and Federal regulatory agencies.

In the event that plan modifications are recommended (Step 6), they will be reviewed by a Core Group and appropriate options considered (Step 2). The results of the option analysis will then be passed on to the APA and the resource agencies for negotiation of modifications to the plan (Step 3). Following the reaching of an agreement on the modifications, they will be implemented (Step 4) and monitored (Step 5).

Following satisfactory implementation of any plan modifications, the mitigation planning process and monitoring will terminate (Steps 7 and 8).

(b) Mitigation of Impacts on Botanical Resources

The discussion of mitigation of impacts on botanical resources centers around avoidance, minimization, compensation, and rectification. Avoidance and minimization are, in many instances, related. These types of mitigation involve refraining from unnecessary ground disturbance and regulating particularly disruptive activities, especially those involving heavy machinery and ATV use during summer and fall.

Some of these first mitigation considerations have been incorporated into the timing of construction, the layout and the location of certain proposed facilities. For example, placing of the transmission corridor close to the access road will minimize impact on vegetation by encouraging use of the road for access to tower structures. Winter construction would also limit ground disturbance.

Locating some temporary facilities or undertaking some construction activities within the future impoundment zone will also help minimize the impact on vegetation. If, for instance, access roads or other ground disturbing activities related to the selective clearing of the drawdown area are restricted to the impoundment zone, which will eventually be flooded, then associated impacts will be limited.

The location, too, within the reservoirs of several of the potential borrow areas is another example of how the total impact on vegetation will be minimized.

As mentioned above, regulation of ATV use is an important aspect of avoidance/minimization mitigation methods. During the construction period, if ATV use from the access road is restricted, then a potential impact on vegetation will be minimized. If this restriction is extended into the operation stage (especially from Devil Canyon to Watana), then impact will be further limited.

Another mitigation technique of this type concerns permafrost. In areas along the access road where drainage patterns may be changed, installing culverts or other drainage viaducts will control impacts associated with those changes. A sufficiently thick insulating layer of gravel, placed directly on the vegetation mat, will limit the potential for melting of permafrost. This standard construction technique will avoid those impacts on vegetation associated with permafrost disturbance.

Slash from spruce trees that are cut from the access road or transmission right-of-way will increase the potential for spruce bark beetle infestation. The burning of the spruce slash would limit or remove this potential.

In areas that will be directly affected, such as the impoundment zones, dams and spillways, airstrip and other permanent facilities, the elimination of vegetation/habitat area cannot be avoided. Compensation for losses of wildlife habitat could be provided, however, in adjacent open and woodland spruce stands and/or downstream balsam poplar stands. Downstream balsam poplar stands, in particular, provide the greatest opportunity for increased browse production and are located in prime moose range, where increased browse production can be more fully utilized by a consistently productive herd. Compensation techniques could include clearing (commercial or otherwise) and/or burning to enhance sprouting of poplar, birch, and willow species. Commercial clearing of downstream stands will be economically attractive, and will benefit moose, and will probably also increase the value of timber in the area, as decadent and diseased stands of balsam poplar and birch are cut and replaced by younger, healthier growth. Compensation, as a mitigation technique, for the benefit of wildlife is discussed in greater detail in the wildlife section [3.9 (c)].

Although permanent facilities will eliminate certain areas as vegetation/habitat types, impact from temporary facilities or activities can be somewhat rectified by reclamation. Standard construction practices of either recontouring or creating gentle slopes will help avoid erosion problems and will aid reclamation efforts. Borrow areas, access road cuts, areas of construction activity, and temporary facility sites will be revegetated upon completion of construction. This revegetation process will be greatly simplified and accelerated by stockpiling both topsoil and the organic layer during construction.

The stockpiling and redistribution of this material is the most important part of reclamation. Redistribution of these materials and subsequent fertilization will, in many instances, restore the vegetation cover. The first step in the process is to mix organic material into the upper 10 cm of mineral soils. Adequate fertilization can be accomplished by using fertilizer mixtures high in phosphorous [such as (N,P,K) 10-20-10, 8-32-16, etc.] and applying the fertilizer at a rate sufficient to supply 85 to 110 kg of nitrogen per hectare (75 to 100 lbs. of nitrogen per acre). During the second and third growing seasons, follow-up treatments at one-half to one-third the original rate will probably be warranted.

With topsoil in place, fertilization alone will often provide the necessary impetus for natural revegetation. Where erosion potential or aesthetic considerations are great, however, more intensive revegetation practices involving mulching and seeding, preferably with native species, will be employed. Experience in other regions of Alaska indicates that a relatively light seeding rate, which would establish a sparse stand of grass, is the best way to encourage rapid re-invasion of native plants. Ten to 20 well-established grass plants per square meter (one or two per square foot) would be adequate on sites not threatened by erosion.

(c) Mitigation of Impacts on Wildlife Resources

Following is a discussion of various means that could be employed to mitigate the impacts on wildlife resources that will be incurred as a result of the Susitna project. Mitigation options are identified for each impact issue. The options are then discussed and the most viable courses of action are identified.

Since the impacts are not of equal significance, they have been grouped into three categories. The results of this grouping are presented on Table 3.68. The impact issue numbers on Table 3.68 correspond to the numbers associated with the discussion below. The three categories are high priority, moderate priority, and low priority. Criteria applied in the determination of these categories included the importance of the resource (both biological and consumptive), the likelihood of the impact occurring, and the severity of the impact on the resource. The purpose of this approach was to insure that the emphasis of the mitigation effort is applied in the most appropriate manner.

- (W-1) Watana and Devil Canyon Impoundments - Mink and River Otter

  Creation of both impoundments will result in the loss of riverine and terrestrial habitat and an associated decrease in the available food base [See Sections 3.6 (a)(ii) and 3.6(b)(ii)].

  o Mitigation Options

  Due to the nature of this impact, compensation is the only form of mitigation that is feasible. Since it would be impossible to create suitable terrestrial habitat, in-kind compensation would require taking appropriate steps to insure that the aquatic habitat created by the impoundments would supply an adequate food base for these two furbearer species. If that approach is not possible, some form of out-of-kind compensation would be required.

  o Discussion

  There would be a negative impact on mink and river otter as a result of the elimination of a considerable amount of both terrestrial and riverine habitat. Conversely, the creation of two large impoundments will result in a net increase in the amount of aquatic habitat available. The important question is how suitable the impoundments will be in providing available feeding opportunities for mink and river otter. The impoundments may, without any action on the part of the applicant, provide an adequate food base to compensate for the predicted loss. Until further details are available, it is difficult to quantify this potential. There are thus three scenarios associated with this situation: 1) the impoundments will be suitable for a healthy fisheries resource and that resource will develop naturally, 2) the reservoirs will be suitable for the establishment of a fisheries resource but the introduction of fish will be required to stimulate the growth of that resource, and 3) the impoundments will not be capable, from a limnological standpoint, of supporting an adequate fisheries resource.

o Conclusion

The predicted impacts on mink and river otter could be mitigated to some degree by a program of establishing a viable fisheries resource in the two impoundments. The first step in such a program would entail determining the suitability of the impoundments to support fish. If the impoundments were determined to be suitable for fish, and if natural processes were determined to be insufficient to develop such a fish resource, a stocking program could be implemented to stimulate the creation of a suitable fish population, which would also provide recreational fishing opportunities. If the development of a fisheries resource, either naturally or as a result of artificial means, were not to prove feasible, the impact could be compensated for through some other species.

- (W-2) Watana and Devil Canyon Impoundments - Pine Marten

Creation of both impoundments will result in the loss of pine marten habitat by flooding [see Sections 3.6(a)(ii) and 3.6(b)(ii)].

o Mitigation Options

It will be impossible to avoid this impact entirely, and unless a project with a lower pool elevation were to be built, no minimization opportunities exist. Therefore, the only feasible form of mitigation is through compensation in an out-of-kind manner.

o Discussion

Due to the nature of pine marten habitat, it will be impossible to manage or create compensatory habitat in the project area. In addition, this species will be severely affected in the project area because the bulk of suitable marten habitat lies within the project impoundment zones.

o Conclusion

Since the marten is an important resource to trappers, any out-of-kind compensatory action would most appropriately involve other furbearer species if at all possible. If the loss of marten habitat and the resultant impact on marten were to be compensated for by improving the habitat for some other furbearer species, either within the project area or outside of the project area, the result would be no net loss to the total furbearer resource. If full compensation were not accomplished, the net loss to the resource would be attributable to the Susitna hydroelectric project.

- <u>(W-3) Watana and Devil Canyon Impoundments - Cliff-nesting Raptors</u>

Due to inundation, a total of 42.5 km of good nesting cliffs will be lost. This reduction in the number of available nesting sites will result in an increase in the importance of the remaining good nesting cliffs in the vicinity of the proposed impoundments [see Sections 3.6(a)(iii) and 3.6(b)(iii)].

o <u>Mitigation Options</u>

Although it would be impossible to avoid this impact, it could be minimized by taking action to allow raptors to utilize the remaining sites. If the raptors do not find the remaining nest sites acceptable, or if attempts to protect these sites fail, it is unlikely that the impact could be compensated for in any in-kind manner, thus necessitating an out-of-kind act of compensation. The following options exist and would serve to minimize the impact by protecting remaining sites.

1. Planning by people such as recreation specialists could attempt to avoid schemes that would bring people in proximity to cliff-nesting sites, at least during the sensitive time period (gyrfalcon: 15 February-15 August and golden eagle: 1 April-31 August) or until June 1 when a nesting site could be determined to be inactive.

2. Activities associated with the clearing of woody material from the impoundments could be scheduled so as to avoid those areas where suitable nesting habitat is expected to remain following flooding.

3. During the construction and operation phases of the project, helicopter traffic could be restricted, unless absolutely necessary, from those areas that are suitable nesting sites. This restriction would need to apply only during the sensitive time period. See Impact Issue W-23 for details on air traffic restrictions.

o <u>Discussion</u>

It would be preferable that raptors currently nesting along the river not be unduly harassed during the construction phase. This protection would increase the likelihood of these birds utilizing alternative sites as presently used sites are inundated. It would be possible to identify potential alternative sites prior to the start of construction. If these sites could be protected, the impact associated with the loss of presently used sites might be minimized.

o Conclusion

If the options identified above were to be implemented, the impact on cliff-nesting raptors could be reduced. Of the three options, numbers 1 and 3 would have the greatest likelihood of achieving the desired reduction in impact. Option number 2 might or might not prove of importance depending on the proximity of areas to be cleared to nesting sites. It is anticipated, that due to topographic factors, the amount of clearing necessary near nesting sites would probably be minimal. If the remaining nest sites were to prove to be unacceptable to raptors, the possibility of erecting artificial nest platforms could also be investigated.

- (W-4) Watana and Devil Canyon Impoundment - Bald Eagle

The two impoundments will result in the loss of bald eagle feeding habitat and the flooding of two of the six active nests and the one known inactive nest in the area, [see Sections 3.6(a)(iii) and 3.6(b)(iii)].

o Mitigation Options

A variety of steps could be taken to minimize, and if necessary, compensate for the loss of nesting sites and feeding habitat.

1. During the clearing of the impoundments, clumps of tall spruce trees (where they are available) could be left uncut along the impoundment at 1 to 2 km intervals. The clumps selected should be located in the cleared zone as far from the normal high pool level as possible to avoid their being washed away during unusually high water periods. If other conditions permit the existence of a large eagle population, but suitable trees are not available, artificial perching sites could also be provided.

2. Following inundation, eagle nesting could be monitored to determine if eagles are successfully locating and using alternative sites. If it were determined that the eagle population had suffered due to a failure to use the remaining nesting opportunities, artificial nesting platforms could be erected in suitable locations.

3. If limnological conditions were suitable, and the impoundments did not naturally develop a suitable fisheries resource, efforts could be undertaken to stock fish species to generate a good food base for bald eagles. Species with recreational fishing potential could be selected.

o Discussion

Although some eagle nests and suitable nesting sites will be lost as a result of the project, the creation of two large impoundments may, if suitable conditions exist, result in a greater abundance of bald eagles using this area in the future than are currently found here. If the proper steps were taken, this potential increase in eagle abundance and some form of management could function as a form of out-of-kind compensation to offset losses suffered by other species.

o Conclusion

The three mitigation options identified above would all be feasible and if implemented could serve not only to minimize the magnitude of the predicted impact, but also possibly to increase the present bald eagle population as a form of compensation for impacts on other species. Of the three options, numbers 2 and 3 would be the most important in terms of achieving the desired goal.

- (W-5) Watana and Devil Canyon Impoundments - Forest-dwelling and Riverine Bird and Small Mammal Species

The two impoundments will inundate a large percentage of the forested habitats in the vicinity of the project with a resulting negative impact on those bird and small mammal species that utilize these habitat types [see Sections 3.6(a)(iii) and 3.6(b)(iii)].

o Mitigation Options

It will be impossible to avoid this impact entirely, and unless a project with a lower pool level is selected, no minimization opportunities exist. In-kind compensation is also not feasible since it would be impossible through habitat management techniques to create comparable habitat in the project area. Thus, the only form of mitigation that is feasible is out-of-kind compensation through a different species or group of species.

o Discussion

In the vicinity of the project the type of habitat associated with this group is found primarily within the impoundment zones. Thus, avian and small mammal species that utilize the vegetation cover types that will be inundated will be severely impacted within the project area.

o Conclusion

Since direct in-kind compensation is not practical, the only practical way to offset the losses incurred in this situation would be to increase compensatory efforts in regard to other species where practical mitigation options do exist. One possibility along these lines would be to compensate for this loss of terrestrial habitat by taking advantage of the newly created aquatic habitat (see Impact Issue W-17).

- (W-6) Watana and Devil Canyon Impoundments - Upper Basin Moose Population

The inundation resulting from the two impoundments will reduce the capacity of the area to support moose. Details of this impact are presented in Sections 3.6 (a)(i) and 3.6(b)(i).

o Mitigation Options

The only appropriate form of mitigation in regard to this impact issue would be compensation: it would be feasible through habitat management to compensate for the loss that will be incurred. Habitat management efforts could be carried out in any of the following areas: 1) the upper basin adjacent to the new impoundments, 2) selected portions of the lower basin, 3) a combination of upstream and downstream areas, or 4) some area totally removed from the influence of the project.

The only practical approach to improving moose habitat in the upstream area may be through prescribed burning. In the downstream area, it would be possible to improve moose habitat directly either on selected river islands and/or associated riparian areas, or in more upland situations east of the river. On the islands with more mature stands of timber, logging operations could provide the needed habitat alterations: in those areas that do not contain mature balsam poplar trees, prescribed burning could provide the needed alterations. In upland areas, either burning, crushing, logging, or a combination of all three are possible management options.

o Discussion

The first determination is whether the mitigation efforts should be implemented in the immediate vicinity of the impact (upstream) or if more distant areas are acceptable (downstream). The factors in this decision would be the consequences for the moose population itself, for related species, and for sportsmen. Along the lower river, there are proven techniques available that would, with a high degree of certainty, be effective in achieving the desired mitigation. On the other hand, in the upper basin the only practical option appears to be prescribed burning, and this technique may not be able to produce the desired results under the environmental conditions present. An upstream management effort might so alter the habitat as to enable the existence of a moose population at an artifically high level, and unless long-term management efforts were continued, there would ultimately be a reduction in carrying capacity. (Of course, management efforts in the downstream area might also result in a high moose population that would require long-term management.) By not managing the upstream area, the moose population would be allowed to reach a new, lower level that natural conditions could support.

The status of moose in the upper basin is important to a variety of other species, including: (1) wolves and bears, which prey on moose; (2) caribou, which would probably incur higher wolf predation if the moose population decreased; and (3) numerous scavengers, such as the wolverine and red fox that frequently utilize wolf-killed moose for food. Therefore, allowing the project to reduce the carrying capacity of the upper basin for moose would have indirect impacts on other species.

The impact on sportsmen, although not a biological consideration, should also be factored into the choice. Failing to support upstream moose would not be taken favorably by hunters who use that area, but likewise the improvement of moose habitat in the downstream area would be viewed positively by sportsmen there. In addition, improved access to the upper basin will probably result in greater hunting pressure and an associated demand for game.

An associated aspect is the impact that habitat management would have on other species: some species in addition to moose would also benefit from this type of habitat alteration, while other species would be negatively influenced.

As noted in the list of mitigation options, both the upstream and downstream areas might not be acceptable, and management efforts could be considered for other appropriate portions of the state. Areas of possible consideration could be portions of the upper Susitna basin far removed from the project areas, the Tanana Flats near Fairbanks, the Kenai Peninsula, etc.

o Conclusion

The impact on moose and other species that utilize moose could be mitigated by improving habitat in both the upper basin adjacent to the proposed impoundments and in the lower basin (see Impact Issue W-13). If habitat management in the upper basin were to be conducted, research efforts would first have to be undertaken to gain an understanding of how burning would affect vegetation and, if the results were to prove favorable, a program of prescribed burning could be undertaken. Since the effectiveness of burning is currently questionable, a program of moose habitat improvement along the lower river could also be developed. The ultimate decision as to the distribution of effort between these two areas would have to await the determination of the usefulness of burning in the upper basin.

- (W-7) Watana and Devil Canyon Impoundment - Black Bear

The two impoundments will severely impact local black bear populations [see Sections 3.6(a)(i) and 3.6(b)(i)] by eliminating a large portion of both foraging habitat and denning sites.

o Mitigation Options

The only options in regard to this impact issue are compensation by improving black bear habitat in some other area or compensation in an out-of-kind fashion through some other species.

o Discussion

The presence of a large and healthy brown bear population in adjacent areas and the restriction of forested habitats to the river area restricts the areas inhabited by black bears. Therefore, the black bear population in the project area will be severely impacted, since the impoundments will result in the elimination of most of this habitat in the area. Although the biological consequences to the total Alaskan black bear population will be minimal, black bears are of local value as a game animal. Since there is no possibility of managing the adjacent areas for black bears, the choices are to compensate through mitigation efforts directed at other species, to attempt to improve black bear habitat in areas outside of the upper basin, or to do both. Although the black bear is an abundant species in Alaska, as evidenced by the liberal game regulations, demands for this species as a game animal will probably increase in the future. Thus, this resource will probably be more important in the future than it is now.

o Conclusion

A thorough literature review of the habitat requirements of black bears could be conducted to identify any practical management techniques. These techniques could be implemented in conjunction with moose management along the lower river to improve the same areas for black bears. Encouraging greater black bear abundance, however, could reduce moose calf survival and thus be counterproductive to the goals of the moose management program. On the other hand, the loss of black bears could be compensated for by improving the status or abundance of other species, as, for instance, the above mentioned moose.

- (W-8) Watana and Devil Canyon Impoundments - Brown Bear

The impoundments created by the Watana and Devil Canyon dams will flood an area that is currently used as spring foraging habitat by brown bears [see Section 3.6(a)(i) and 3.6(b)(i)].

o Mitigation Options

Out-of-kind compensation is the only appropriate form of mitigation of this impact.

o Discussion

The distribution of the brown bear is not as restricted to the impoundment area in the upper basin, as is the distribution of the black bear, and thus the inundation of that area will result in the elimination of only a portion of the total area used by this species. As in the case of the black bear (see Impact Issue W-7), it would be impossible to create in another area habitat similar to that lost to inundation. At the present time, it is impossible to predict how much the loss of this area, which appears to be most important during spring, will mean to the brown bear population. This loss, however, will be only one of several project-related impacts on brown bears (see Impact Issues W-14, W-16, W-17, W-18, W-20, and W-23); it may not be in itself of a critical nature, but in conjunction with other impacts may severely influence the future of this species in the project area.

o <u>Conclusion</u>

Little could be done to compensate directly for this impact. Some level of mitigation could be achieved by: 1) increasing compensation efforts directed towards other species, and 2) implementing mitigation options for other impacts on this species to reduce the combined impact on brown bears.

- <u>(W-9) Watana and Devil Canyon Impoundments - Wolf</u>

The Watana and Devil Canyon impoundments will have a negative impact on several wolf packs. The two impoundments will flood moose habitat, and the predicted result is a reduction in the number of moose that will be able to inhabit the project area [see Sections 3.6(a)(i) and 3.6(b)(i)]. This reduction in the number of moose will affect wolves since moose serve as an important, if not the most important, food source for wolves.

o <u>Mitigation Options</u>

The only feasible form of mitigation would be to take steps to maintain the present abundance of moose in the upper basin. If this were to prove impossible, the impact on wolves would have to be compensated for in some out-of-kind manner.

o <u>Discussion</u>

The extent to which the reduction in moose will impact this species is difficult to predict, although it will certainly have some negative impact. Although wolves feed on moose, they also kill numerous caribou; the distribution of caribou, however, varies both from year to year and also among seasons. Thus, caribou do not represent as consistently available a source of food as do moose. Whether or not the upper basin could successfully be managed for moose is questionable and the extent to which the moose population could be maintained through management is unknown (see discussion on Impact Issue W-6). Yet, the location of moose management efforts and their success would be one factor that would influence greatly the future status of wolves in the upper basin.

o Conclusion

If the options for managing upper basin moose (as identified in Impact Issue W-6) were to be implemented successfully, the impact on wolves could be minimized. The project will impact wolves in other ways, and although each impact may not appear severe by itself, collectively they represent a major impact on this species; therefore, the total impact of the project on wolves will depend on the overall mitigation of impacts on wolves.

- (W-10) Watana Impoundment - Dall Sheep

The impoundment created by the Watana dam seasonally will flood a major portion of the Jay Creek mineral lick and thus may negatively impact the sheep population that currently uses it [see Section 3.6(a)(i)].

o Mitigation Options

Compensation for this loss would be the only possible form of mitigation. An artifical lick within the range of the sheep that currently use the Jay Creek lick could replace the inundated mineral lick.

o Discussion

It appears that at least a portion of the Jay Creek lick will be inundated during a part of the year. It is possible, however, that the lick will not be under water during May and June, when most use of the lick occurs. Whether or not the lick will still be usable or acceptable to sheep under project conditions is a matter for speculation. It is also not known how dependent the sheep population is on this lick. Considering the frequency of use and the willingness of sheep to expose themselves to predation in order to reach the lick, however, it must be of some significance to them.

o Conclusion

The following steps could be taken to mitigate this impact:

1. Efforts currently underway to determine the chemical composition of the lick and the number of sheep using the lick could continue.

2. Following inundation, monitoring efforts could be undertaken to actually document the reaction of sheep to the change and the extent to which they continue to use the lick.

3. If the lick is abandoned following flooding, or if the use of it is reduced substantially, an artifical lick could be established using mineral blocks specifically designed to match or improve upon the chemical composition of the current lick. The artificial lick would need to be placed within the natural range of these sheep and preferably in a location where sheep would be less vulnerable to predation.

- (W-11) Watana Impoundment - Caribou

It is possible that ice conditions and/or floating debris will act as a barrier to migrating caribou [see Section 3.6(a)(i)].

o Mitigation Options

The potential problems associated with floating debris acting as a barrier would be minimized by totally clearing all woody material from the reservoir site. If problems were to materialize with floating debris, a removal program could eliminate the barrier. Another option, which would also mitigate the potential impact of hazardous ice conditions, would be to erect temporary fences to direct migrating caribou to safer crossing points. If attempts to direct the Nelchina herd to safe crossing points were to fail, and the herd were to be blocked totally from reaching the present calving area, the only other mitigation option would be to insure that the area it selects for calving would be protected during the calving period.

o Discussion

The severity of this impact will depend on four factors: 1) whether or not conditions actually develop which create barriers, 2) whether or not the caribou are able to locate safe crossing points, 3) whether or not the herd has to cross the impoundment, and 4) if they are forced to calve in a new area, whether or not that area will prove suitable for successful calving. In the past, the Nelchina herd frequently has wintered north of the Susitna River and so has crossed the river as it moves to the calving area on the south side. During the past few years, however, it has wintered east of the calving area (particularly on the Lake Louise Flats) and so has moved in a westerly direction to reach the calving area. Likewise, the herd has not recently moved across the river from south to north after calving, although such a post-calving movement frequently has occurred in the past. It is impossible to predict whether or not the current movement patterns will persist after the impoundment is created. Considering the tendency of caribou herds to suddenly shift migratory patterns, however, it is likely that sometime following inundation they will again attempt to cross in a southerly direction en route to the calving area and/or in a northerly direction following the calving period.

If, as a result of the project rafts of debris, shelf ice, or both exist, and if and when such a crossing takes place, the movement of the herd could be blocked or altered. The conditions present during a crossing attempt will probably vary greatly from area to area and from year to year, and presently it is predicted that caribou will attempt to locate safe crossing points if faced with hazardous conditions. They may also attempt to circumvent the situation by moving around the entire impoundment on the eastern end. If they fail to select safe crossing points, it might be possible to erect temporary fences to alter the direction of their movement and guide them to safer points. If all this were to fail and the herd were to be blocked totally by the Watana impoundment and forced to calve elsewhere, some means could be found to insure the total protection of the herd from human disturbance as it attempts to adjust to a new calving situation.

o Conclusion

If the potential for severe impacts on caribou materializes, they could be avoided or minimized through a program of monitoring, fencing, protection, and debris removal. To eliminate some of the unknowns associated with mitigating these potential impacts, the movements of the herd could be monitored from late winter through the post-calving period. Any such monitoring effort would need to continue until it were to be demonstrated that the herd had either successfully negotiated the impoundment in crossing, or had established a new calving area that would reduce the need for future crossings. In other words, such a monitoring effort would have to continue for at least several years following the first attempt of the herd to cross the impoundment. It is impossible, of course, to predict at this point how long it might be until the Nelchina herd actually attempts a crossing under operating conditions. During the first several springs following the initiation of the project, a reconnaissance survey could be conducted to ascertain the condition of drawdown ice conditions and the existence of any floating debris sufficiently extensive to serve as a barrier.

This information would be needed if an attempt to alter the direction of migratory movements by fencing were to be made. Depending on this review of crossing conditions, a plan for establishing temporary fences could be prepared; if it appears that traditional crossing points will be difficult for caribou to negotiate, fencing material could be placed so that, if monitoring efforts indicated the likelihood of an attempted crossing, fences could be erected quickly.

The fencing would create a visual barrier, not necessarily a physical one. Thus, relatively inexpensive material such as snow fencing or even burlap sheeting could be used. In order to avoid undue interference with other species, such a fencing effort would be employed only when the herd is migrating towards the river and appears to be heading for hazardous crossing points.

If a new calving area is established, it may be feasible to protect the herd from human disturbance during the calving period. Such protection could include a total closure to all human activity during the calving and post-calving periods as well as air traffic restrictions specifying a minimum flight altitude of at least 300 m (1,000 ft) above ground during the calving period and over the post-calving aggregation.

- (W-12) Operation of Devil Canyon Dam - Downstream Beavers

Changes in the flow regime caused by the Devil Canyon dam will affect beavers living downstream from the dam [see Section 3.6 (d)(iii)]. Reduced summer flows may result in the availability of fewer sloughs for use by these aquatic furbearers. The daily fluctuations in flow may also cause unstable ice conditions and make it very difficult for beavers to maintain winter food caches.

o Mitigation Options

The predicted impact on aquatic furbearers in this area could be minimized by reducing the degree of daily flow fluctuations during the winter months and by operating the dam so that flow regimens are as close to natural conditions as possible.

o Discussion

The exact extent of this impact is difficult to predict at this time and will differ between the areas north and south of Talkeetna. Although there may be less summer habitat available, it is possible that higher winter flows may actually increase the amount of suitable overwintering habitat for beavers. If unstable ice conditions exist due to daily fluctuations, however, there could be a net decrease in beaver abundance because they will not be able to maintain food caches which are normally frozen in place by ice. It is anticipated that such ice problems would be most prevalent north of Talkeetna which has comparatively fewer beavers than the area south of Talkeetna.

In addition to serving as an important fur resource, beavers inhabiting the floodplain of the lower Susitna River also aid in the creation of moose browse by cutting trees and opening areas for the generation of early successional shrub species.

Thus, any negative impact on beavers in this area could indirectly reduce the winter carrying capacity for moose. At this time, it is impossible to state what proportion of the moose browse is the result of beaver activity in comparison to other factors that influence the generation of browse.

o Conclusion

If the Devil Canyon dam were to be operated so as to reduce the magnitude of daily fluctuations, then the possibility of negatively impacting downstream beavers would be reduced. Since the activities of beavers can influence the status of other species, such as moose, studies documenting the degree of this influence could also be undertaken. Such studies would be necessary if the total impact on downstream moose, and thus the level of compensatory efforts required, were to be determined (see Impact Issues W-6 and W-13).

- (W-13) Operation of Devil Canyon Dam - Downstream Moose

Downstream from Devil Canyon to Cook Inlet there may be an alteration of plant succession trends due to flow regulation. As a result, there may be a reduction over time in the amount of winter browse available to moose that rely on this area during winter, especially when deep snows prevail [see Section 3.6(d)(i)].

o Mitigation Options

There are several management techniques that could be employed to improve moose habitat in this area in order to compensate for possible reductions in the quantity of browse. These include: 1) commercial logging of mature balsam poplar trees on selected islands; 2) prescribed burning of islands that are not dominated by mature balsam poplar trees; 3) logging, burning, or crushing of vegetation in upland areas east of the river.

o Discussion

Based on the information currently available, it is difficult to accurately predict the extent of this impact. Trends in the quantity of browse will be predictable, as the nature of the river and the number of factors that influence the creation and movements of islands are understood. Still, it will probably be impossible to ever determine the actual quantity of browse that may be lost as a result of the project. If the regulation of the river does cause a reduction in the creation of new islands (and thus areas suitable for the invasion of browse species such as willow), it is expected that two changes will occur in sequence. First, many areas that would have been washed away under present flow conditions will remain secure enough for the development of moose browse; as a result, there will be a short-term (10 - 20 years) increase in the amount of browse available to moose. But, second, as plant succession proceeds and the vegetation matures there will be a gradual long-term reduction in the capacity of the riparian area to support moose during deep snow conditions; there will thus be a reduction in the abundance of moose.

o Conclusions

The possible loss of moose browse could be mitigated if a habitat management program were developed to improve the habitat in the area south of Devil Canyon to support wintering moose. As previously discussed (Impact Issue W-6), this area could also compensate for moose habitat losses in the upper basin.

Moose currently use the riparian area during severe winters. They move to the river both from the east and the west. Those who move into this area from the east move down from the foothills of the Talkeetna Mountains, and many are killed crossing the Parks Highway and the Alaska Railroad. If management efforts were to be directed at areas east of these two transportation corridors, these moose might no longer move into the riparian area to browse. On the other hand, management efforts directly on the river could be undertaken to provide browse for those moose that would continue to enter the riparian area from the west.

The first step would be to identify appropriate areas for management activities; considerations would include ownership and vegetation types, and a correlation of this information with census and movement data being collected by ADF&G. Where appropriate, blocks of mature trees could be removed by commercial logging operations. Prescribed burning could also be used; but due to the extent of human habitation in this area, there could be severe constraints on burning. The use of vegetation crushers also would be a possible management technique in areas where burning and logging might not be feasible.

- (W-14) Clearing of Woody Material From the Impoundments - All Upstream Big Game Species

Big game species will avoid the area being cleared during the period of clearing [see Sections 3.6(a)(i) and 3.6(b)(i)].

o Mitigation Options

In order to minimize the magnitude of this impact on animals existing adjacent to the proposed impoundment zones, the clearing of woody material in the drawdown zone could be conducted during the later portion of the filling period. This would also leave more habitat intact for a longer time. Therefore, the temporal magnitude of the habitat loss that will result from the impoundment will be reduced. In certain cases, the timing of clearing activities could be scheduled so as to minimize disturbance of important wildlife areas.

o Discussion

There is little justification for a large mitigative effort in this area since this impact will be relatively short and basically will impact animals that will be far more severely impacted by inundation and the associated permanent loss of habitat. In addition, there will be differences in the severity of the disturbance depending on the associated big game species.

o Conclusion

If the impoundment zone were to be cleared during the filling period, then the temporal magnitude of this impact could be minimized. The only other mitigation opportunities associated with this impact concern the Jay Creek mineral lick (see Impact Issue W-10). Since sheep may be able to use this lick following inundation, disturbance resulting from any necessary clearing activities in this vicinity could be avoided if no clearing were to be conducted within 2 km (1 mile) of the lick during the months of May and June. This would enable the uninterrupted use of the lick by sheep and possibly allow for continued use following filling.

- (W-15) Clearing of Woody Material from the Watana Impoundment - Caribou

The activities associated with the clearing of woody material from the Watana impoundment will disturb caribou migration to the calving area south of the river and/or post-calving movement to the area north of the river [see Section 3.6(a)(i)].

o Mitigation Options

Two options exist to avoid or minimize the magnitude of this impact: 1) clearing activities could be scheduled to avoid areas used as crossings during the migratory period, and 2) travel lanes could be left uncut to provide sheltered routes across the impoundment zone during the construction period.

o Discussion

Caribou movement patterns are unpredictable. During the clearing period a major movement of the Nelchina herd through the impoundment zone en route to or from the calving area may or may not occur. (Such movements have occurred in the past.)

In order to avoid undue disturbance of this critical activity, certain steps could be taken to minimize disturbance of migrating caribou. Late winter and early spring monitoring of the herd could be conducted to predict if any action were necessary. Clearing schedules could be kept flexible enough to accommodate a shift in the location of clearing efforts if necessary.

It can be argued that little attention should be devoted to this short-term impact since a reservoir will ultimately cover the area in question. Even though the disturbance of migration caused by clearing activities admittedly is a short-term impact, it is also one of many forms of impact to which the Nelchina herd will be subjected as a result of the project (see Impact Issues W-11, W,14, W-17, W-18, W-20, W-22, and W-23). Each impact may not by itself represent a severe impact on the herd, but collectively there could be a major disruption of the activities of this herd with associated negative consequences. Therefore, it is important that each caribou-related impact issue be mitigated to the fullest extent possible in order to minimize the collective effects of all forms of impact.

The major issue in this case is the disruption of the movement of the herd to and from its calving area. If the herd is permitted to cross the river during the clearing and filling phases of the project, its chances of making successful crossings during operation will be increased.

o <u>Conclusion</u>

This impact could be avoided or minimized if travel lanes were to be left uncut until absolutely necessary. Such travel lanes would have to be located between Deadman and Jay creeks and would have to be at least 0.8 km wide. Three or four such lanes would appear to be adequate and would have to be continuous from one side of the impoundment zone to the other.

During the clearing period, the Nelchina herd could be monitored by ADF&G (especially in late winter and early spring) so that the possibility of the herd attempting to cross the river from north to south could be determined. If such monitoring efforts indicate that a crossing is about to occur, clearing operations could be halted in the crossing area for the four to six week period during which crossing normally takes place. (This will likely occur from early April to mid-May.) Any monitoring effort could continue during the early post-calving period, and, if it appears that the post-calving aggregation of cows and calves will cross the river moving north, clearing activities could be temporarily halted in the area of crossing.

- <u>(W-16) Construction Camps/Villages and All Access Roads - Red Fox, Black Bear, Brown Bear, Ground Squirrel, Gulls, and Raven</u>

These species could be negatively impacted as a result of illegal feeding by personnel associated with the construction and operation of the Susitna project. Improper disposal of garbage would also result in an impact on these species.

o Mitigation Options

The following options exist to avoid and/or minimize impacts associated with the feeding of wild animals by humans and the acquired dependency of wild animals on available refuse. Current plans to cover the landfills with soil on a daily basis would help minimize this potential problem.

1. All camp facilities (especially landfills) could be securely fenced with the bottom edge of the fences buried 0.5 m (18 in) below ground.

2. Secure garbage containers could be available in all work areas, and all refuse could be collected and incinerated or disposed of in a properly operated landfill.

3. Work crews could be hired and charged with picking up all discarded refuse from work areas and along all access roads.

4. State laws prohibiting the feeding of wild animals could be strictly enforced by security personnel and repeated violators dismissed from their positions of employment and permanently prohibited from future work on any aspect of the project.

5. A mandatory education program for all project personnel could be prepared and implemented.

o Discussion

Through proper planning and a concerted effort, this is one impact that could be minimized, if not totally avoided. The key element in the successful execution of these options would be the personnel responsible for the actions of all workers associated with the construction effort. It therefore would be critical that all supervisory personnel be impressed with the need to prevent illegal feeding of wildlife and be committed to maintaining a preventative program to that end. All construction contracts and union agreements entered into for this project could clearly identify the agreed-upon rules and regulations that pertain to this issue and the consequences to workers who fail to comply.

o Conclusion

If the mitigation options identified above were to be implemented and if the Watana landfill were to be covered daily as planned, the probability of avoiding or minimizing this impact would be very high.

- (W-17) Main Access Road, Borrow Areas, Access Roads to Borrow Areas, and Construction Camps - All Furbearer Species, Many Avian and Small Mammal Species, and All Big Game Species Except Dall Sheep

These project components will result in a loss of habitat for the indicated wildlife resources. Details of these impacts are presented in Sections 3.6(a), 3.6(b), 3.6(c) and 3.6(e).

o Mitigation Options

The magnitude of this impact could be reduced by arranging camp facilities compactly and keeping them as close to work areas as feasible. Permanent facilities (main access road and town site) will represent a permanent loss of habitat, and compensatory actions through habitat management could be implemented. Areas containing temporary facilities (borrow areas, roads to borrow areas, and temporary camp facilities) could be restored to a condition that would provide usable wildlife habitat.

o Discussion

There are basically three levels of consideration involved with this issue. First, through careful planning the magnitude of the habitat loss associated with these project components could be minimized to some degree. Second, temporary use areas, such as borrow areas and portions of camp facilities, could be restored to allow for some future use by wildlife. And third, unavoidable losses that will result from the permanent portion of the project could be mitigated through compensatory action.

o Conclusion

If the following steps are taken, the anticipated habitat losses associated with the project components mentioned above could be mitigated.

1. As presently proposed, camp facilities will be arranged compactly and located close to work areas in order to avoid undue habitat disturbance.

2. Presently there are plans to restore temporary use areas (borrow areas, roads to borrow areas, and temporary portions of the camp). All topsoil removed from these areas will be stockpiled and saved. In addition, any topsoil removed from areas that will be permanently disturbed could be saved and added to the stockpiles. Following the use of each area, the topsoil will be reapplied and the area regraded, if necessary, to avoid erosion. Restored areas will then be seeded lightly with grasses and fertilized to stimulate the initial growth of native vegetation. During the first year of such an effort,

the recommended fertilizer is a mix high in phosphorous (such as N,P,K 10-20-10 or 8-32-16) applied at a rate sufficient to supply 85-110 kg of nitrogen per hectare (75-100 lbs per acre). During the second growing season, these areas should be fertilized at a rate one-half that of the initial treatment. During the third growing season, they should be fertilized at a rate one-third that of the initial treatment.

3. To compensate for permanent losses to big game species, habitat management efforts could be directed toward moose.

   In the case of avian species, efforts could be expended to improve habitat for certain waterfowl in the newly created aquatic habitat of the impoundments in order to compensate for the loss of terrestrial habitat and associated terrestrial species. Once the limnological suitability of the impoundments to support a good fisheries resource can be determined, an adequate fisheries food base in the impoundments could be insured by stocking appropriate fish species. This aspect of such a compensation program would also benefit aquatic furbearers, and such stocking would additionally have recreational potential. Following the establishment of a food base, nest boxes could be erected in adjacent forest areas to provide nesting opportunities for cavity-nesting waterfowl such as goldeneye and bufflehead.

- <u>(W-18) Borrow Areas and Access Roads to Borrow Areas - All Upstream Big Game Species Except Dall Sheep</u>

  The activities associated with borrow excavation and transportation will cause an avoidance reaction by and resultant habitat loss to big game species during the construction period [see Section 3.6(c)(i)].

  o <u>Mitigation Options</u>

    The only option to minimize the magnitude of this impact would be to schedule activity and equipment movement so as to allow animals to utilize the area adjacent to the borrow areas for a portion of each 24-hour period.

  o <u>Discussion</u>

    Limiting human activity in these areas to certain portions of the day may prove effective only for some species. It is likely that moose would benefit from such an arrangement, while species with a greater aversion to man, such as wolf and wolverine, would not respond positively to such an approach.

  o <u>Conclusion</u>

    Duration of this impact will be only the construction period, and it is likely that any scheduling program would be only partially effective. Thus, restoration of these areas so as to secure the long-term availability of the habitat could be more effective than a scheduling program.

- (W-19) All Access Roads - Moose and Caribou

Moose and caribou may be killed as a result of collisions with vehicles using both the main access road and the access roads to borrow areas [see Section 3.6 (e)].

o Mitigation Options

Although it is unlikely that this impact could be totally avoided, steps could be taken to minimize the magnitude of this impact. Construction workers, and especially truck drivers, could be educated concerning the value of wildlife in the area and the need to minimize negative impacts through careful and thoughtful driving. Warning signs could be erected in areas of high collision potential. Speed limits that would reduce the frequency of collisions could be posted and enforced. During winter months when moose and caribou may frequent roads to take advantage of superior traveling conditions, numerous pull-off areas could be plowed clear to give animals opportunities to escape vehicles.

o Discussion

The severity of this impact will depend on several factors, the volume and speed of project-associated traffic, the attitude of the drivers, and the depth and duration of winter snow. Collisions will be a continuing hazard, to both wildlife and motorists, during operation of the project, especially if public access is allowed.

o Conclusion

In conjunction with the educational program to reduce the illegal feeding of animals (see Impact Issue W-16), an attempt could be made to impress upon workers (especially those workers who will be driving trucks and other large equipment) the value of wildlife and the need to avoid killing animals through collisions with vehicles. Speed limits could also be established on the access road and strictly enforced. The appropriate rate of speed would depend on the design of the road, the types of vehicles using the road, etc. To mitigate this potential impact, the speed limit could be kept as low as possible while still allowing for the timely movement of equipment and personnel. Due to the increased frequency of collisions after dark, it would also be advantageous to have two speed limits: one for daylight hours and a lower limit for night. The placement of warning signs at known crossing points could alert motorists to the increased likelihood of encountering moose or caribou on the road.

When extremely deep snow conditions prevail, pull-off areas could be provided along the road to provide opportunities particularly for moose to get out of the way of vehicles. The number of such pull-off areas and the spacing between them would probably vary depending on the associated vegetation cover type and the distribution of the impacted species. Therefore, prior to road construction, areas could be identified where pull-off points will be needed.

- (W-20) Access Roads and Construction Camps - All Upstream Furbearer and Big Game Species, Except Dall Sheep

These project components will result in increased human activity and resulting disturbance and harassment of wildlife, and in increased hunting and trapping pressure on the wildlife resource [see Sections 3.6(a)(i), 3.6(b)(i) and 3.6(e)(i)].

o Mitigation Options

During both the construction and post-construction period there are three options associated with human access and activity in the project areas. First, no effort could be undertaken to restrict or control human access or activity; second, efforts could be undertaken to restrict totally additional activity; and third, is a compromise option in which human access would be permitted during certain times of the year and/or in certain areas.

o Discussion

The improved access associated with the Susitna project and the impact of that improved access on both furbearer and big game species may represent the most severe single avenue of impact on wildlife as a result of this project. It may exceed those impacts associated with habitat loss due to inundation and other aspects of the project that disturb habitats. It is therefore very important that the negative aspects of this source of impact be minimized to the greatest extent possible. Because of the differences in the available control options and also differences in the magnitude of the impact potential, this issue will be considered separately for the construction period and the post-construction period.

Construction Period

During this period there will be a great number of people in the area throughout the year, and the potential for disturbing wildlife is very high. It is assumed, however, that no public use of the access road will be allowed during the construction period. Thus, during this period the opportunity for controlling human activity is greatest since the majority of personnel in the area will be under the direct control of the camp managers and will be in the area primarily for work purposes.

Therefore, although the potential for negative impact is great during the construction period, the opportunity to minimize that impact also would be available and could be used.

Post-construction Period

It is assumed that following construction the access road to Devil Canyon will be open to the general public for whatever use they wish to make of it. It is also assumed that imposing some restrictions on public use beyond Devil Canyon is a potential mitigation option. The magnitude and nature of human activity during this period is expected to differ from that of the construction period, and thus different considerations apply to mitigation planning for the post-construction period.

o Conclusion

The specific steps that could be taken to mitigate these impacts differ in the construction and the post-construction periods and are thus discussed separately.

Construction Period

The best policy that could be adopted for the construction period would be that project personnel would have no greater access to the upper basin than that available to the general public except, of course, access to the actual construction sites. All project personnel could be required to travel directly from the start of the access road to the camp or work area without stopping except in emergencies. Personnel could be restricted from leaving the access road for any reason including to hunt or trap. From mid-April to mid-September, all traffic could be restricted to a time period extending from two hours after sunrise to two hours before sunset in order to provide opportunities for big game species, especially brown bears, to cross the highway without being disturbed by traffic. The need for continuing such a restriction could be determined by means of a monitoring program during the first year of access road use under this restriction.

Post-construction Period

Following the construction period, when the road (at least to Devil Canyon) is open to the general public, ADF&G could monitor the status of big game populations in the area and take whatever regulatory steps would be practical to prevent a game harvest in excess of that which would allow for a sustained yield. The value of continuing some restrictions in access beyond Devil Canyon could be evaluated during the initial years of the post-construction period. In order to minimize undue disturbance of big game, in particular, caribou during the calving and post-calving period, ATV activity from the access road could be prohibited entirely or at least from 1 May to 15 August of each year.

There would be considerable merit to prohibiting ATV use entirely. Such a prohibition would help reduce long-term destruction of vegetation. Restriction of ATV use would be particularly important between Devil Canyon and Watana, where the road traverses open terrain.

- (W-21) Construction Camps and Village - Red Fox and Wolf

The housing of domestic dogs at the camps and villages represents the potential for the introduction of rabies into native canid species. Improper control of dogs could also result in the creation of a population of feral dogs [see Sections 3.6(a)(ii) and 3.6(b)(ii)].

o Mitigation Options

There are two options available to avoid or minimize the possibility of this impact taking place: 1) total prohibition of all dogs in the camp facilities, or 2) regulations concerning the housing and control of domestic dogs.

o Discussion

It is believed that at the present time rabies and feral dogs are not a problem in the upper Susitna basin. The housing of domestic dogs at the camp facilities represents the potential for both of these situations to change. The introduction of rabies would have a potentially severe impact on native carnivores, especially foxes and wolves, which are highly susceptible to the disease. The establishment of a feral dog population would also be a negative impact, although the potential severity of that impact is less than the scenario of a rabies epidemic.

o Conclusion

This impact could be avoided or minimized while still permitting the housing of domestic dogs by camp residents if certain precautions were exercised. Such precautions would include registering all dogs housed in the camp with the camp manager. To prevent the introduction of rabies, certification of immunization could accompany any such registration rule. The potential problem of dogs becoming feral could be avoided by requiring dogs to be under control at all times. If any dog were found outside of the camp area, and not under direct control of the owner, the dog could be destroyed by camp security personnel if reasonable attempts to capture it were to prove futile.

- (W-22) Construction Camps and Access Roads - All Upper Basin Wildlife Species

If unauthorized fires occur, the result could be the destruction or alteration of habitat for many wildlife species. The impacts on the wildlife resource that could result from unplanned fires are great.

o Mitigation Options

In order to avoid this impact, preventative measures could be taken to minimize the potential for the occurrence of uncontrolled fires. Adequate fire fighting equipment could be made available to extinguish any fires that occur at those times and places where the impact would be undesirable (see following discussion).

o Discussion

It has been recognized that fire can be a positive ecological force, rejuvenating vegetation, improving certain wildlife habitats, and releasing soil nutrients. According to field evidences of old burns and restricted tree ages, fire has long been a natural part of the ecosystem in this area. Burns in other northern areas seem to be related to weather patterns and climatic changes. The same may be said for the upper Susitna basin. Hence, the effects of fires of human origin would not be incongruent with the overall scheme of nature. If human safety and property were not threatened, there might be instances when fires could be left to burn their natural course.

On the other hand, since the consequences of fire can be extensive, proper precautions would have to be taken. In addition, in attempting to maintain control over the vegetation/habitat types in specific areas, uncontrolled fire is generally undesirable.

o Conclusion

Part of an education/orientation program for workers (Impact Issues W-16 and W-19), could deal with fire prevention, fire fighting plans and the potential harm to wildlife that fire represents. A program of fire prevention and fire fighting plans could be prepared by the camp manager and strictly enforced. Adequate fire fighting equipment and knowledgeable operators could also be available in the event that a fire occurs. To identify the potential for fires occurring, and thus the level of preventative measures needed during periods of high fire potential, camp personnel could periodically contact the BLM for an evaluation of fire potential. This would be especially important during periods of hot, dry weather. If these precautions were to be taken, the potential for a fire that would negatively impact wildlife would be greatly reduced. Fires that would ultimately benefit wildlife and do not threaten human safety or property could be allowed to burn. A plan could be prepared which would outline various levels of fire suppression to be employed in various portions of the project area.

- (W-23) Air Traffic - All Big Game Species, Raptors, and Trumpeter Swans

These species will be negatively impacted as a result of disturbance caused by air traffic, especially low-flying, large helicopters.

o Mitigation Options

Although there is no way to totally avoid disturbing wildlife as a result of air traffic, there are several options for minimizing this impact. In general, restrictions in both the altitude and location of flying activity could be employed to keep the disturbance to a minimum. Seasonal restrictions also could prove helpful in some cases. Since wildlife species vary in their sensitivity to aircraft disturbance, restrictions could be developed to avoid the most sensitive species (such as brown bears, nesting raptors and trumpeter swans).

o Discussion

It is anticipated that over time some species will acclimate to air traffic, and the negative aspects of disturbance will be reduced. Other species (trumpeter swans, brown bears, and nesting raptors, for example) may be negatively impacted before any such adjustment level is achieved, if one ever is. Therefore, it is very important that air traffic restrictions be designed to minimize impact on such sensitive species.

o Conclusion

If the impact of air traffic disturbance on wildlife is to be minimized, the following restrictions would be required:

1. All air traffic would fly directly to and from the camps or work sites with no unnecessary diversions.

2. Flight distances and weather permitting, all air traffic would maintain an altitude of at least 150 m (500 ft) above ground throughout the upper basin during all seasons.

3. A minimum altitude of 300 m (1000 ft) above ground should be maintained in the following areas:
   - caribou calving area (May and June) and over any post-calving aggregations (June and July)
   - wolf dens (April through July)
   - bald eagle nests (15 March - 31 August) including a horizontal restriction zone of a 0.4-km (0.25 mi) radius
   - gyrfalcon nests (15 February - 15 August) including a horizontal restriction zone of a 0.4-km (0.25 mi) radius
   - golden eagle nests (1 April - 31 August) including a horizontal restriction zone of 0.8-km (0.50 mi) radius
   - the Jay Creek sheep lick (May and June)
   - nesting trumpeter swans near the Oshetna River and other adjacent areas in the upper reaches of the Watana impoundment (May through July).

Some of these areas would have to be identified on a yearly basis in order to keep the location of such critical areas up to date and available for review by personnel responsible for controlling air traffic.

4. Minimize the number of private planes using the Watana airstrip, perhaps by limiting the availability of tie-down spaces.

(d) Mitigation of Impacts on Fish Resources

Under pre-project conditions, fish in the Susitna River are subject to highly variable stream conditions. These conditions are controlled by the extremes in weather and climate of the region. During the summer months, high flows are caused by melting glacial ice, and even higher peak flows occur when a storm coincides with the already high summer flows. In the winter, neither of these events take place, and the flow is reduced to less than 5% of its summer volume. These circumstances, in conjunction with with the streambed and sediment conditions that accompany them, make the Susitna mainstem a less than ideal fishery habitat. In fact, most salmon spawning activity is confined to tributaries and slough environments.

The primary impact areas of the hydroelectric development are the reservoir areas and the Susitna River from Talkeetna to Devil Canyon. The dams themselves will not curtail the migration of any anadromous species because Devil Canyon is, even now, a natural barrier to such migration. The project will, however, alter in many ways the conditions to which fish are subject. Post-project conditions, for example, will alter the timing and volume of downstream flows. Summer peaks will be reduced, and winter flows will increase. Both of these changes could be beneficial to the fish using the Susitna River, but adverse effects are also possible.

The degree to which the project will change conditions and the impacts accompanying those changes will also vary by project stage and location. The stages considered are construction, including filling, and operation and maintenance. The project locations are the Devil Canyon and Watana impoundments, the Susitna River reach downstream to Talkeetna, the reach between Talkeetna and Cook Inlet, and the access road and transmission line routes.

For both the project stages and the locations, various mitigation options are available. These approaches have been preliminarily examined with close attention to the following order: avoiding the impact, minimizing the impact, rectifying the impact, reducing or eliminating the impact over time, and compensating for the impact. Reducing or eliminating impacts includes basic monitoring both of the resource as impacts develop and of the planned mitigation measures.

Mitigation options for dealing with the project's impacts can be categorized in several ways. Operational procedure is one such category. Operational procedures can be designed that will avoid or minimize impacts on the fish or allow for the rectification, reduction over time, or compensation of impacts. Some of these procedures may be project limiting, however, because they may offset project economics or power output.

Regulation of downstream flow to meet fishery needs would be the primary operational procedure for mitigative purposes. An additional flow that could be provided through operational procedures would provide a sufficient amount of water at the proper time to permit or to stimulate outmigration. The power operational flow could probably be adjusted to meet this need. Although daily peaking at the Devil Canyon facility is, in general, viewed as potentially detrimental, under certain circumstances daily peaking for a short time during this period of outmigration could be beneficial to the fishery. Operational procedures that are primarily for power production, with some possible minor modifications, will stabilize the river channel, change the formation of tributary deltas, and reduce summer floods.

Construction or design procedures can also avoid adverse impacts or, at least, minimize them. These include the use of special valves for spilling excess water to avoid or minimize dissolved gas supersaturation and the use of multilevel intakes to regulate water temperatures. Both of these techniques will be described below.

Modification of the existing stream by excavating or by adding gravel to build spawning areas is another type of mitigation opportunity. The placement of the dams on the Susitna River will act to control the extreme conditions that occur naturally and, as will be discussed, may make the conditions in the mainstem more favorable for fish.

Such modifications of the stream, side channels, or sloughs could replace or even increase the amount of usable habitat. The construction of artificial spawning channels or hatcheries can also be used as a mitigative measure to compensate for loss of fish production, but maintaining existing habitat or creating new habitats by way of the modifications just mentioned are more promising options.

A final category of possible mitigation is the management of existing fishery resources to increase their productivity, including the possible stocking of unproductive but viable areas.

- Impoundments

  The impacts associated with construction will be of relatively short duration and masked by the inundation of the area. Intensive management of the recreational fishing in the tributaries above the impoundment water level during the construction stage, however, could protect the grayling populations not directly affected by the construction activities. In addition, insuring that effluent discharges are compatible with the stream's water quality, or discharging waste effluents from the sewage treatment facility somewhere other than into Deadman Creek above the Watana impoundment's upper water level, would protect the grayling fishery that will remain after inundation.

For the resident fish, the inundation of the mainstem will probably result in the formation of new habitats that are as hospitable to the fish as former habitats. Furthermore, since no anadromous fish occur above Devil Canyon, no impacts on anadromous fish are associated with the actual impoundments.

Avoiding or minimizing impacts associated with operation and maintenance of the Watana impoundment is restricted by engineering and economic aspects of the project. For example, fluctuation of the water level and storage of water is necessary to provide needed power during the cold months, which are also the periods of low flow. On the other hand, however, the annual fluctuations of approximately 27 m (90 ft) in Watana will inhibit the formation of a littoral zone, which is a general requirement for cover and food for rearing fish in lakes; for some species, it is also a necessity for spawning habitat.

Adverse impacts may be rectified by managing the stream areas not inundated or by developing a resident sport fishery in the reservoirs, the latter of which could provide a replacement for lost stream fishery habitat. Development of a resident reservoir fishery may be limited by post-project water quality of the reservoirs.

The ability to establish a fishery in the reservoir will depend on the water quality characteristics that develop. Although fisheries in other glacially fed lakes in this region have not been very productive, indications are that conditions could be present that would allow at least a limited fishery to be established in the impoundments. A clear, productive upper layer of water in the reservoir will aid in the development of such a fishery. Initial investigations on the settling rate of incoming sediment, combined with the length and depth of the Watana reservoir, indicate that the necessary clear layer could develop. The fraction of incoming sediment measuring two microns or less, however, may cause the reservoir to remain cloudy in summer and, thus, limit the prospects for establishing a good reservoir fishery.

Gas balance of nitrogen and oxygen in the Devil Canyon reservoir is another impact that can be solved. Installing cone-type valves for spilling instead of using conventional spillways will solve the problem of entraining nitrogen and oxygen and thus eliminate a problem for fish in the Devil Canyon reservoir and downstream. A further control is to prevent the valve discharges from plunging more than .6 m, on the average, below the surface. This precaution would keep the levels at or above those naturally occurring. These measures are part of the proposed design.

As previously mentioned, the placement of the Devil Canyon facility at the upper limit of the salmon migration is a positive factor in the design of the project. No part of the present range or habitat of the five species of Pacific salmon is excluded by the project. Although it is not within the scope of this study to evaluate the enhancement potential of the upper Susitna River basin above Devil Canyon, whether or not the project precludes this possible enhancement can be evaluated on a preliminary basis. For example, to permit salmon access farther into the upper basin, the natural barrier of Devil Canyon (without the project) or the barrier represented by the dams (with the project) would need to be circumvented in some manner.

More significant, however, is the consideration that any enhancement plans for the basin above Devil Canyon requiring the use of the Susitna for outmigration would be made more difficult by the downstream passage problems presented by the dams. A suggestion has been offered in the past for enhancing the salmon resources of the upper basin by connecting Lake Louise to the Copper River drainage. Such enhancement, while never entertained by the present study, would not be precluded by the Susitna project. Of course, if any suitable habitat for salmon presently exists in the areas of the planned impoundment zones, it would be eliminated by inundation. Obviously, any proposed action to permit salmon access to the reaches of the upper basin where they do not occur naturally would have other environmental implications that would need to be evaluated.

- Downstream

Mitigation activities associated with downstream impacts during the construction stage would be minimal. Avoiding or minimizing impacts could be accomplished principally by close inspection of the work to see that all prudent measures are undertaken to reduce turbidity or to prevent any toxic materials from entering the river.

Impacts associated with downstream temperature regimes could be avoided during some periods of the year and minimized during other periods by the use of multilevel intakes which would provide a mixed flow with water temperatures equal or near to naturally occurring conditions. The appropriate multilevel intakes, if included in the design, will allow for temperature regulation of discharged waters. Downstream water temperatures can then be regulated to follow the naturally occurring temperature regime as closely as possible and thus to reduce or minimize the impact on fish resources. Table 3.70 gives the predicted temperature values with intake structures that will draw from the surface and the depths of the reservoirs. Stream reaches that will have the correct temperature conditions for egg development and emergence at the proper time could be considered for management of salmon fisheries and for modifications to provide additional habitat.

If the primary water supply for developing salmon eggs during the winter comes from aquifers that are charged by high water levels in the Susitna River, then presently projected flows during the summer will not be sufficient to recharge these aquifers. In addition, during the post-project period, the projected summer flows will not allow salmon access to many slough and side channel areas. Avoidance of this impact may require increasing the river flows either during the summer or sometime before the winter season begins for whatever length of time is necessary to recharge the aquifers. It is believed that a downstream flow of approximately 19,000 cfs for about 50 to 60 days, keyed specifically to spawning salmon needs, would avoid most or all of the impacts on the salmon fishery in the Talkeetna to Devil Canyon reach by allowing slough and side channel access. Some flow less than 17,000 cfs for the same period of time could minimize the impacts, but what that flow rate is is unknown.

For success in reconstructing habitat areas, modifying existing habitats, and altering the streambed in any way, a stipulated flow would have to be maintained that would provide the necessary water of the required quality. The alteration of the sloughs or mainstem to provide for spawning type habitat would be similar to creating an artificial spawning channel but with the benefit of maintaining the wild stock of fish. Flows adequate for outmigration would need to be maintained for any management or other mitigation option to work. Flow regulation fitted to the needs of outmigrating salmon could probably be accommodated within the constraints of project operations. The need for and success of this flow manipulation for outmigration would be dependent, however, upon having previously maintained or established conditions necessary for spawning, incubation, and rearing of some of the salmon species.

Rearing habitat for species that currently use the slough and side channel areas may still be available in the mainstem during the post-project period. It is not known whether the conditions that may be present would meet the habitat needs for rearing.

Artificial spawning channels and hatcheries could also be considered. The use of artificial spawning channels and hatcheries can be used to replace the fish that would be lost during the post-project period. The placement of these type of facilities, however, depends on finding a source of water that is suitable. In addition, for the fish produced from artificial spawning channels and/or hatcheries to be useful to the commercial fishery the location is critical. Such facilities must be placed in a location that will allow maximum harvest of hatchery or spawning channel fish without affecting the management of the natural runs.

The use of the mainstem Susitna as a transportation route should not be affected by the project flows. Likewise, tributary access should not be blocked, as it is anticipated that high flows from the tributaries will lower the mouths to the post-project stream levels. Once the flows can be regulated from the partially filled reservoirs, certain levels could be provided to coincide with the timing of the salmon runs. At these times, stipulated flow levels would be implemented that are suited to the needs of the salmon with consideration either to improvements of the stream channel or side sloughs or to other mitigative measures which may be undertaken.

Stable summer flows and increased winter flows, accompanied by a reduction in turbidity during the summer, should increase the habitat available for resident fish. In addition, another positive impact of increased winter flows will be the possible addition of overwintering areas for both salmon and resident fish. On the basis of available information or post-project mainstem habitat conditions for the rearing of fish, however, it is difficult to assess accurately the actual suitability of this habitat for overwintering.

A more stable channel and reduced or eliminated floods would make it possible to insure that any river area used by fish for spawning would not be destroyed by a major flood. In addition, except during an unusual flood period, any gravel deposited for spawning purposes would not be carried away.

Controlling floods and eliminating flood peaks could be made possible by operational procedures that reduce or eliminate spills. Many operational modes have been examined in an effort to accomplish this objective. Presently, spills from the hydroelectric development are not expected to occur more frequently than four or five times in 30 years, with only one of the spills being of significant volume. Additionally, consistent, stable summer flows may be necessary to mitigate post-project impacts in the Devil Canyon to Talkeetna reach.

Prior to completion of the Devil Canyon dam, the downstream reach of the Susitna may be affected by daily peaking at the Watana reservoir. During this period, currently projected to be nine to ten years long, the daily fluctuations in flow are expected to be about 4,000 cfs, with flows ranging from approximately 8,000 cfs to 12,000 cfs. The Devil Canyon cofferdam will be in place during this time, however, and its presence is expected to attenuate, to some extent, the daily flow variation downstream. Should additional regulations of these flows be necessary for fishery mitigation, a re-regulation device could be installed on the cofferdam. Once the Devil Canyon dam is in place, the peaking at Watana will not affect the downstream reach because Devil Canyon will have the effect of re-regulating the flows. Some daily peaking is currently planned for the Devil Canyon facility, but it will be of relatively small magnitude. Significant power peaking flows, however, would cause downstream impacts of a much greater magnitude.

A construction activity that could potentially provide a positive impact is associated with the construction of the tailrace tunnel at Devil Canyon. It has been suggested that the rock excavated during construction of the tailrace tunnel be crushed to the size of spawning gravel and returned to the Susitna River. If this action were taken, the gravel would be a positive addition to the Susitna's substrate, since in the reach from Devil Canyon to Talkeetna, the river is presently thought to contain very limited suitable spawning gravel. The reduction in flow and the limiting of flood peaks, both described above, will make it possible for spawning-size gravel to possibly provide a substrate for improving fishery habitat in the mainstem.

Another aspect of flow that has been examined is the mechanism for spilling from the two dams. The present plan provides for all floods up to the one-in-50-year flood to be passed through cone-type valves. As described above under Impoundments, this procedure for spilling will reduce the plunging of spilled waters to an average of about 0.6 m or less. This control of plunging flows will provide benefits downstream similar to those afforded the reservoir, that is, it should keep the supersatura- tion of gases, particularly nitrogen and oxygen, at or below the level that occurs naturally below Devil Canyon.

Below the confluence of the Chulitna, Susitna, and Talkeetna rivers, the contribution of waters from the Chulitna and Talkeetna rivers is expected to reduce greatly or to eliminate the potential for impacts resulting from flow alteration in the upper river. In addition, the load contribution from the Chulitna River will probably mask any reduction in suspended material caused by settling behind the dams. As one progresses downstream, the differences between pre- and post-project conditions will be less and less apparent until, eventually, any change will be well within the range of natural fluctuations. No adverse water quality changes are expected in the lower Susitna River. Possibly the change in flows below Talkeetna could lower the stage in certain areas and thus limit access to some of the sloughs and side channels used for spawning. Should this happen, then a possible mitigation measure that would avoid impacts or minimize them would consist of some alteration at the mouths of the sloughs or tributaries.

Reducing or eliminating impacts through stream stocking and lake fertilization may also be used. Several lakes in the Susitna River drainage that may have management potential have already been identified by the Fisheries Rehabilitation Enhancement & Development (FRED) Division of ADF&G. These, plus other possible locations, could be considered for future management activities.

The number of fish that will be adversely affected by the project represents a relatively small portion of the total fish population using the Susitna River system. Mitigation of these adverse impacts could most likely be accomplished by a program combining various approaches; such techniques may even improve the fisheries. Although improvement of fish stocks is not a requirement, considering the present size of the stocks versus its potential size with active management, improvement of the fish resource is a definite possibility.

- Access Road - Borrow Areas - Transmission Lines

A majority of potential impacts associated with the construction, operation, and maintenance of access roads, borrow areas, and transmission lines can either be reduced significantly or eliminated completely. A major portion of the impacts associated with public access and stream sedimentation will be avoided if the mitigation measures already described by Acres are implemented (Acres American Access Route Selection Report 1981). For example, it is assumed that the access road will be controlled as a private road during construction of both dams and that, subsequent to construction, management policies will be established for future use of the road. Furthermore, many potential impacts can be avoided if restrictions on off-road vehicle use are imposed and if some restrictions are placed on public access beyond Devil Canyon. Additionally, it has been assumed that, whenever feasible, borrow sites for the access road (as well as those for dam construction) will have a buffer strip of undisturbed land between them and any nearby aquatic habitat. Such a buffer strip, however, is not currently planned for Borrow Area F, along Tsusena Creek, although the streambed itself will not be excavated. Finally, it has been assumed that borrow sites will be revegetated [Section 3.9 (b) (ii)].

o Road Design and Construction

Road design and construction can incorporate measures to minimize mass-movement erosion of sediment into streams represented by soil creep, slump earth flows, debris avalanches, and debris torrents. Control of these phenomena can be accomplished by avoiding placing roads on the midslope of steep, unstable slopes; by reducing excavation to a minimum; in conjunction with a balanced earthwork design, by designing cut and fill slopes at proper slope angles; by providing vegetative or artificial stabilization of cut and fill slopes; and by constructing retaining walls to contain unstable slopes. Except at stream crossings, roads can be situated so as to provide a buffer strip of undisturbed land between the road and any streams. In addition, if bridges and arch culverts are used for stream crossings where anadromous or migratory resident fishes are present, the potential for impact on these species will be minimized. It is assumed that culverts will be of appropriate size and design and will be installed properly to permit fish passage. Any low water crossings may cause impacts if downstream fish resources are present. Where any such crossings are used, impacts can be reduced if the crossings are properly maintained and utilized only by light vehicular traffic and not by large construction vehicles.

It is assumed that permafrost areas will be avoided whenever possible. Any permafrost regions that cannot be avoided could perhaps be crossed on slopes where bedrock is near the mantle surface. If high ice waste piles are compact and covered with some form of insulation, rapid melting and subsequent siltation in streams can be prevented.

Erosion resulting from drainage from road surfaces can be minimized. Designs such as open-top culverts, rolled grades, cross drains, or shallow ditches are usually suitable drainage devices.

Some potential impacts can be avoided if construction work within or adjacent to streams and water channels is not attempted during periods of high streamflow, intensive rainfall, when migratory fish are spawning, or during crucial rearing times. This mitigation approach applies to transmission line construction as well as to access road construction.

Stream disturbance and resultant impact on fish can occur if logs are skidded or yarded across any stream; such impacts are avoidable. Similar potential impacts can be avoided if log landings are not located on the banks of any stream containing a viable fishery. Logging operations could leave a buffer strip of undisturbed ground and brush along the stream bank. In addition, if heavy equipment is not operated on the stream banks or in the stream channels, it will help minimize siltation. Finally, logging debris can be chipped for use in stabilizing cut banks.

Oil residue from construction equipment and the possible bacterial and nutrient contamination of aquatic habitats resulting from the presence of construction personnel can be minimized by following the standard precautions of the construction industry. It is assumed that oil from machinery will be disposed of properly and not buried at the site. Portable chemical toilets will eliminate possible bacterial and/or nutrient contamination.

- Public Access/Angling Pressure

To control public access further and to protect the fisheries resource from unwarranted angling pressure, additional mitigation measures can be implemented. These would include recommendations made to the proper Alaska management and regulatory agencies to control fishing pressure in the region. Such recommendations will apply especially to the salmon fishery in Indian River and to the grayling and lake trout fishery of the upper basin. Some potential impacts will be avoided if the pioneer road is made inaccessible to public use following its original use.

TABLE 3.1: COMMON AND SCIENTIFIC NAMES OF PLANT SPECIES APPEARING IN THE TEXT

Common Name	Scientific Name
alpine sweetvetch	*Hedysarum alpinum*
American green alder	*Alnus crispa* or *A. c.* subsp. *crispa*
American red raspberry	*Rubus idaeus*
balsam poplar (cottonwood)	*Populus balsamifera*
bearberry	*Arctostaphylos* spp.
Beauverd spiraea	*Spiraea beauverdiana*
bigelow sedge	*Carex bigelowii*
birch	*Betula* spp.
black spruce	*Picea mariana*
bladderwort	*Utricularia vulgaris*
bluejoint	*Calamagrostis canadensis*
bog blueberry	*Vaccinium uliginosum*
bunchberry	*Cornus canadensis*
bur reed	*Sparganium angustifolium*
cotton grass	*Eriophorum* spp.
crowberry	*Empetrum nigrum*
currant	*Ribes* spp.
diamond willow	*Salix planifolia*
dryas	*Dryas* spp.
dwarf arctic birch	*Betula nana*
feltleaf willow	*Salix alaxensis*
feather moss	*Hylocomnium* sp.
highbush cranberry	*Viburnum edule*
horsetail	*Equisetum* spp.

TABLE 3.1 (continued)

Common Name	Botanical Name
Labrador tea	*Ledum groenlandicum*
larch (tamarack)	*Larix laricina*
lupine	*Lupinus* spp.
mare's tail	*Hippuris vulgaris*
meadow horsetail	*Equisetum arvense* or *E. pratense*
mountain cranberry	*Vaccinium vitis-idaea*
nagoonberry	*Rubus arcticus*
northern Labrador tea	*Ledum decumbens*
oak fern	*Gymnocarpium dryopteris*
paper birch	*Betula papyrifera*
prickly rose	*Rosa acicularis*
resin birch	*Betula glandulosa*
sedge	*Carex* spp.
Sitka alder	*Alnus sinuata* or *A. crispa* subsp. *Sinuata*
sphagnum moss	*Sphagnum* spp.
tall blueberry willow	*Salix novae-angliae*
thinleaf alder	*Alnus tenuifolia*
trembling aspen	*Populus tremuloides*
twinflower	*Linnaea borealis*
water sedge	*Carex aquatilis*
white spruce	*Picea glauca*
willow	*Salix* spp.
woodland horsetail	*Equisetum silvaticum*
wormwood	*Artemisia telisii*
yellow pond lily	*Nuphar polysepalum*

TABLE 3.2: HECTARES AND PERCENTAGE OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES IN THE UPPER SUSITNA RIVER BASIN (ABOVE GOLD CREEK)[a]

VEGETATION/HABITAT TYPE	Hectares (b)	Percent of Total Area
Total Vegetation	1,387,607	85.08
Forest	348,232	21.35
Conifer	307,586	18.86
Woodland spruce	188,391	11.55
Open spruce	118,873	7.29
Closed spruce	323	0.02
Deciduous	1,290	0.08
Open birch	968	0.06
Closed birch	323	0.02
Mixed	39,355	2.41
Open	23,387	1.43
Closed	15,968	0.98
Tundra	394,685	24.20
Wet sedge grass	4,839	0.30
(Mesic) sedge grass	184,358	11.30
Herbaceous alpine	807	0.05
Mat and cushion	65,001	3.99
Mat and cushion/sedge grass	139,680	8.56
Shrubland	644,690	39.53
Tall shrub	129,035	7.91
Low shrub	515,655	31.62
Birch	33,549	2.06
Willow	10,645	0.65
Mixed	471,461	28.91
Unvegetated	243,392	14.92
Water	39,840	2.44
Lakes	25,162	1.54
Rivers	14,678	0.90
Rock	113,712	6.97
Snow and ice	89,841	5.51
Total Area	1,630,999	100.00

a. Based on maps produced at a scale of 1:250,000.

b. Differences in resolution as a result of differences in scale may result in some discrepancies for common areas between these figures and those presented in Table 3.3.

TABLE 3.3: HECTARES AND PERCENTAGE OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES FOR THE AREA 16 KM ON EITHER SIDE OF THE SUSITNA RIVER FROM GOLD CREEK TO THE MACLAREN RIVER[(a)]

VEGETATION/HABITAT TYPE	Hectares[(b)]	Percent of Total Area
Forest	142,306	30.75
Conifer	115,048	24.87
Woodland spruce-black	62,993	13.62
Woodland spruce-white	13,291	2.87
Open spruce-black	28,304	6.12
Open spruce-white	10,460	2.26
Deciduous	4,393	.94
Open birch	1,498	0.32
Closed birch	2,324	0.50
Closed balsam poplar	571	0.12
Mixed	22,865	4.94
Open conifer deciduous	9,639	2.08
Closed conifer deciduous	13,226	2.86
Tundra	114,728	24.81
Wet sedge grass	3,517	0.76
Sedge grass	27,505	5.95
Sedge shrub	20,073	4.34
Mat and cushion	63,633	13.76
Shrubland	177,264	38.34
Open tall shrub	15,524	3.36
Closed tall shrub	15,767	3.41
Birch shrub	42,880	9.27
Willow shrub	8,230	1.78
Mixed low shrub	94,863	20.52
Herbaceous	18	0.01
Grassland	1,079	0.23
Disturbed	24	0.01
Unvegetated	26,979	5.83
Rock	16,603	3.59
Snow and ice	249	0.05
Water		
River	4,236	0.92
Lake	5,891	1.27
Total Area	462,398	99.98

a. Based on maps produced at a scale of 1:63,360.

b. Differences in resolution as a result of differences in map scale may result in some discrepancies for common areas between these figures and those presented in Table 3.2.

TABLE 3.4: HECTARES AND PERCENT OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES WITHIN THE HEALY TO FAIRBANKS TRANSMISSION CORRIDOR

VEGETATION/HABITAT TYPE (a)	Hectares	Percent of Total Area
Forest	86,830	77.9
Woodland spruce	1,812	1.6
Open spruce	31,739	28.5
Closed spruce	1,347	1.2
Woodland deciduous	993	.9
Open deciduous	12,553	11.3
Closed deciduous	10,384	9.3
Woodland conifer-deciduous	961	0.9
Open conifer-deciduous	12,502	11.2
Closed conifer-deciduous	4,125	3.7
Open spruce/open deciduous	948	0.9
Open spruce/wet sedge-grass/ open deciduous	1,993	1.8
Open spruce/low shrub/wet sedge-grass/open deciduous	7,008	6.3
Open spruce/low shrub	465	0.4
Tundra	4,407	3.9
Wet sedge-grass	2,268	2.0
Sedge grass	277	0.2
Sedge shrub	566	.5
Sedge-grass/mat and cushion	1,296	1.2
Shrubland	17,199	15.4
low mixed shrub	15,405	13.8
willow shrub	58	.05
low shrub/wet sedge-grass	1,736	1.6
Agricultural land	175	.2
Disturbed	431	.4
Unvegetated	2,467	2.2
Lakes	196	.2
River	2,143	1.9
Gravel	128	.1
TOTAL AREA	111,509	100.0

a. The Tanana Flats portion of the transmission corridor is an area of extremely complex mosaics of various vegetation types. As a result, various complexes were recognized.

TABLE 3.5: HECTARES AND PERCENT OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES WITHIN THE WILLOW TO COOK INLET TRANSMISSION CORRIDOR

VEGETATION/HABITAT TYPE	Hectares	Percent of Total Area
Forest	25,851	67.0
Woodland spruce	2,457	6.3
Open spruce	3,402	8.8
Closed spruce	3,226	8.4
Open birch	16	.04
Closed birch	3,638	9.4
Open balsam poplar	100	.3
Closed balsam poplar	172	.5
Open conifer-deciduous	1,697	4.4
Closed conifer-deciduous	11,143	28.9
Wet sedge-grass	9,123	23.7
Shrubland	2,213	5.7
Closed tall shrub	92	.2
Low mixed shrub	2,121	5.5
Lakes	1,011	2.6
Disturbed	381	1.0
TOTAL AREA	38,579	100.0

TABLE 3.6: VASCULAR PLANT SPECIES RECORDED IN THE UPPER SUSITNA RIVER BASIN WHICH ARE OUTSIDE OF THEIR RANGE AS REPORTED BY HULTEN (1968)

	Equisetum fluviatile
	Lycopodium selago spp. selago
	Lycopodium complanatum
(a)	Picea mariana
	Carex filifolia
	Danthonia intermedia
	Luzula wahlenbergii
	Veratrum viride
	Platanthera convallariaefolia
	Platanthera dilatata
	Platanthera hyperborea
	Listera cordata
	Echinopanax horridum
	Senecio sheldonensis
(a)	Myrica gale
	Ranunculus occidentalis
	Potentilla biflora
(a)	Rubus idaeus
	Rubus pedatus
	Galium triflorum
	Pedicularis kanei kanei
	Pedicularis parviflorus
	Potamogeton robbinsii

a. Viereck and Little (1972) include the upper Susitna River basin in the range of this species.

TABLE 3.7: HECTARES OF DIFFERENT WETLAND TYPES[a] BY PROJECT COMPONENT

	Watana Facility							
			Borrow Areas					
Wetland Type	Impoundment, Dam and Spillways	Camp, Village and Airstrip	A	D	E	F	H	I
Palustrine forested	7,408		252	16	133	80	345	15
Palustrine scrub-shrub	1,126	142	62	212		199	38	
Palustrine emergent	139		8	8				
Lacustrine emergent	4							
Lacustrine	54	8						
Riverine	2,182							
TOTAL	10,913	150	322	236	133	279	383	15

	Devil Canyon Facility		
Wetland Type	Impoundment, Dam and Spillways	Camp and Village	Borrow Area K
Palustrine forested	800		11
Palustrine scrub-shrub	43		29
Palustrine emergent	12		
Lacustrine emergent			
Lacustrine	1		
Riverine	810		
TOTAL	1,666	-0-	40

a. Wetland types according to Cowardin, et al. (1979).

TABLE 3.8: COMMON AND SCIENTIFIC NAMES OF FURBEARER AND BIG GAME SPECIES MENTIONED IN THE TEXT

Beaver
Castor canadensis

Muskrat
Ondatra zibethicus

Coyote
Canis latrans

Gray wolf
Canis lupus

Red fox
Vulpes fulva

Black bear
Ursus americanus

Brown bear
Ursus arctos

Pine marten
Martes americana

Least weasel
Mustela nivalis

Short-tailed weasel
Mustela erminea

Mink
Mustela vison

Wolverine
Gulo gulo

River otter
Lutra canadensis

Lynx
Felis lynx

Moose
Alces alces

Barren ground caribou
Rangifer tarandus

Dall sheep
Ovis dalli

TABLE 3.9: SUMMARY OF ELEVATIONAL USE (IN METERS) BY APPROXIMATELY 200 RADIO-COLLARED MOOSE (BOTH SEXES AND ALL AGE CLASSES) FROM OCTOBER 1976 THROUGH MID-AUGUST 1981 IN THE UPPER SUSITNA AND NELCHINA RIVER BASINS OF SOUTHCENTRAL ALASKA

Month -	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Mean elevation	853	834	788	785	805	820	840	850	837	913	900	900	838
Standard deviation	140.8	142.6	134.8	140.8	136.9	130.0	161.9	155.3	137.7	148.9	146.4	145.0	
Range of elevation													
Min.	549	427	518	457	427	396	---	549	549	427	442	457	
Max.	1,189	1,189	1,402	1,250	1,158	1,341	1,280	1,463	1,219	1,280	1,341	1,402	
Sample size	66	98	285	204	341	424	218	174	130	193	168	116	2,417

TABLE 3.10: NELCHINA CARIBOU HERD POPULATION ESTIMATES, IN FALL UNLESS OTHERWISE NOTED

Year	Total Estimate	Female Estimate	Male Estimate	Calf Estimate
1955	40,000[a]	-	-	-
1962	71,000[b]	-	-	-
1967	61,000[c]	-	-	-
1972	7,842	4,800	1,622	1,420
1973	7,693	4,646	1,268	1,779
1976	8,081	4,979	1,663	1,439
1977	13,936	7,509	2,868	3,559
1978	18,981	9,866	4,429	4,686
1980	18,713	9,164	5,673	3,876
1981	20,730[d]	10,172	6,195	4,364

a. Watson and Scott (1956), February census.
b. Siniff and Skoog (1964), February census, perhaps should be adjusted downward by as many as 5,000 caribou due to presence of Mentasta herd.
c. Felt by some to be an unreasonably high estimate.
d. Preliminary estimate, awaiting final female harvest data.

TABLE 3.11: REPORTED HUNTER HARVEST OF THE NELCHINA CARIBOU HERD, 1972-1981

Year	Total Harvest	Females		Males	
		No.	(%)	No.	(%)
1972	555	153	(28)	338	(72)
1973	629	203	(33)	411	(67)
1974	1,036	343	(34)	656	(66)
1975	669	201	(31)	441	(69)
1976	776	201	(26)	560	(74)
1977	360	77	(22)	275	(78)
1978	539	111	(21)	416	(79)
1979	630	90	(14)	509	(81)
1980	621	117	(21)	453	(79)
1981 (a)	856	144	(18)	675	(82)

a. Preliminary data

TABLE 3.12: SUMMARY OF TERRITORY SIZES FOR WOLF PACKS STUDIED AS PART OF THE SUSITNA HYDROELECTRIC PROJECT STUDIES DURING 1980 and 1981 IN SOUTHCENTRAL ALASKA

Pack		Territory Size (km^2)
Fish Lake		943
Susitna		1,453
Susitna-Sinona		1,208
Tolsona		2,541
Tyone Creek		943
Watana		1,383
	$\bar{x}$	1,412
	S.D.	541

TABLE 3.13: ESTIMATE OF NUMBERS OF WOLVES BY INDIVIDUAL PACK INHABITING THE SUSITNA HYDROELECTRIC STUDY AREA IN SPRING AND FALL 1980 AND 1981

Pack Area	Spring 1980 (Post-Hunt)	Fall 1980 (Prehunt)	Spring 1981	Fall 1981
Butte Lake	3-4?	3-4+	3	5
Fish Lake	?	2	9	12+
Jay Creek	6	7-8?	?	10
Keg Creek	?	?	2-3	2-3
Maclaren River	2	4-5	?	2-3
Portage Creek	?	?	?	6
Stephan Lake	2+	11	?	?
Susitna	4	10	5	4
Susitna-Sinona	4	4-5	2	?
Tolsona	9	16	13	15
Tyone Creek	4	2	0	?
Upper Talkeetna River	?	?	?	2
Watana	5	14	8	14
Total	40	77	42-43	72-74

TABLE 3.14: SUMMARY OF WOLF DEN AND RENDEZVOUS SITES DISCOVERED FROM 1975 THROUGH 1981 OCCURRING WITHIN AN 80 KILOMETER RADIUS OF THE PROPOSED SUSITNA HYDROELECTRIC PROJECT IN SOUTHCENTRAL ALASKA

Kilometers from upper water-level	Site		
	Pack Name	Type Site	Year of Documented Use
8	Watana	Rendezvous	80& 81
	Watana	Den	80, 81
	Deadman	Den	75
	Jay Creek	Den	78
	Stephan Lake	Den	76
24	Tyone Creek	Den	79
32	Susitna	Rendezvous	80
	Susitna	Rendezvous	80
	Brushkana	Den	75
40	Mendeltna	Rendezvous	76
	Susitna	Den	79 & 80
	Keg Creek	Den	75, 76, & 78
	Clearwater	Den	76
48	Tolsona	Den 80 & Mendeltna Rendezvous 77	
	Tolsona	Rendezvous 80 & Mendeltna Den 77	
48	Mendeltna	Rendezvous	77
	Mendeltna	Den	77
56	Mendeltna	Rendezvous	77
	Mendeltna	Rendezvous	77
	Mendeltna	Den	76, 77
64	Hogan Hill	Den	78
80+	Hogan Hill	Den	75
	Sinona	Den	78
	Sinona	Den	77

TABLE 3.15: COMPARISONS OF FOOD REMAINS IN WOLF SCATS COLLECTED AT DEN AND RENDEZVOUS SITES IN 1980 AND 1981 FROM GMU-13 OF SOUTHCENTRAL ALASKA

Food Items	1980 727 Scats		1981 290 Scats	
	# Items	% Occurrences	# Items	% Occurrences
Adult Moose	105	12.00	24	6.15
Calf Moose	369	42.17	87	22.31
Moose, Age Unknown	22	2.51	21	5.38
Adult Caribou	30	3.43	31	7.95
Calf Caribou	13	1.49	19	4.87
Caribou, Age Unknown	8	0.91	5	1.28
Moose or Caribou	31	3.54	9	2.31
Beaver	48	5.49	37	9.49
Muskrat	26	2.97	24	6.15
Snowshoe Hare	55	6.29	21	5.38
Microtine	40	4.57	37	9.49
Unidentified Small Mammal	15	1.71	20	5.13
Bird	16	1.83	8	2.05
Fish	1	0.11	2	0.51
Vegetation	22	2.51	5	1.28
Wolf	4	0.46	1	0.26
Unknown	70	8.00	39	10.00
Total	875	100.00	390	100.00

TABLE 3.16: AVERAGE SPRING AGES OF SUSITNA AREA BROWN BEAR SUBPOPULATIONS[(a)]

Subpopulations	Males: Average Spring Age (Years)	Males: (Range)	Males: n	Females: Average Spring Age (Years)	Females: (Range)	Females: n	Avg. Both Sexes (Years)	% Males
GMU 13 fall harvests, 1970-1980	8.0	(3.5-23.5)	208	7.7	(3.5-28.5)	191	7.9	52
1979 Upper Susitna studies (Miller & Ballard 1980)	7.4	(3.5-21.5)	17	7.4	(3.5-16.5)	15	7.4	53
1980-81 Susitna Hydro studies[(b)]	7.7	(3.5-14.5)	14	7.9	(3.5-13.5)	15	7.8	48
Su-Hydro studies radio-collared bears w/ ≥ 5 locations[(b)]	6.0	(3.5-10.5)	4	8.6	(3.5-13.5)	13	8.0	24

a. Includes only bears of known sex and age that are 3.0 or older, spring age calculated as age + .5 years.

b. Average of age at first capture

TABLE 3.17: REPORTED BROWN BEAR DENSITIES IN NORTH AMERICA

mi^2/bear	km^2/bear	Location	Source
0.6	1.6	Kodiak Island, AK	Troyer and Hensel 1964[a]
6.0	15.5	Alaska Peninsula, AK	Unpublished data (Glenn pers. comm.)[b]
8.2	21.2	Glacier Nat. Park, Montana	Martinka 1974[a]
11.0	28.5	Glacier Nat. Park, B. C.	Mundy and Flook 1973[a]
9-11	23-27	SW Yukon Territory	Pearson 1975[a]
16-24	41-62	Upper Susitna R., AK	Miller and Ballard 1980
88 (16-300)[c]	288 (42-780)[c]	Western Brooks Range (NPR-A), AK	Reynolds 1980
100	260	Eastern Brooks Range, AK	Reynolds 1976

a. Taken from Pearson 1975.

b. Data refer to a 1,800 mi^2 intensively studied area of the central Alaska Peninsula.

c. Mean is for the whole of the Nat. Pet. Reserve, AK, the range represents values for different habitat types in this reserve where the highest density occurred in an intensively studied experimental area.

TABLE 3.18: COMPARISONS OF MEAN HOME RANGE SIZE OF BROWN BEARS RADIO-COLLARED[a] IN 1978,[b] 1980 AND 1981 STUDIES IN GMU-13

	MALES[c] 1978	MALES 1980	MALES 1981	FEMALES[c] 1978	FEMALES 1980	FEMALES 1981	BOTH SEXES[c] 1978	BOTH SEXES 1980	BOTH SEXES 1981
Mean home range size (km^2)	769	845	1061	408	160	343	572	409	487
S.D	396	439	1390	222	48	302	356	422	660
Range =	282-1381	495-1409	100-2655	193-734	82-233	50-1136	193-1381	82-1409	50-2655
n	10	4	3	12	7	12	22	11	15
Mean age of sample	6.9	5.5	7.0	8.8	8.9	8.4	7.9	7.6	8.1
Range	3-11	3-10	4-11	4-13	3-13	3-14	3-13	3-13	3-14
Mean No. relocations/ bear =	16.2	10.8	12.7	24.9	11.7	20.8	21.0	11.4	19.1
Range =	8-29	8-14	8-21	12-33	6-15	13-35	8-33	6-15	8-35
% Males							45	36	20
% of females w/newborn cubs				8	0	33			

a. Includes all bears 3 years of age or older
b. Source: Ballard et al. (in press)
c. Includes data through 1 September 1981 only, actual 1981 home range sizes will be larger when all 1981 points are included in analysis

TABLE 3.19: COMPARISON OF REPORTED HOME RANGE SIZES OF BROWN/GRIZZLY BEARS IN NORTH AMERICA[a]

Area	Sex	Sample size	Mean home range (km^2)	Source
Kodiak Island, Ak.	M	7	24	Berns et al. 1977
	F	23	12	
Yellowstone National Park	M	6	161	Craighead 1976
	F	14	73	
Southwestern Yukon	M	5	287	Pearson 1975
	F	8	86	
Northern Yukon	M	9	414	Pearson 1975
	F	12	73	
Western Montana	M	3	513	Rockwell et al. 1978
	F	1	104	
Nelchina Basin	M	14	790	Susitna studies (1978 & 1980 results only)
	F	19	316	
Northwestern Alaska	M	8	1350	Reynolds 1980
	F	18	344	

a. Adapted from Reynolds 1980

TABLE 3.20: EARLY SPRING USE OF DEVIL CANYON AND WATANA IMPOUNDMENT AREAS BY RADIO-COLLARED BROWN BEARS [a]

BEAR ID (age)	Bear visited impoundment area?[a] (No. observations in/total observations) Spring 1980	Spring 1981	Mean elevation of observations in impoundment area (S.D.) 1980	1981
MALES				
G342 (2)	---	no (0/4)	---	---
G293 (3)	no (0/4)	no (0/1)	---	---
G214 (4)	yes (2/4)(to Watana)	---	2038(-)	---
G280 (5)	no (0/3)	yes (10/16)(to Watana)	---	2030(331)
G308a (6)	no (0/2)	---	---	---
G294 (10)	yes (4/4)(to Devil)	no (0/3)	1721(344)	---
sub totals	(6/17)	(10/24)		
FEMALES				
G335 (2)	---	no (0/20)	---	---
G281 (3)	yes (3/5)(to Watana)	yes (9/26)(to Watana)	2025(-)	2119(254)
G340 (3)	---	yes (9/26)(to Watana)	---	2083(301)
G308b (5)	yes (1/5)(to Devil)	yes (6/7)(to Devil)	1350(-)	1863(309)
G344 (5)[b]	---	no (0/6) (w/2 cubs	---	---
G331 (6)	---	yes (1/8)(to Watana)	---	1850(-)
G341 (6)	---	yes (12/17)(to Watana)	---	2160(474)
G313 (6)	no (0/5)	no (0/10)	---	---
G277 (10)	no (0/4)	---	---	---
G312 (10)[b]	yes (1/4 to Watana	no (0/10) w/2 cubs	1750(-)	---
G334 (10)	---	yes (1/22)(to Watana)	---	2525(-)
G283 (12)[b]	yes (3/5)(to Devil	no (0/9) w/2 cubs	2500(-)	---
G299 (13)	no (0/2)	yes (4/10)(to Watana)	---	2063(103)
G337 (13)[b]	---	no 0/7 w/3 cubs	---	---
subtotals	(8/30)	(42/178)		
total	(13/37)	(52/202)		

a. Defined as within 1 mile of impoundment prior to 19 June.

b. Females with newborn cubs tend to remain at high elevations throughout the summer.

TABLE 3.21: NUMBER OF AERIAL BROWN BEAR OBSERVATIONS BY MONTH IN EACH OF FIVE HABITAT CATEGORIES

Habitat	May	June	July	August	September	Oct.-April	Row Total (%)
SPRUCE	44	50	17	16	9	5	141
Row %	31.2	35.5	12.1	11.3	6.4	3.5	(25.0)
Column %	31.0	29.6	19.3	17.6	25.0	13.2	
RIPARIAN	16	26	22	20	4	1	89
Row %	18.0	29.2	24.7	22.5	4.5	1.1	(15.8)
Column %	11.3	15.4	25.0	22.0	11.1	2.6	
SHRUBLAND	39	75	46	52	21	5	238
Row %	16.4	31.5	19.3	21.8	8.8	2.1	(42.2)
Column %	27.5	44.4	52.3	57.1	58.3	13.2	
TUNDRA	12	14	1	1	0	0	28
Row %	42.9	50.0	3.6	3.6	0	0	(5.0)
Column %	8.5	8.3	1.1	1.1	0	0	
OTHER	31	4	2	2	2	27	68
Row %	45.6	5.9	2.9	2.9	2.9	39.7	(12.1)
Column %	21.8	2.4	2.3	2.2	5.6	71.1	
Column Total	142	169	88	91	36	38	564
(%)	(25.2)	(30.0)	(15.6)	(16.1)	(6.4)	(6.7)	(100.0)

TABLE 3.22: AVERAGE SPRING AGES[(a)] OF BLACK BEAR SUBPOPULATIONS IN THE SUSITNA AREA AND KENAI PENINSULA

	Males			Females				
Subpopulations	Average Spring Age (Years)	(Range)	n	Average Spring Age (Years)	(Range)	n	Avg. Both Sexes (Years)	% Males
GMU 13 harvests* 1973-1980	5.6	(2.5-18.5)	115	5.9	(2.5-11.5)	60	5.7	66
1980-1981 Su-Hydro studies**	6.6	(2.5-10.5)	19	8.1	(4.5-12.5)	13	7.2	59
Su-Hydro studies radio-collared bears w/ $\geq$ 5 relocations**	6.9	(2.5-10.5)	14	8.0	(4.5-11.5)	11	7.4	56
Kenai Peninsula studies 1978-1980***	6.2	(-)	45	5.0	(-)	42	5.6	52

a. Includes only bears of known sex and that are 2.0 years or older, spring age calculated as + .5 years.

* Includes all bear ($\geq$ 2 years) aged and sexed, in recent years not all teeth have been sectioned and read

** Represents age at first capture

*** Based on total bears known to be alive in each of the years of the study (same bear counted more than once). This procedure should yield a relatively older mean age than the procedure used in calculating mean age in Susitna studies. Data from the Kenai Peninsula from C. Schwartz, ADF&G, pers. comm.

TABLE 3.23: DENSITIES OF BLACK BEARS AS ESTIMATED IN STUDIES CONDUCTED IN DIFFERENT LOCALITIES

Source	Location	mi^2 Per Bear	km^2 Per Bear
McIlroy (1972)[a]	Alaska (coastal population)	0.1	0.3
Lindzey and Meslow (1977)	Washington (an island population)	0.3	0.8
Poelker and Hartwell (1973)	Washington (mainland population)	0.7-1.0	1.8-2.6
Piekielek and Burton (1975)	California	0.8-1.0	2.1-2.6
Beecham (1980)	Idaho (Council area)	0.8	2.1
	Idaho (Lowell area)	0.9	2.3
Jonkel and Cowan (1971)	Montana (Bear Creek)	0.8-1.7	2.1-4.4
LeCount (1980)	Arizona	0.8	2.1
Pelton and Burghardt (1976)	Tennessee	0.5-1.0	1.3-2.6
Kemp (1972)	Alberta	1.0	2.6
Modafferi (1978)	Prince William Sound, Alaska	1.2	3.1
Schwartz and Franzmann (1981)	Kenai Peninsula, Alaska	1.5	3.9
Erickson and Petrides (1964)	Michigan	3.4	8.8
Spencer (1955)	Maine	5.6	14.5
Clarke (1977)	New York (Adirondacks)	2.6	6.7
	New York (Catskills)	3.7	9.6
	New York (Allegany State Park)	10.0	25.9

a. Probably estimated during season concentration.
Source: Modified from Modafferi 1978

TABLE 3.24: COMPARISONS OF MEAN HOME RANGE SIZE OF BLACK BEARS RADIO-TRACKED IN 1980 and 1981 STUDIES IN GMU 13 [a]

	MALES			FEMALES			BOTH SEXES		
	1980	1981	1980 & 1981	1980	1981	1980 & 1981	1980	1981	1980 & 1981
Mean home range size (km^2)	46	250	153	16	219	117	31	235	136
S.D	42	180	167	16	368	274	35	278	223
Range	4-136	37-611	4-611	3-45	12-1036	3-1036	3-136	12-1036	3-1036
n	10	11	21	10	10	20	20	21	41
Mean age of sample	6.3	7.4	6.9	7.8	8.1	8.0	7.1	7.7	7.4
Range	2-10	3-11	2-11	5-11	4-12	5-12	2-11	3-12	2-12
Mean No. relocations/ bear =	9.2	19.4	14.5	10.4	16.5	13.5	9.8	18.0	14.0
Range	5-17	7-40	5-40	6-20	6-34	6-34	5-20	6-40	5-40
% Males							50	52	51
% of Females w/newborn cubs				30	40	35			

a. Includes all bears 2 years of age or older

TABLE 3.25: NUMBER OF AERIAL BLACK BEAR OBSERVATIONS BY MONTH IN EACH OF FIVE HABITAT CATEGORIES

Habitat	May	June	July	August	September	Oct.-April	Row Total (%)
SPRUCE	82	95	54	68	44	15	358
Row %	22.9	26.5	15.1	19.0	12.3	4.2	(39.4)
Column %	50.3	46.3	35.8	31.8	30.8	46.9	
RIPARIAN	23	33	23	18	23	1	121
Row %	19.0	27.3	19.0	14.9	19.0	.8	(13.3)
Column %	14.1	16.1	15.2	8.4	16.1	3.1	
SHRUBLAND	50	70	69	119	71	9	388
Row %	12.9	18.0	17.8	30.7	18.3	2.3	(42.7)
Column %	30.7	34.1	45.7	55.6	49.7	28.1	
TUNDRA	3	3	3	6	2	0	17
Row %	17.6	17.6	17.6	35.3	11.8	0	(1.9)
Column %	1.8	1.5	2.0	2.8	1.4	0	
OTHER	5	4	2	3	3	7	24
Row %	20.8	16.7	8.3	12.5	12.5	29.2	(2.6)
Column %	3.1	2.0	1.3	1.4	2.1	21.9	
Column Total	163	205	151	214	143	32	908
(%)	(18.0)	(22.6)	(16.6)	(23.6)	(15.7)	(3.5)	(100.0)

TABLE 3.26: TABULATION OF NOVEMBER, 1980 AERIAL SNOW TRANSECT DATA, INDICATING THE NUMBER OF FURBEARER TRACKS, BY SPECIES NOTED ON TRANSECT [a]

Transect Number	Species					
	Pine Marten	Red Fox	Short-tailed Weasel	Mink	River Otter	Transect Totals
01	41	1	3	5	2	52
02	80	0	7	1	6	94
03	91	9	5	3	0	108
04	198	0	20	0	3	221
05	84	0	11	1	0	96
06	163	0	6	0	1	170
07	202	23	39	0	2	266
08	86	11	0	2	5	104
09	85	11	1	2	0	99
10	125	20	95	2	3	245
11	39	30	58	2	1	130
12	40	38	96	5	1	180
13	7	60	77	5	3	152
14	112	10	328	6	3	459
Species TOTALS	1353	213	746	34	30	2376

a. See Figure 3.20 for location of transects

TABLE 3.27: BACKGROUND INFORMATION FOR RADIO-COLLARED MARTEN, TSUSENA CREEK AREA, 1980

Collar Number	Sex	Age Class	Weight (g)	Capture Date	Remarks
519	male	adult	1440	22 Aug 80	Testes scrotal
				23 Aug 80	Released from trap
				25 Sep 80	Released from trap
520	male	adult	1370	27 Aug 80	Testes scrotal
518	male	adult	1380	9 Sep 80	Testes receding
			1120	25 Nov 80	Transmitter dead, last heard 12 Nov, transmitter re-placed
516	male	?	1260	2 Nov 80	This animal caught by a trapper on 28 Nov.

TABLE 3.28: OCCURRENCE OF BEAVER SIGNS ALONG THREE SECTIONS OF THE LOWER SUSITNA RIVER[(a)]

River Section	Kilometers Surveyed	Beaver Sign: Number Cuttings	Cuttings per Km	Number Houses	Houses per Km
Section I	62	12	.19	2	.03
Section II	30	7	.23 (.46)[(b)]	2	.06 (.12)
Section III	26	16	.62 (1.86)	4	.15 (.45)
Entire Survey	118	35	.30	8	.07

a. Section I=Devil Canyon to Confluence with Talkeetna and Chulitna Rivers, Section II=Confluence with Talkeetna and Chulitna Rivers to Confluence with Montana Creek, Section III=Confluence with Montana Creek to Delta Islands

b. Numbers in parenthesis are adjustments to realistically reflect signs present in Sections II and III. Signs were multiplied by a correction factor of 2 in Section II and a factor of 3 in Section III. The increasing width and braiding of the river permitted the team to see approximately half the signs in Section II and only a fourth to a third in Section III.

TABLE 3.29: RESULTS OF OTTER AND MINK SURVEYS, SUSITNA RIVER, 10 THROUGH 12 NOVEMBER 1980. NUMBERS OF TRACKS OF EACH SPECIES OBSERVED AT NORTH AND SOUTH SIDES OF 37 RIVER CHECK POINTS[a]

Checkpoint	North		South	
Numbers	Otters	Mink	Otters	Mink
01	3	0	0	0
02	0	2	0	0
03	0	0	0	0
04	0	0	3	1
05	0	0	2	0
06	0	0	0	0
07	0	1	0	1
08	0	0	0	2
09	0	0	1	0
10	0	0	0	2
11	4	1	0	1
12	3	1	0	0
13	0	0	0	1
14	2	0	3	1
15	0	0	4	0
16	3	1	0	2
17	0	3	0	4
18	0	0	0	2
19	0	0	1	2
20	2	0	1	0
21	1	1	0	0
22	0	0	0	0
23	2	1	0	2
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	4	0
28	0	0	4	0
29	0	0	0	2
30	0	0	0	0
31	0	0	0	0
32	0	0	0	3
33	0	2	0	3
34	0	1	0	2
35	0	1	2	3
36	0	0	2	2
37	0	1	0	2

a. See Figure 3.20 for location of checkpoints

TABLE 3.30: TABULATIONS OF NOVEMBER, 1980 AERIAL SNOW TRANSECT DATA, INDICATING THE DISTRIBUTION OF FURBEARER TRACKS, BY SPECIES NOTED IN VARIOUS VEGETATION TYPES

Vegetation[a] Type	Species: Pine Marten	Red Fox	Short-Tailed Weasel	Mink	River Otter	Vegetation Type Totals
White Spruce Forest	35	1	4	0	0	40
Birch Forest	3	0	2	0	0	5
Poplar Forest	0	0	1	0	0	1
Black Spruce Forest	0	2	0	0	0	2
Mixed Forest	54	0	1	0	0	55
Mat & Cushion Tundra	3	5	29	0	0	37
Sedge-grass Tundra	7	3	0	0	0	10
White Spruce Woodland	525	5	88	1	0	619
Black Spruce Woodland	605	61	401	3	1	1071
Mixed Woodland	29	0	5	0	0	34
Low Shrub	12	9	8	0	0	29
Medium Shrub	35	108	190	0	0	333
Alder Shrub	25	2	11	0	0	38
River Ice (Including Shelf Ice)	2	1	2	20	20	45
Lake Ice	0	4	0	0	0	4
Creek Ice	6	0	2	4	2	14
Marsh	3	4	0	3	0	10
River Bar	9	8	1	3	7	28
Rock	0	0	1	0	0	1
Species Totals	1353	213	746	34	30	2376

a. 0-10% Forest Canopy Cover = Shrub
11-60% Forest Canopy Cover = Woodland
60+% Forest Canopy Cover = Forest
25+% Secondary Tree Species = Mixed

TABLE 3.31: COMMON AND SCIENTIFIC NAMES OF BIRDS MENTIONED IN TEXT

Common loon
Gavia immer

Arctic loon
Gavia arctica

Red-throated loon
Gavia stellata

Red-necked grebe
Podiceps grisegena

Horned grebe
Podiceps auritus

Whistling swan
Olor columbianus

Trumpeter swan
Olor buccinator

Brant
Branta bernicla

Canada goose
Branta canadensis

White-fronted goose
Anser albifrons

Snow goose
Chen caerulescens

Mallard
Anas platyrhynchos

Gadwall
Anas strepera

Pintail
Anas acuta

American green-winged teal
Anas crecca carolinensis

Blue-winged teal
Anas discors

American wigeon
Anas americana

Northern shoveler
Anas clypeata

Redhead
Aythya americana

Ring-necked duck
Aythya collaris

Canvasback
Aythya valisineria

Greater scaup
Aythya marila

Lesser scaup
Aythya affinis

Common goldeneye
Bucephala clangula

Barrow's goldeneye
Bucephala islandica

Bufflehead
Bucephala albeola

Oldsquaw
Clangula hyemalis

Harlequin duck
Histrionicus histrionicus

White-winged scoter
Melanitta deglandi

Surf scoter
Melanitta perspicillata

Black scoter
<u>Melanitta nigra</u>

Common merganser
<u>Mergus merganser</u>

Red-breasted merganser
<u>Mergus serrator</u>

Goshawk
<u>Accipiter gentilis</u>

Sharp-shinned hawk
<u>Accipiter striatus</u>

Red-tailed hawk
<u>Buteo jamaicensis</u>

Golden eagle
<u>Aquila chrysaetos</u>

Bald eagle
<u>Haliaeetus leucocephalus</u>

Marsh hawk
<u>Circus cyaneus</u>

Osprey
<u>Pandion haliaetus</u>

Gyrfalcon
<u>Falco rusticolus</u>

Peregrine falcon
<u>Falco peregrinus</u>

Merlin
<u>Falco columbarius</u>

American kestrel
<u>Falco sparverius</u>

Spruce grouse
<u>Canachites canadensis</u>

Ruffed grouse
<u>Bonasa umbellus</u>

Willow ptarmigan
<u>Lagopus lagopus</u>

Rock ptarmigan
<u>Lagopus mutus</u>

White-tailed ptarmigan
<u>Lagopus leucurus</u>

Sandhill crane
<u>Grus canadensis</u>

American golden plover
<u>Pluvialis dominica</u>

Surfbird
<u>Aphriza virgata</u>

Semipalmated plover
<u>Charadrius semipalmatus</u>

Common snipe
<u>Capella gallinago</u>

Whimbrel
<u>Numenius phaeopus</u>

Upland sandpiper
<u>Bartramia longicauda</u>

Spotted sandpiper
<u>Actitis macularia</u>

Solitary sandpiper
<u>Tringa solitaria</u>

Greater yellowlegs
<u>Tringa malanoleuca</u>

Lesser yellowlegs
<u>Tringa flavipes</u>

Wandering tattler
Heteroscelus incanus

Pectoral sandpiper
Calidris melanotos

Baird's sandpiper
Calidris bairdii

Least sandpiper
Calidris minutilla

Semipalmated sandpiper
Calidris pusilla

Sanderling
Calidris alba

Northern phalarope
Lobipes lobatus

Long-billed dowitcher
Limnodromus scolopaceus

Long-tailed jaeger
Stercorarius longicaudus

Herring gull
Larus argentatus

Mew gull
Larus canus

Bonaparte's gull
Larus philadelphia

Arctic tern
Sterna paradisea

Great horned owl
Bubo virginianus

Hawk owl
Surnia ulula

Short-eared owl
Asio flammeus

Boreal owl
Aegolius funereus

Belted kingfisher
Megaceryle alcyon

Common flicker
Colaptes auratus

Hairy woodpecker
Picoides villosus

Downy woodpecker
Picoides pubescens

Black-backed three-toed woodpecker
Picoides arcticus

Northern three-toed woodpecker
Picoides tridactylus

Eastern kingbird
Tyrannus tyrannus

Say's phoebe
Sayornis saya

Alder flycatcher
Empidonax alnorum

Olive-sided flycatcher
Nuttallornis borealis

Western wood pewee
Contopus sordidulus

Horned lark
Eremophila alpestris

Violet-green swallow
Tachycineta thalassina

Bank swallow
Riparia riparia

Tree swallow
Iridoprocne bicolor

Cliff swallow
Petrochelidon pyrrhonota

Gray jay
Perisoreus canadensis

Black-billed magpie
Pica pica

Common raven
Corvus corax

Black-capped chickadee
Parus atricapillus

Boreal chickadee
Parus hudsonicus

Brown creeper
Certhia familiaris

Dipper
Cinclus mexicanus

American robin
Turdus migratorius

Varied thrush
Ixoreus naevius

Hermit thrush
Catharus guttata

Swainson's thrush
Catharus ustulatus

Gray-cheeked thrush
Catharus minimus

Wheatear
Oenanthe oenanthe

Townsend's solitaire
Myadestes townsendi

Arctic warbler
Phylloscopus borealis

Golden-crowned kinglet
Regulus satrapa

Ruby-crowned kinglet
Regulus calendula

Water pipit
Anthus spinoletta

Bohemian waxwing
Bombycilla garrulus

Northern shrike
Lanius excubitor

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

Rusty blackbird
Euphagus carolinus

Pine grosbeak
Pinicola enucleator

Gray-crowned rosy finch
Leucosticte tephrocotis

Common redpoll
Carduelis flammea

Pine siskin
Carduelis pinus

White-winged crossbill
Loxia leucoptera

Savannah sparrow
Passerculus sandwichensis

Dark-eyed junco
Junco hyemalis

Tree sparrow
Spizella arborea

White-crowned sparrow
Zonotrichia leucophrys

Golden-crowned sparrow
Zonotrichia atricapilla

Fox sparrow
Passerella iliaca

Lincoln's sparrow
Melospiza lincolnii

Lapland longspur
Calcarius lapponicus

Smith's longspur
Calcarius pictus

Snow bunting
Plectrophenax nivalis

TABLE 3.32: RELATIVE ABUNDANCE OF LOONS, GREBES, AND WATERFOWL, UPPER SUSITNA RIVER BASIN, ALASKA, BASED PRIMARILY ON TOTAL NUMBER OBSERVED ON 1980 and 1981 AERIAL SURVEYS AND 1981 GROUND SURVEYS

Spring Migration (Aerial & Ground, 1981)

No.	Species	
802	Scaup spp.	COMMON
394	Mallard	
366	Pintail	
262	American wigeon	FAIRLY COMMON
215	Green-winged teal	
210	Scoter spp.	
140	Goldeneye spp.	
102	Oldsquaw	
52	Merganser spp.	UNCOMMON
51	Snow goose (=1 flock)	
46	Canada goose	
43	Northern shoveler	
43	Swan spp.	
31	Redhead	
23	Bufflehead	
11	Common loon	
8	Arctic loon	
6	White-fronted goose	
5	Red-necked grebe	
4	Canvasback	
3	Red-throated loon	
3	Horned grebe	
3	Blue-winged teal	RARE
3	Gadwall	
2	Ring-necked duck	

Fall Migration (Aerial: 7 Sept-3 Oct 80, 15 Sept-23 Oct 81)

No.	Species	
2658	Scaup spp.	--COMMON
905	Mallard	FAIRLY COMMON
874	American wigeon	
718	Goldeneye spp.	
551	Scoter spp.	
514	Bufflehead	
299	Merganser spp.	UNCOMMON
277	Swan spp.	
233	Pintail	
142	Green-winged teal	
111	Oldsquaw	
71	Canada goose	
35	Horned grebe (1980)	
33	Red-necked grebe	
28	Northern shoveler	
17	Common loon	
14	Ring-necked duck (1980)	RARE
1	Blue-winged teal (1980)	

Summer (Ground, 1981)

No.	Species	
94	Scaup (incl. 41 Lesser, 27 Greater)	FAIRLY COMMON
81	White-winged scoter (incl. flock of 65)	
60	Pintail	
59	Trumpeter swan[a]	
55	Oldsquaw	
47	Mallard	
33	Surf scoter	
32	American wigeon	
28	Green-winged teal	
26	Black scoter	
25	Common loon	
24	Harlequin duck	
16	Northern shoveler	UNCOMMON
11	Red-breasted merganser	
8	Red-throated loon	
8	Barrow's goldeneye	
7	Red-necked grebe	
7	Common goldeneye	
5	Horned grebe	
5	Common merganser	
4	Arctic loon	

a. 40 from aerial survey

TABLE 3.33: RELATIVE ABUNDANCE OF LARGE LANDBIRDS AND CRANES, UPPER SUSITNA RIVER BASIN, ALASKA, BASED PRIMARILY ON TOTAL NUMBER OBSERVED 17 APRIL-23 OCTOBER 1981, EXCLUDING OBSERVATIONS FROM AIRCRAFT

No.	Species	
182	Rock Ptarmigan	COMMON
139	Common Raven	COMMON
137	Willow Ptarmigan	COMMON
71	Golden eagle	FAIRLY COMMON
52	Spruce grouse	FAIRLY COMMON
40	Marsh hawk	FAIRLY COMMON
27	Bald eagle	UNCOMMON
21	White-tailed ptarmigan	UNCOMMON
16	Goshawk	UNCOMMON
15	Sandhill Crane	UNCOMMON
07	Gyrfalcon	UNCOMMON
07	Great horned owl	UNCOMMON
07	Short-eared owl	UNCOMMON
06	Red-tailed hawk	UNCOMMON
03	Merlin	UNCOMMON
02	Sharp-shinned hawk	UNCOMMON
02	Hawk owl	UNCOMMON
01	Osprey	RARE
01	American kestrel (1980)	RARE
01	Ruffed grouse	RARE
01	Boreal owl	RARE

TABLE 3.34: RELATIVE ABUNDANCE OF SHOREBIRDS AND GULLS, UPPER SUSITNA RIVER BASIN, ALASKA, BASED PRIMARILY ON TOTAL NUMBER OBSERVED 17 APRIL-23 OCTOBER 1981, BUT SUPPLEMENTED BY DATA FROM LATE SUMMER AND FALL 1981 FOR RARE SPECIES

No.	Species	
163	Mew gull	COMMON
146	American golden plover	COMMON
114	Common snipe	COMMON
103	Spotted sandpiper	COMMON
78	Northern phalarope	FAIRLY COMMON
69	Arctic tern	FAIRLY COMMON
58	Lesser yellowlegs	FAIRLY COMMON
55	Long-tailed jaeger	FAIRLY COMMON
51	Least sandpiper	FAIRLY COMMON
44	Bonaparte's gull	UNCOMMON
34	Baird's sandpiper	UNCOMMON
22	Semipalmated plover	UNCOMMON
20	Herring gull	UNCOMMON
19	Greater yellowlegs	UNCOMMON
17	Whimbrel	UNCOMMON
12	Semipalmated sandpiper	UNCOMMON
09	Wandering tattler	UNCOMMON
09	Pectoral sandpiper	UNCOMMON
06	Solitary sandpiper	UNCOMMON
03	Long-billed dowitcher	UNCOMMON
06	Upland sandpiper (1980)	RARE
01	Surfbird (1980)	RARE
01	Sanderling (1980)	RARE

TABLE 3.35: RELATIVE ABUNDANCE OF SMALL LANDBIRDS, UPPER SUSITNA RIVER BASIN, ALASKA, BASED PRIMARILY ON TOTAL NUMBER OBSERVED 17 APRIL-23 OCTOBER 1981, SUPPLEMENTED BY DATA FROM LATE SUMMER AND FALL 1980 FOR THE LESS NUMEROUS SPECIES

No.	Species	
1161	Common redpoll	ABUNDANT
669	Savannah sparrow	
631	White-crowned sparrow	
588	Lapland longspur	
583	Tree sparrow	
420	Horned lark	COMMON
398	Dark-eyed junco	
343	Ruby-crowned kinglet	
316	Yellow-rumped warbler	
288	Water pipit	
258	Varied thrush	
257	Gray jay	
249	Wilson's warbler	
225	Bohemian waxwing	
211	American robin	
195	Hermit thrush	
179	White-winged crossbill	FAIRLY COMMON
163	Fox sparrow	
146	Swainson's thrush	
145	Blackpoll warbler	
129	Boreal chickadee	
98	Snow bunting	
71	Arctic warbler	
64	Tree swallow	
62	Violet-green swallow	
55	Northern waterthrush	
54	Gray-cheeked thrush	
53	Bank swallow	UNCOMMON
46	Cliff swallow	
45	Gray-crowned rosy finch	
42	Black-capped chickadee	
41	Golden-crowned sparrow	
35	Lincoln's sparrow	
33	Rusty blackbird	
29	Dipper	
26	Pine siskin	
23	Northern three-toed woodpecker	
23	Wheatear	
22	Black-billed magpie	
16	Belted kingfisher	
16	Olive-sided flycatcher	
14	Alder flycatcher	
13	Common flicker	
11	Brown creeper	
10	Hairy woodpecker	
10	Orange-crowned warbler	
09	Pine grosbeak	
05	Say's phoebe	
03	Northern shrike (+27 in 1980)	
02	Townsend's solitaire (+4 in 1980)	
02	Smith's longspur (+5 in 1980)	
01	Downy woodpecker (+8 in 1980)	
01	Golden-crowned kinglet (+11 in 1980)	
1	Black-backed three-toed woodpecker (1980)	RARE
4	Western wood pewee (1980	
2	Yellow warbler (+3 in 1980)	
1	Eastern kingbird (1980)	--ACCIDENTAL

TABLE 3.36: AVIAN HABITAT OCCUPANCY LEVELS, UPPER SUSITNA RIVER BASIN, BREEDING SEASON, 1981

Avian Census Plot	No. species (No. breeding species)	Density (No. territories/ 10 ha)	Biomass (Grams/ 10 ha)	Species diversity (H')
Cottonwood Forest	21(16)	60.9	3653	2.55
Mixed Deciduous-Coniferous Forest II	22(13)	34.6	1836	2.07
Mixed Deciduous-Coniferous Forest I	18(14)	41.8	1709	2.47
Paper Birch Forest	18(10)	38.1	1814	2.05
White Spruce Scattered Woodland	23(16)	43.8	1775	2.29
Black Spruce Dwarf Forest	23(13)	24.8	1166	2.43
Low-Medium Willow Shrub	14(6)	45.4	1413	1.56
White Spruce Forest	18(8)	15.7	1059	1.83
Medium Birch Shrub	10(5)	32.5	952	1.48
Tall Alder Shrub	15(10)	12.5	888	2.05
Dwarf-Low Birch Shrub	11(6)	10.6	355	1.29
Alpine Tundra	8(7)	3.9	211	1.73

TABLE 3.37: NUMBER OF TERRITORIES OF EACH BIRD SPECIES ON EACH 10-HECTARE CENSUS PLOT, UPPER SUSITNA RIVER BASIN, ALASKA, 1981

Species	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cotton-Wood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
Pintail				v[b]								
Goshawk					v					v		
Marsh hawk												v
Spruce grouse					v	v	v	1.0	1.0	v	v	
Ruffed grouse										+[a]		
Willow ptarmigan		0.5		v								v
Rock ptarmigan		0.7										
White-tailed ptarmigan	+											
American golden plover	v											
Greater yellowlegs											+	
Common snipe			v	v							0.5	1.0
Baird's sandpiper	0.8	v										
Long-tailed jaeger		v										
Short-eared owl		v		v								
Common flicker									v			
Hairy woodpecker						1.0			1.0			
Downy woodpecker						0.5						
N. three-toed woodpecker								v	0.3	1.0	v	v
Alder flycatcher												
Olive-sided flycatcher						1.0			v	v		
Horned lark	0.3	v										
Tree swallow			v	v		v						
Gray jay					1.0		v	0.5	0.5	1.0	+	v
Black-billed magpie					v							
Common raven												v
Black-capped chickadee						1.8	v	v	v			
Boreal chickadee							v	1.7	1.0	v	v	1.0
Brown creeper						2.0			1.0			
American robin					0.5		v			v	0.5	0.5
Varied thrush					1.5	10.0	3.5	2.5	3.3	2.9	v	v
Hermit thrush					2.2	v	6.1	3.8	v			
Swainson's thrush						6.9	5.5	5.4	8.0	3.0	v	v
Gray-cheeked thrush						3.8	v	v			3.9	2.5
Arctic warbler			4.8	3.6							2.8	
Ruby-crowned kinglet						v	v	3.3	1.0	4.2	0.8	4.0
Water pipit	0.5											
Bohemian waxwing												v
Orange-crowned warbler											v	
Yellow-rumped warbler					+	7.0	9.8	7.5	9.5	1.0	0.8	2.5
Blackpoll warbler			v			4.4	3.9	1.8	0.5		2.0	1.5
Northern waterthrush						6.1	+	2.5	v			
Wilson's warbler			8.8	9.2	1.2	4.0	3.8	4.0			9.4	
Rusty blackbird												v
Common redpoll		v	v	1.5	v	2.5	2.0	2.0	3.0	v	0.5	1.0
Pine siskin							v			v		
White-winged crossbill					v	v		v	v	v	v	v
Savannah sparrow	1.0	5.8	3.0	12.3						v	2.5	0.8
Dark-eyed junco					2.8	1.8	2.5	3.9	4.5	2.5	2.0	2.0
Tree sparrow		2.5	11.8	15.0	1.5						7.9	2.6
White-crowned sparrow		0.3	4.1	3.8	+	3.5					6.5	2.5
Fox sparrow				v	1.6	4.6	1.0	1.9	v		3.5	2.9
Lincoln's sparrow				v								
Lapland longspur	1.0	0.8										
Snow bunting	0.2											

a. Small portion of a breeding territory on census plot, counted as 0.1 in density and diversity calculations

b. Visitor to plot

TABLE 3.38: NUMBER OF ADULT WATERBIRDS (OR INDEPENDENT YOUNG) AND BROODS FOUND ON 28 WATERBODIES (TOTAL = 20.5 KM^2 OF WETLANDS), UPPER SUSITNA RIVER BASIN, ALASKA, JULY 1981

Species (a)	No. Adults	No. Broods
White-winged scoter	81 (incl. flock 65)	0
Arctic tern	48	0
Oldsquaw	47	11
Mew gull	43	7
Lesser scaup	36	4
Scaup sp.	9	1
Surf scoter	33	2
Black scoter	26	11
Scoter sp.	6	1
Greater scaup	25	0
Northern phalarope	23	0
Common loon	22	3
Trumpeter swan	16	1
Mallard	10	1
Red-throated loon*	8	0
American wigeon	8	6
Red-necked grebe	7	1
Pintail	7	2
Northern shoveler	7	1
Goldeneye sp.	6	1(Common goldeneye)
Horned grebe	5	5
Bonaparte's gull	5	0
Bald eagle	3	0
Arctic loon	2	0
Green-winged teal	2	1
Red-breasted merganser	1	1
Merganser sp.	1	0
TOTAL	487	60
No./km^2	23.8	2.9

a. Arranged in decreasing order of adult numbers.

TABLE 3.39: SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON SURVEYED WATERBODIES DURING AERIAL SURVEYS OF THE UPPER SUSITNA RIVER BASIN, FALL 1980

	DATE OF SURVEY						
Species	7 Sept	11 Sept	16 Sept	20 Sept	26 Sept	3 Oct	TOTAL
Loon spp.				4	1		5
Common loon		3	2	3			8
Red-necked grebe	2	3	4		5	3	17
Horned grebe	1	4	17	9	2	2	35
Swan spp.		34	29	9	12	20	104
Canada goose				1	20		21
American wigeon		155	325	97	88	56	721
Green-winged teal		30	83	9	1	2	125
Mallard	10	64	14	116	110	124	438
Pintail	60	60	53	21	3	4	201
Blue-winged teal		1					1
Northern shoveler		8	20				28
Ring-necked duck			2	12			14
Scaup spp.	165	347	499	370	293	180	1854
Oldsquaw	7	4	13	13	16	4	57
Black scoter		8	38	25	24	10	105
Scoter spp.[(a)]				6	56	72	134
Surf scoter		5	4	2			11
White-winged scoter	10			1	6	1	18
Bufflehead		33	40	95	127	101	396
Goldeneye spp.	15	36	68	124	95	133	471
Merganser spp.		8	30	36	68	19	161
TOTAL BIRDS	270	803	1241	953	927	731	4925
Total wetland area surveyed (km^2)	13.11	22.08	25.76	27.53	29.00	24.25	
Density (birds/km^2 of wetlands)	20.6	36.4	48.2	34.6	32.0	30.1	

a. Surf or White-winged scoter

TABLE 3.40: SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON SURVEYED WATERBODIES DURING AERIAL SURVEYS OF THE UPPER SUSITNA RIVER BASIN, FALL 1981

	DATE OF SURVEY					
Species	15-16 Sept	26 Sept	26 Sept-9 Oct	12-19 Oct	20-23 Oct	TOTAL
Common loon	2	3	3	1		9
Arctic loon						
Red-throated loon						
Loon spp.						
Red-necked grebe	12	3	1			16
Horned grebe						
Whistling swan		18	24			42
Trumpeter swan	6		10	14		30
Swan spp.		41	25	22	13	101
Canada goose				50		50
Mallard	41	153	131	142		467
Pintail	32					32
Green-winged teal	13	3				16
Northern shoveler						
American wigeon	133		14	5		152
Canvasback						
Redhead						
Scaup, greater and lesser	479	166	51	90		786
Goldeneye, common & Barrow's	18	125	68	36		247
Bufflehead	17	20	29	52		118
Oldsquaw	15	31	7	1		54
White-winged scoter			69	13		82
Surf scoter				29		29
Black scoter	1	6	2	1		10
Scoter spp.	69		1	92		162
Common merganser			1	2		3
Red-breasted merganser						
Merganser spp.	77	38		18		133
TOTAL BIRDS	915	607	436	568	13	2539
Total wetland area surveyed (km^2)	25.68	25.68	21.31	11.57	6.62	
Km^2 of 100% frozen waterbodies surveyed[a]	0	1.41	3.91	3.76[b]	2.00	
Density (birds km^2 of wetlands	35.6	23.6	20.5	49.1	1.96	

a. Other waterbodies had at least some open water.
b. An additional 9.22 km^2 of 100% frozen waterbodies were not surveyed in mid-October because they were known to be frozen. By late October only Stephan Lake and one adjacent lake still had some open water.

TABLE 3.41: SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON SURVEYED WATERBODIES DURING AERIAL SURVEYS OF THE UPPER SUSITNA RIVER BASIN, SPRING, 1981

	DATE OF SURVEY			
Species	3 May	10 May	26 May	TOTAL
Common loon			4	4
Arctic loon			5	5
Red-throated			2	2
Loon spp.		3	4	7
Red-necked grebe			4	4
Horned grebe		1	1	2
Whistling swan				
Trumpeter swan	2		6	8
Swan spp.		11	10	21
Canada goose				
Mallard	97	78	121	296
Pintail	71	70	116	257
Green-winged teal	67	47	38	152
Northern shoveler		12	28	40
American wigeon	5	94	99	198
Canvasback		1		1
Redhead			28	28
Scaup, greater and lesser		103	513	616
Goldeneye, common and Barrow's		51	38	89
Bufflehead		2	10	12
Oldsquaw		2	84	86
White-winged scoter			16	16
Surf scoter		4	35	39
Black scoter		1	42	43
Scoter spp.		12	74	86
Common merganser			7	7
Red-breasted merganser			2	2
Merganser spp.			25	25
TOTAL BIRDS	242	492	1312	2046
Total wetland area surveyed (km^2)	25.68	25.68	25.68	
Km^2 of 100% frozen waterbodies surveyed[(a)]	14.31	1.97	0	
Density (birds/km^2 of wetlands)	9.4	19.2	51.1	

a. Other waterbodies had at least some open water.

TABLE 3.42: WATERFOWL NOTED ALONG THE SUSITNA RIVER BETWEEN DEVIL CANYON AND COOK INLET, 7 MAY 1981

Devil Canyon to Talkeetna

Mallard - 18	Canvasback - 2
Pintail - 13	Goldeneye spp. - 11
American green-winged teal - 34	Merganser spp. - 7
American wigeon - 2	

Talkeetna to Montana Creek

Mallard - 23	Goldeneye spp. - 6
American green-winged teal - 5	Bufflehead - 2
Scaup spp. - 2	Merganser spp. - 6

Montana Creek to Kashwitna Lake[a]

Mallard - 23	Goldeneye spp. - 2
Pintail - 3	Bufflehead - 14
American green-winged teal - 3	Scoter spp. - 2
American wigeon - 14	Merganser spp. - 61

Kashwitna Lake[a] **to Yentna River**

Mallard - 7	Goldeneye spp. - 3
American wigeon - 4	Merganser spp. - 8

Yentna River to Cook Inlet

Loon spp. - 8	Mallard - 2
Grebe spp. - 4	American wigeon - 9
Swan spp. - 60	Canvasback - 4
Canada goose - 1	Scaup spp. - 100
Brant - 2	Goldeneye spp. - 10
White-fronted goose - 80	Merganser spp. - 172
Geese spp. - 9	

a. Approximately halfway between Kashwitna River and Willow Creek.

TABLE 3.43: LOCATION OF ACTIVE RAPTOR AND RAVEN NEST SITES, UPPER SUSITNA RIVER BASIN, ALASKA, 1980 AND 1981

Nest	Species	Substrate elevation m (feet)	Active (a) 1980	Active (a) 1981	Nest Location
A	Bald eagle	490 (1600)	X	0	8.0 km up Susitna River from the mouth of Watana Creek. On wooded island in live, 15 m white spruce.
B	Bald eagle	690 (2260)	X	X	4.5 km up Oshetna River from its confluence with the Susitna River. Nest 4 m from edge of west river bank in a 22 m white spruce.
C	Golden eagle	750 (2450)	X	0	3.5 km upriver from Vee Canyon and 0.7 km up a narrow canyon on the north side of the Susitna River. Nest 26 m up a 33 m cliff, 100 m back from and 6.7 m above unnamed creek.
D	Golden eagle	700 (2300)	X	0	4.0 km up the Susitna River from the mouth of Jay Creek and in canyon on north side of the Susitna. Nest 5 m up 13 m cliff, 10 m back from and 18 m above unnamed creek.
E	Golden eagle	640 (2100)	X	X	2.5 km up Jay Creek from its junction with Susitna River. Nest 5 m up 30 m cliff, 150 m from west bank and 115 m above Jay Creek.
F	Golden eagle	550 (1800)	X	0	1.0 km down Susitna River from the mouth of Kosina Creek. Nest 32 km up 38 m cliff on north riverbank.
G	Golden eagle	490 (1600)	X	0	4.0 km down Susitna River from the mouth of Watana Creek. Nest 13 m up 23 m cliff, 40 m back from and 34 m above the north bank of the river.
H	Unknown	490 (1600)	X	0	6.8 km down Susitna River from mouth of Devil Creek and 4.0 km up a gorge on south side of the Susitna. Nest 100 m up 105 m cliff of creek canyon. Occupied by a gyrfalcon in 1974 (White 1974).

a. X = active
   0 = inactive
   - = site not located in 1980

Nest	Species	Substrate elevation m (feet)	Active (a) 1980	1981	Nest Location
I	Golden eagle	365 (1200)	X	X	0.5 km up Devil Creek from its mouth. Nest 30 m up 45 m vegetated cliff, 100 m back from and 120 m above Devil Creek, on west bank.
J	Raven	520 (1700)	X	?	1.0 km up Devil Creek from its mouth. Nest near top of cliff of west bank. Could not relocate nest in 1981.
K	Bald eagle	760 (2500)	X	X	9.0 km up Deadman Creek from its mouth. Nest on top of 15 m broken-topped cottonwood, 25 m from north side of Deadman Creek.
L	Bald eagle	275 (900)	X	X	1.0 km up Susitna River from confluence with Indian River. Nest on top of 23 m broken-topped cottonwood, 4 m from north river bank.
M	Golden eagle	305 (1000)	-	X	2.0 km up Susitna River from the mouth of Portage Creek. Nest on moderate-sized cliff on north bank, but not relocated on ground check.
N	Bald eagle	580 (1900)	-	X	On south shore of small lake, 1.0 km east of NE end of Stephan Lake. Nest on top of 13 m broken-topped cottonwood.
O	Raven	470 (1550)	-	X	2.0 km up Fog Creek from mouth. Nest 9 m up 23 m cliff on west bank, 17 m back from and 23 m above creek.
P	Raven	550 (1800)	-	X	5.0 km up Tsusena Creek from mouth. Nest on cliff on east bank of creek.
Q	Raven	625 (2050)	-	X	1.0 km up Deadman Creek from mouth. Nest 13 m up 32 m cliff on east bank of creek.
R	Golden eagle	975 (3200)	-	X	8.0 km down Susitna River from the mouth of Kosina Creek. Nest 7 m up 12 m cliff on tor above south bank of river.

Nest	Species	Substrate elevation m (feet)	Active(a) 1980	Active(a) 1981	Nest Location
S	Bald eagle	540 (1775)	0	X	2.0 km up Susitna River from the mouth of Kosina Creek. Nest 25 m up 33 m cliff on north bank of river.
T	Golden eagle	685 (2250)	0	X	4.0 km up Susitna River from the mouth of Jay Creek, in canyon on north side of river. Nest 1 m up 5 m vegetated cliff, 14 m back from and 33 m above unnamed creek.
U	Gyrfalcon	715 (2350)	-	X	At Vee Canyon. Nest 100 m up 113 m cliff at south bank of Susitna River.
V	Golden eagle	750 (2450)	0	X	3.5 km up Susitna River from Vee Canyon and 0.7 km up narrow canyon on north side of Susitna River. Nest 8 m up 12 m cliff, 81 m back from and 67 m above unnamed creek.
00	Goshawk	550 (1800)	-	X	2.0 km southwest of Devil Canyon dam site.

TABLE 3.44: BALD EAGLE OBSERVATIONS NOTED DURING THE 26 JUNE 1981 FLIGHT ALONG THE SUSITNA RIVER FROM COOK INLET TO PORTAGE CREEK

	Seward Meridian		
Observation	Range	Township	Comments
Active nest	7W	16N	
Active nest	7W	16N	1 adult bird on nest
1 adult bird	6W	18N	
1 immature bird	6W	18N	
Active nest	6W	19N	
1 adult bird	5W	20N	
1 adult bird	5W	22N	
Active nest	5W	22N	
Active nest	5W	22N	
1 adult bird	5W	24N	
Active nest	5W	25N	
1 adult bird	5W	25N	
Active nest	5W	26N	1 adult bird on nest
Active nest	3W	30N	1 adult bird on nest
1 immature bird	2W	31N	
1 immature bird	2W	31N	
Active nest	2W	31N	2 adult birds on nest

TABLE 3.45: BREEDING CHRONOLOGIES OF EAGLES, GYRFALCON, AND COMMON RAVEN IN INTERIOR ALASKA

Species	Status[a]	DATES OF PHASES OF BREEDING CYCLE				
		Arrival/courtship	Egg-Laying	Incubation	Nestlings	Fledging/dispersal
Golden eagle[b]	M	5 Mar-30 Apr	1 Apr-10 May	15 Apr-20 June	1 June-1 Sept	1 Aug-25 Sept
Bald eagle[b]	M/R	10 Mar-1 May	20 Mar-10 May	30 Apr-30 June	20 May-15 Sept	1 Aug-30 Sept
Gyrfalcon[b]	R	1 Mar-10 Apr	1 Apr-20 May	5 Apr-25 June	15 May-15 Aug	10 July-30 Sept
Raven[c]	R	1 Mar-15 Apr	1 Apr-5 May	5 Apr-25 May	25 Apr-25 June	25 May-15 July

a. M = migrant, R = resident
b. Data summarized from Roseneau et al. (1981)
c. Based on calculations from Kessel (unpubl. data) and Brown (1974)

TABLE 3.46: SPECIES OF SMALL MAMMALS FOUND IN THE UPPER SUSITNA RIVER BASIN, ALASKA, 1980 AND 1981

Order INSECTIVORA

Family Soricidae

Sorex cinereus, masked shrew

Sorex monticolus, dusky shrew

Sorex arcticus, arctic shrew

Sorex hoyi, pygmy shrew

Order LAGOMORPHA

Family Ochotonidae

Ochotona collaris, collared pika

Family Leporidae

Lepus americanus, snowshoe hare

Order RODENTIA

Family Sciuridae

Marmota caligata, hoary marmot

Spermophilus parryii, arctic ground squirrel

Tamiasciurus hudsonicus, red squirrel

Family Cricetidae

Clethrionomys rutilus, northern red-backed vole

Microtus pennsylvanicus, meadow vole

Microtus oeconomus, tundra vole

Microtus miurus, singing vole

Lemmus sibiricus, brown lemming

Synaptomys borealis, northern bog lemming

Family Erethizontidae

Erethizon dorsatum, porcupine

TABLE 3.47: HABITAT LOCATIONS BETWEEN COOK INLET AND DEVIL CANYON SAMPLED DURING THE JUVENILE ANADROMOUS AND RESIDENT FISH STUDY

Estuary to Talkeetna	Site[(a)]
Alexander Creek	A, B, C
Anderson Creek	
Kroto Slough Mouth	
Mainstem Susitna Slough	
Mid Kroto Slough	
Deshka River	A, B, C
Delta Islands	
Little Willow Creek	
Rustic Wilderness	
Kashwitna River	
Caswell Creek	
Slough West Bank	
Sheep Creek Slough	
Goose Creek	1, 2[(b)]
Mainstem Susitna West Bank	
Montana Creek	
Mainstem 1	
Sunshine Creek	
Birch Creek Slough	
Birch Creek	
Cache Creek Slough	
Cache Creek	
Talkeetna to Devil Canyon	
Whiskers Creek Slough	
Whiskers Creek	
Slough 6A	
Lane Creek	
Mainstem 2	
Mainstem Susitna - Curry	
Susitna Side Channel	
Mainstem Susitna - Gravel Bar	
Slough 8A	
Fourth of July Creek	
Slough 10	
Slough 11	
Mainstem Susitna Gold Creek	
Indian River	
Slough 20	
Mainstem Susitna - Island	
Portage Creek	

a. Letter designation indicates multiple sampling sites in that particular region.

b. Number designation indicates two different sample locations near mouth of Goose Creek.

TABLE 3.48: COMMON AND SCIENTIFIC NAMES OF FISH SPECIES APPEARING IN THE TEXT

COMMON NAME	SCIENTIFIC NAME
Arctic Lamprey	Lampeta japonica
Bering Cisco	Coregonus laurettae
Lake Whitefish (Humpback whitefish)	Coregonus clupeaformis
Humpback Whitefish	Coregonus pidschian
Alaska Whitefish (Humpback whitefish)	Coregonus nelsoni
Pink Salmon	Oncorhynchus gorbuscha
Chum Salmon	Oncorhynchus keta
Coho Salmon	Oncorhynchus kisutch
Sockeye Salmon	Oncorhynchus nerka
Chinook Salmon	Oncorhynchus tsawytscha
Round Whitefish	Prosopium cylindraceum
Rainbow Trout	Salmo gairdneri
Dolly Varden	Salvelinus malma
Lake Trout	Salvelinus namaycush
Sheefish	Stenodus leucichthys
Arctic Grayling	Thymallus arcticus
Eulachon	Thaleichthys pacificus
Northern Pike	Esox lucius
Longnose Sucker	Catostomus catostomus
Burbot	Lota lota
Threespine Stickleback	Gasterosteus aculeatus
Sculpin	Cottus sp.

TABLE 3.49: APPORTIONED SONAR COUNTS OF CHINOOK SALMON BY SAMPLING STATION, ANADROMOUS ADULT INVESTIGATIONS, 1981

SAMPLING LOCATION	SONAR OPERATING PERIOD	CHINOOK SALMON COUNTED
Susitna Station	27 June-2 September	1,752
Yentna Station	29 June-2 September	427
Sunshine Station	23 June-15 August	2,415
Talkeetna Station	22 June-15 August	1,154

TABLE 3.50: APPORTIONED SONAR COUNTS AND PETERSEN POPULATION (TAG/RECAPTURE) ESTIMATES BY SPECIES AND SAMPLING LOCATION, ADULT ANADROMOUS INVESTIGATIONS, 1981

SAMPLING LOCATION	ESCAPEMENT ESTIMATES							
	SOCKEYE		PINK		CHUM		COHO	
	Sonar	Petersen	Sonar	Petersen	Sonar	Petersen	Sonar	Petersen
Susitna Station	340,232	-	113,349	-	46,461	-	33.470	-
Yentna Station	139,401	-	36,053	-	19,765	-	17,017	
Sunshine Station	89,906	130,489	72,945	49,501	59,630	262,851	22,793	19,841
Talkeetna Station	3,464	4,809	2,529	2,335	10,036	20,835	3,522	3,306
Curry Station	-	2,804	-	1,041	-	13,068	-	1,146

TABLE 3.51: SUMMARY OF FISHWHEEL CATCHES BY SPECIES AND SAMPLING LOCATION, ADULT ANADROMOUS INVESTIGATIONS, 1981

SAMPLING LOCATION	CATCH			
	SOCKEYE	PINK	CHUM	COHO
Susitna Station	4,087	691	250	329
Yentna Station	7,000	2,729	1,415	1,122
Sunshine Station	9,528	7,099	9,168	2,928
Talkeetna Station	398	379	1,285	533
Curry Station	470	229	1,276	182

TABLE 3.52: PETERSEN POPULATION ESTIMATES AND CORRESPONDING 95% CONFIDENCE INTERVALS OF SOCKEYE, PINK, CHUM, AND COHO SALMON MIGRATING TO SUNSHINE, TALKEETNA AND CURRY STATIONS, ADULT ANADROMOUS INVESTIGATIONS, 1981

LOCATION OF POPULATION ESTIMATE	PARAMETER (a)	SPECIES			
		SOCKEYE	PINK	CHUM	COHO
Sunshine Station	m	8,179	5,900	7,600	2,240
	c	4,831	6,175	9,265	2,845
	r	296	736	270	347
	$\hat{N}$	133,489	49,501	262,851	19,841
	95% C.I.	120,219-150,051	46,357-53,101	235,207-297,859	18,061-22,011
Talkeetna Station	m	322	258	1,142	454
	c	4,167	724	5,944	852
	r	279	80	333	117
	$\hat{N}$	4,809	2,335	20,835	3,306
	95% C.I.	4,320-5,424	1,935-2,943	18,413-22,829	2,830-3,975
Curry Station	m	356	181	1,079	131
	c	3,040	69	4,033	105
	r	386	12	333	12
	$\hat{N}$	2,804	1,041	13,068	1,146
	95% C.I.	2,565-3,092	687-2,143	11,849-14,566	748-2,452

a. m = Number of fish marked (adjusted for tag loss)
c = Total fish examined for marks during sampling census
r = Total number of marked fish observed during sampling census

$\hat{N}$ = Population estimate
C.I. = Confidence interval around N

TABLE 3.53: ARCTIC GRAYLING TOTAL CATCH BY MONTH IN THE UPPER SUSITNA RIVER DRAINAGE, 1981.

TRIBUTARY	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL
Fog Creek [(a)]	30	17	38	5	5	95
Tsusena Creek [(a)]	23	75	133	53	9	293
Deadman Creek	53	86	110	23	3	275
Watana Creek	4	52	18	184	55	313
Kosina Creek	139	263	238	73	177	890
Jay Creek	84	181	74	21	68	428
Goose Creek	128	163	82	41	13	427
Oshetna River	24	93	157	73	167	514
Sally Lake	13	4	-	26	-	43
Deadman Lake	-	-	-	-	1	1
TOTAL	498	934	850	499	498	3,279

a. Tributaries in the proposed Devil Canyon impoundment.

TABLE 3.54: RANGES OR VALUES RECORDED FOR PARAMETERS MEASURED AT STUDY SITES IN THE SUSITNA RIVER AND ITS TRIBUTARIES DURING THE SUMMER FIELD SEASON, 1981

RIVER REACH	TEMPERATURE (C°)	DO (mg/l)	Ph	SPECIFIC CONDUCTIVITY (micromhos/cm)	TURBIDITY (NTU)
River Mouth to Talkeetna					
Alexander Creek	11.6-17.8	8.8-10.2	6.4-7.2	78-99	.99-36
Anderson Creek	6.0-14.3	8.4-11.3	6.5-7.9	70-123	4-190
Kroto Slough mouth	5.9-16.8	8.3-9.9	6.8-7.4	89-199	18-150
Mid-Kroto Slough	8.9-15.2	9.8-10.9	7.3-7.4	94-132	21-200
Mainstem Slough	3.6-14.3	9.7-12.0	7.0-7.4	81-137	24-225
Deshka River	3.9-19.4	8.2-12.0	5.95-7.4	28-80	1.60-90
Lower Delta Islands	10.9-13.2	9.7-10.6	7.6	103-118	110-150
Little Willow Creek	2.0-15.5	9.9-12.4	5.45-6.90	34-39	1.5-18
Rustic Wilderness	8.5-14.2	8.9-12.1	6.9-7.5	67-72	61-150
Kashwitna River	6.4-7.1	9.8-12.9	6.4-7.1	24-36	4.5-42
Caswell Creek	9.0-16.0	7.6-11.3	6.1-7.0	17-461	1.0-1.9
Slough West Bank	6.4-10.8	8.0-12.1	6.8-7.6	68-216	21-210
Sheep Creek Slough	7.8-18.0	9.3-11.0	6.2-7.2	29-47	2.2-4.0
Goose Creek	6.3-10.7	9.2-12.1	6.0-7.1	18-37	.4-4.5
Goose Creek Slough	7.7-11.0	10.6-12.1	6.8-7.7	56-82	9.1-12.0
Mainstem West Bank	3.2-10.0	10.5-12.6	6.7-8.0	76-142	6.3-255
Montana Creek	10.9-12.6	10.0-11.9	6.0-6.7	21-37	.3-1.7
Rabideux Creek	15.8-18.9	7.4	6.9-7.0	88-108	22.5-68
Mainstem 1	7.7-12.8	10.3-11.3	6.4-7.5	78-145	25-170
Sunshine Creek	8.9-15.5	9.8-10.9	5.6-7.3	40-65	1.6-23
Birch Creek Slough	8.4-16.0	9.4-10.3	6.2-7.4	67-132	2.4-95
Birch Creek	8.8-15.4	9.4-11.1	5.7-7.2	43-100	.5-7.5
Cache Creek Slough	4.9-14.1	11.2-12.3	6.2-7.7	57-135	80-270
Cache Creek	5.5-11.9	5.0-12.2	5.7-7.3	31-304	.6-22

RIVER REACH	TEMPERATURE (C°)	DO (mg/l)	Ph	CONDUCTIVITY (micromhos/cm)	TURBIDITY (NTU)
Talkeetna to Devil Canyon					
Whiskers Creek Slough	7.6-18.0	10.5-11.6	5.3-6.6	18-43	.5-23
Whiskers Creek	4.8-16.5	10.7-12.8	5.1-6.6	15-31	.6-3.7
Slough 6A	4.8-16.5	11.8	5.6-7.1	42-113	1.0-22
Lane Creek	5.2-9.8	10.9	6.4-7.2	45-65	.6-5.4
Mainstem 2	5.3-15.2	11.6	6.6-7.4	99-158	13-135
Mainstem at Curry	6.9-15.0	9.1-10.9	7.2-7.5	98-152	23-110
Susitna Side Channel	8.1-16.3	9.5-10.3	6.7-7.6	77-129	22-93
Mainstem Susitna Gravel Bar	.6-14.5	9.6-11.0	7.3-7.8	104-167	7.5-230
Slough 8A	4.5-16.4	8.8-10.5	6.8-7.6	118-160	.7-205
4th of July Creek	2.0-15.0	9.5-10.1	6.3-6.7	15-27	.4-3.0
Slough 10	2.7-12.8	9.0-10.7	7.0-7.8	101-171	1.5-130
Slough 11	4.0-9.7	9.3-10.7	6.8-7.1	144-210	1.5-98
Mainstem Susitna-Inside Bend	1.8-11.8	10.5-11.8	7.0-7.6	92-168	9-150
Indian River (mouth)	.5-12.2	8.6-10.6	5.75-7.4	31-52	2-15
Indian River	2.7-8.4	6.8-12.3	5.7-6.8	38-52	.5-3.4
Slough 20	1.5-14.8	10.3-11.0	6.9-7.4	39-104	3.8-11.5
Mainstem Susitna-Island	2.7-11.7	10.3-11.9	7.2-7.5	66-150	13-140
Portage Creek (mouth)	2.9-8.9	10.0-11.0	6.6-7.1	55-98	2.3-25
Portage Creek	1.5-9.4	10.2-12.3	6.05-7.2	48-158	.25-3.8
Devil Canyon Impoundment Zone and Vicinity					
Fog Creek	6.1-10.4	10.4-11.6	7.3-7.5	73-90	.34-1.50
Mainstem by Tsusena Creek	8.6-10.0	9.8-12.2	7.3-7.5	106-107	48-125
Tsusena Creek (mouth and upstream)	7.5-9.8	9.9-13.2	6.8-7.3	55-71	.6-1.8
Watana Impoundment Zone and Vicinity					
Mainstem by Deadman Creek	8.4-12.6	9.9-11.6	7.3-7.7	100-138	51-130
Deadman Creek	7.6-12.4	9.4-16.6	7.0-7.5	44-79	.68-2.3
Mainstem by Watana Creek	8.0-11.7	9.6-11.7	7.1-7.7	109-132	58

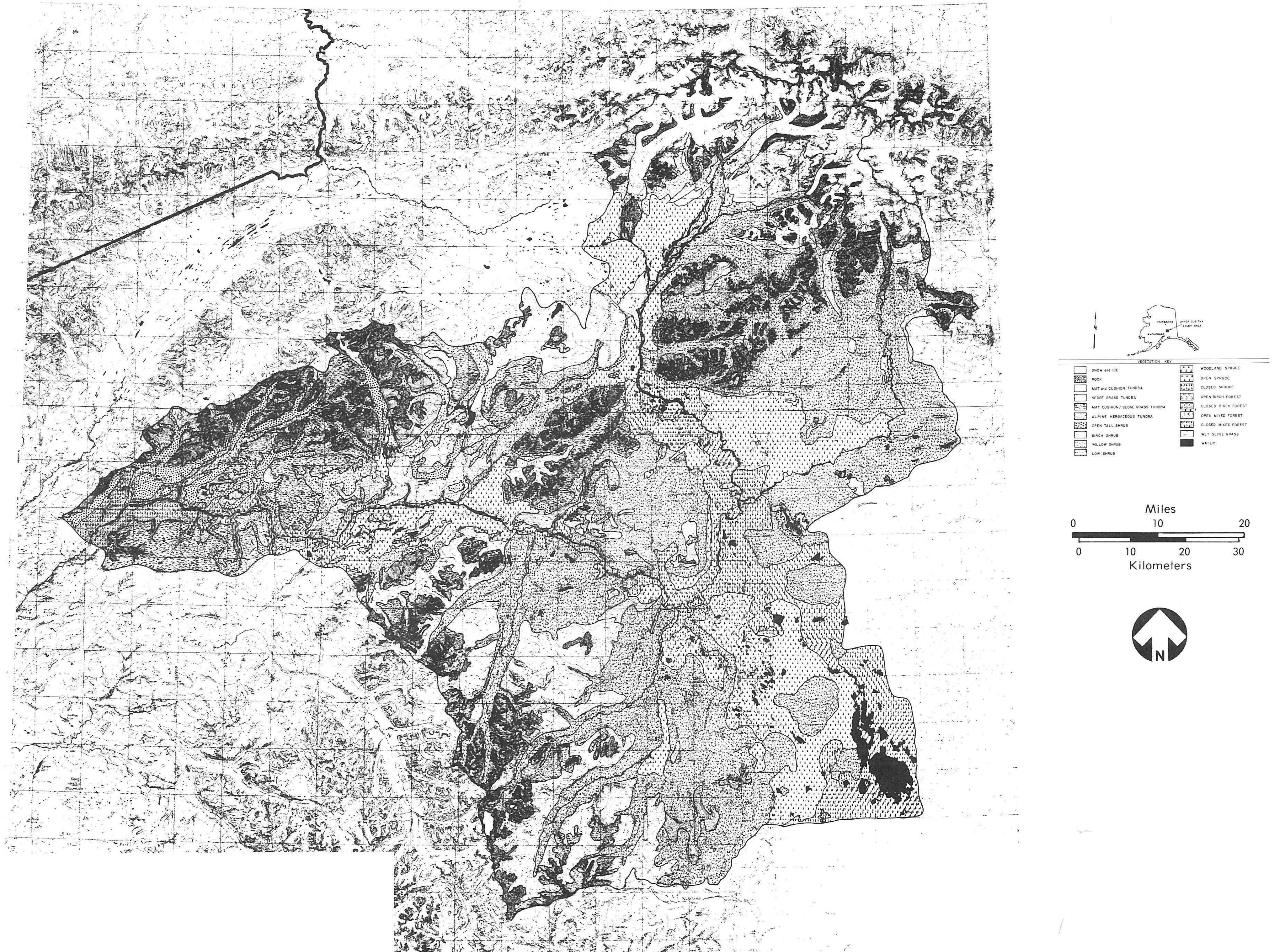
RIVER REACH	TEMPERATURE (C°)	DO (mg/l)	Ph	CONDUCTIVITY (micromhos/cm)	TURBIDITY (NTU)
Watana Impoundment Zone and Vicinity (cont'd)					
Mainstem by Deadman Creek	8.4-12.6	9.9-11.6	7.3-7.7	100-138	51-130
Deadman Creek	7.6-12.4	9.4-16.6	7.0-7.5	44-79	.68-2.3
Mainstem by Watana Creek	8.0-11.7	9.6-11.7	7.1-7.7	109-132	58
Watana Creek	1.5-11.4	9.5-14.3	7.1-7.7	101-248	1.3-9.8
Mainstem by Kosina Creek	3.3-12.4	9.0-12.1	7.1-7.6	106-146	10-145
Kosina	2.7-12.3	9.1-13.7	7.1-7.6	53-68	.5-4.4
Mainstem by Jay Creek	6.7-11.4	9.1-12.3	7.1-7.7	100-135	19-155
Jay Creek	3.6-9.7	9.9-13.2	7.4-7.9	124-175	.5-8.6
Mainstem by Goose Creek	5.0-13.7	8.5-12.0	7.3-7.7	100-152	23-155
Goose Creek	4.2-14.6	8.6-13.8	7.0-7.5	47-66	.32-2.2
Mainstem by Oshetna Creek	6.3-12.2	9.3-12.3	7.4-7.6	101-152	24-175
Oshetna River	5.2-12.6	8.9-12.1	7.2-7.6	65-135	1.2-19

TABLE 3.55: LIST OF ENDANGERED AND THREATENED PLANT SPECIES[a] SOUGHT IN THE UPPER SUSITNA BASIN SURVEYS

Species and Habitat	Unofficial Status [b]
Smelowskia pyriformis Drury & Rollins North American endemic calcareous scree, talus, in upper Kuskokwim R. drainage	Threatened species
Aster yukonensis Cronq. North American endemic river banks, dry streambeds, river delta sands and gravels Kluane Lake, Koyukuk River	Endangered species
Montia bostockii (A. E. Porsild) S. L. Welsh North American endemic wet, alpine meadows, St. Elias Mtns., Wrangell Mtns.	Endangered species
Papaver alboroseum Hult. Amphi-Beringian well-drained alpine tundra, Wrangell Mtns., St. Elias Mtns. Cook Inlet lowlands, Alaska Range	Endangered species
Podistera yukonensis Math & Const. North American endemic S.-facing rocky slopes, grasslands at low elevations, Eagle area, Yukon border	Endangered species
Smelowskia borealis (Greene) Drury & Rollins var. villosa North American endemic alpine calcareous scree, Mt. McKinley Park, Alaska Range	Endangered species
Taraxacum carneocoloratum Nels. North American endemic alpine rocky slopes, Alaska Range, Yukon Ogilvie Mtns.	Endangered species
Other Endangered Species Possibilities	
Cryptantha shackletteana	Upper Yukon River
Eriogonum flavum var. aquilinum	Eagle, Alaska
Erysimum asperum var. angustatum	Upper Yukon River

a. Species information and status from Murray (1980).

b. All species are under review by the U.S. Fish & Wildlife Service for inclusion in the Endangered Species Act of 1973.

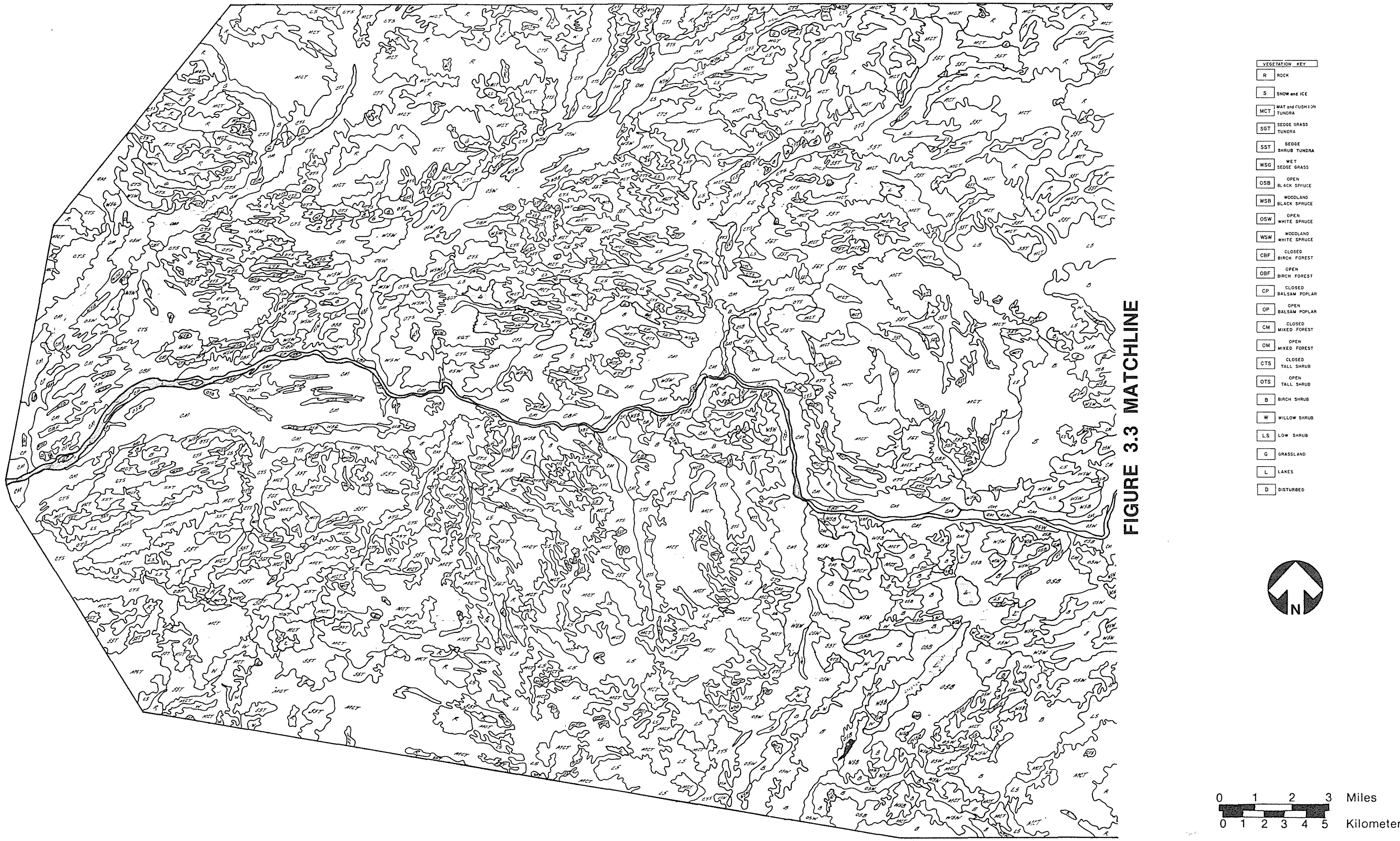


VEGETATION MAP OF THE UPPER SUSITNA RIVER BASIN

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 3.1

ACRES



VEGETATION / HABITAT MAP OF AN AREA WITHIN 16 KM OF THE UPPER SUSITNA RIVER, WESTERN PORTION

PREPARED BY TES / UNIVERSITY OF ALASKA

FIGURE 3.2

ACRES

VEGETATION / HABITAT MAP OF AN AREA WITHIN 16 KM OF THE UPPER SUSITNA RIVER, CENTRAL PORTION

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 3.3

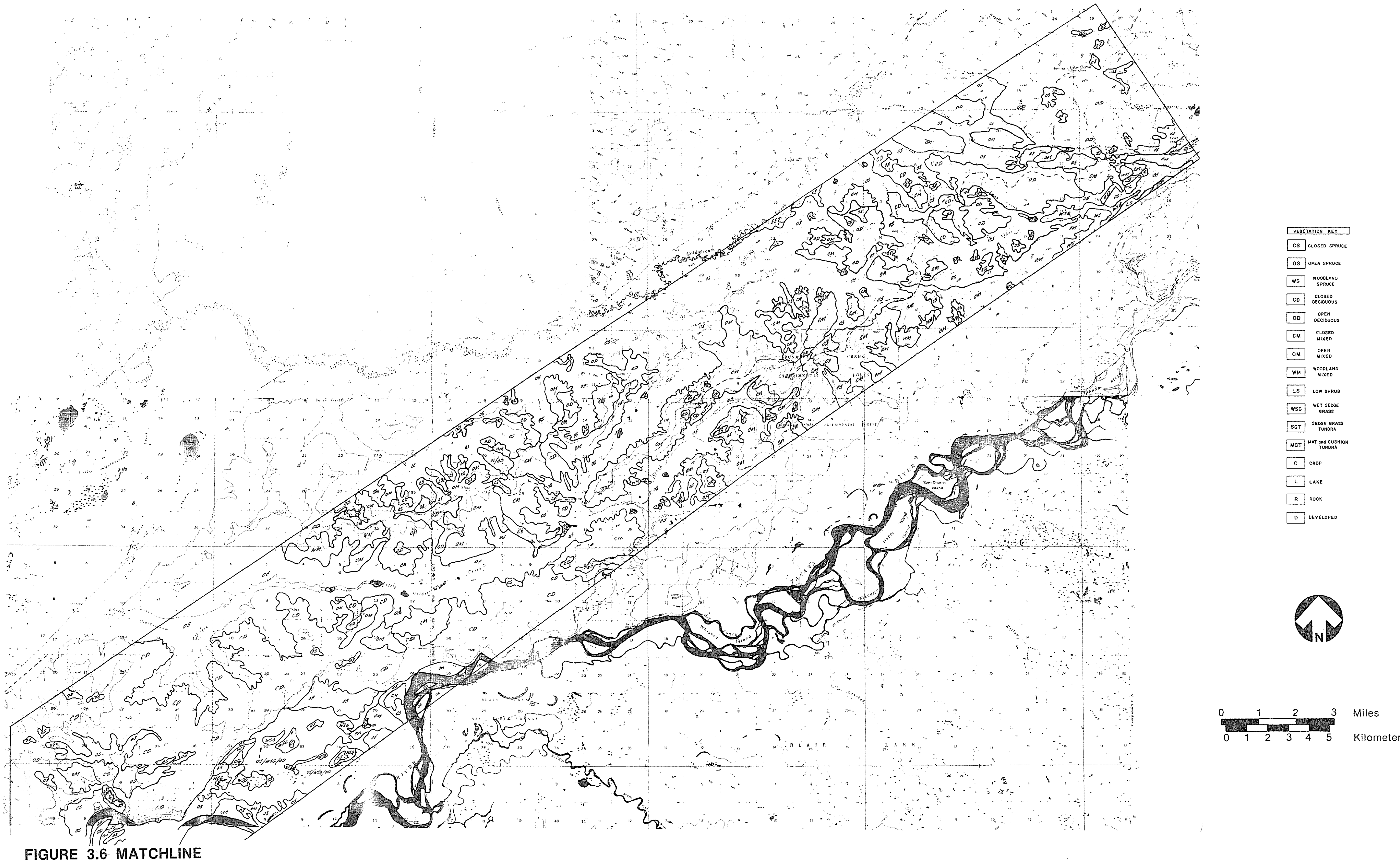
ACRES

VEGETATION / HABITAT MAP OF AN AREA WITHIN 16 KM OF THE UPPER SUSITNA RIVER, EASTERN PORTION

PREPARED BY TES / UNIVERSITY OF ALASKA

FIGURE 3.4

ACRES

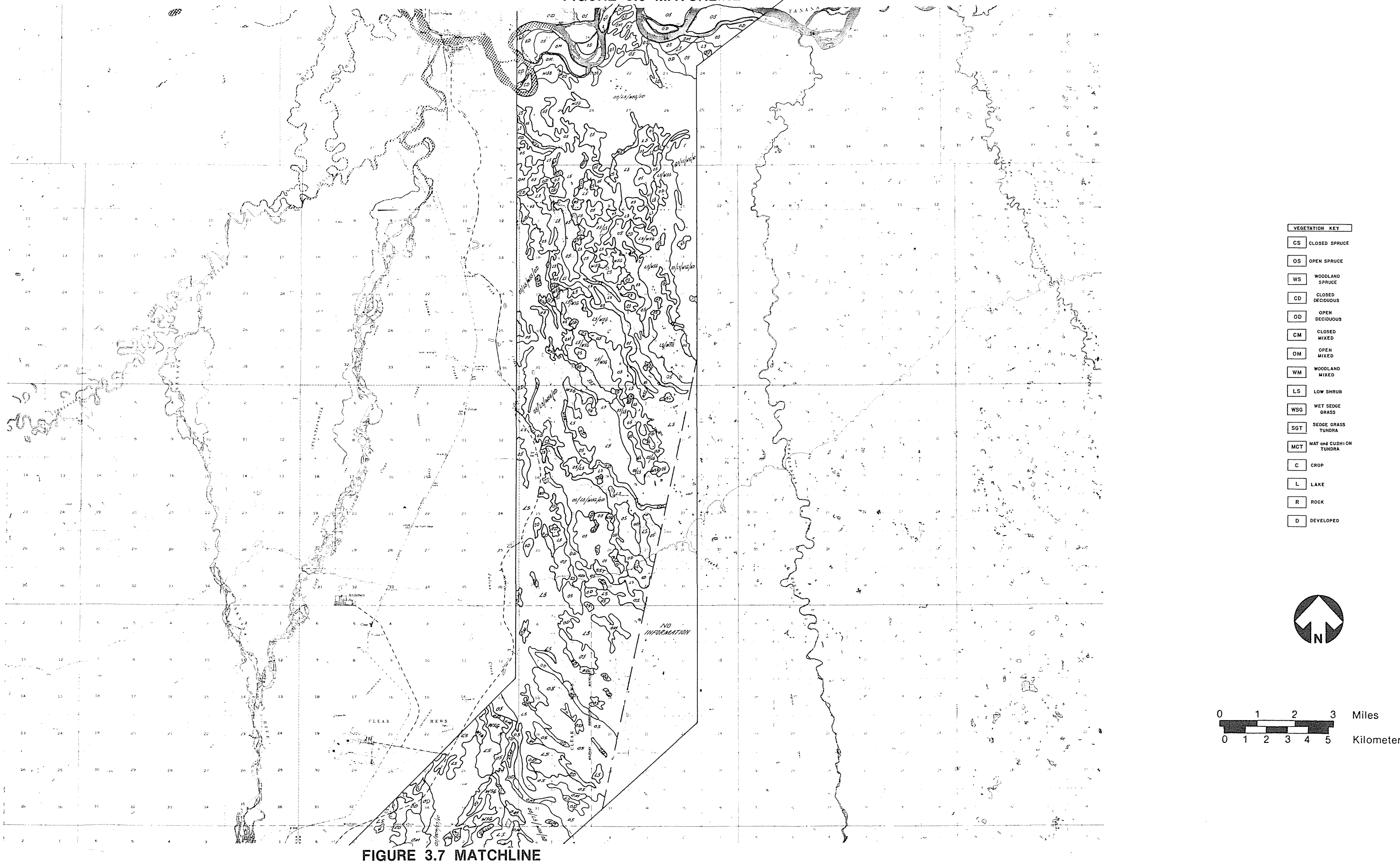


VEGETATION / HABITAT MAP OF HEALY TO FAIRBANKS TRANSMISSION CORRIDOR, NORTHERN PORTION

PREPARED BY TES / UNIVERSITY OF ALASKA

FIGURE 3.5

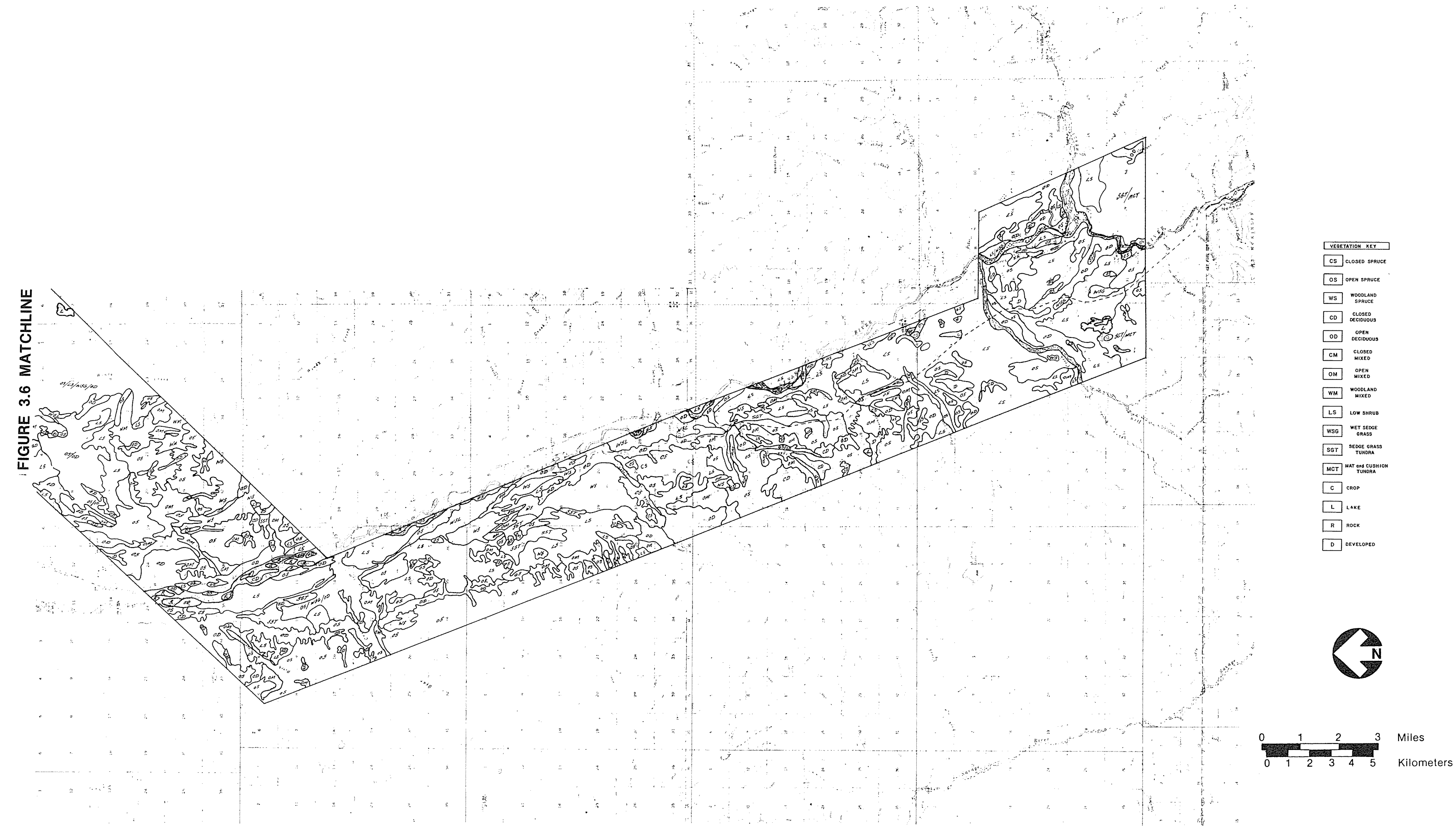
ACRES



VEGETATION / HABITAT MAP OF HEALY TO FAIRBANKS TRANSMISSION CORRIDOR, CENTRAL PORTION

PREPARED BY TES / UNIVERSITY OF ALASKA

FIGURE 3.6

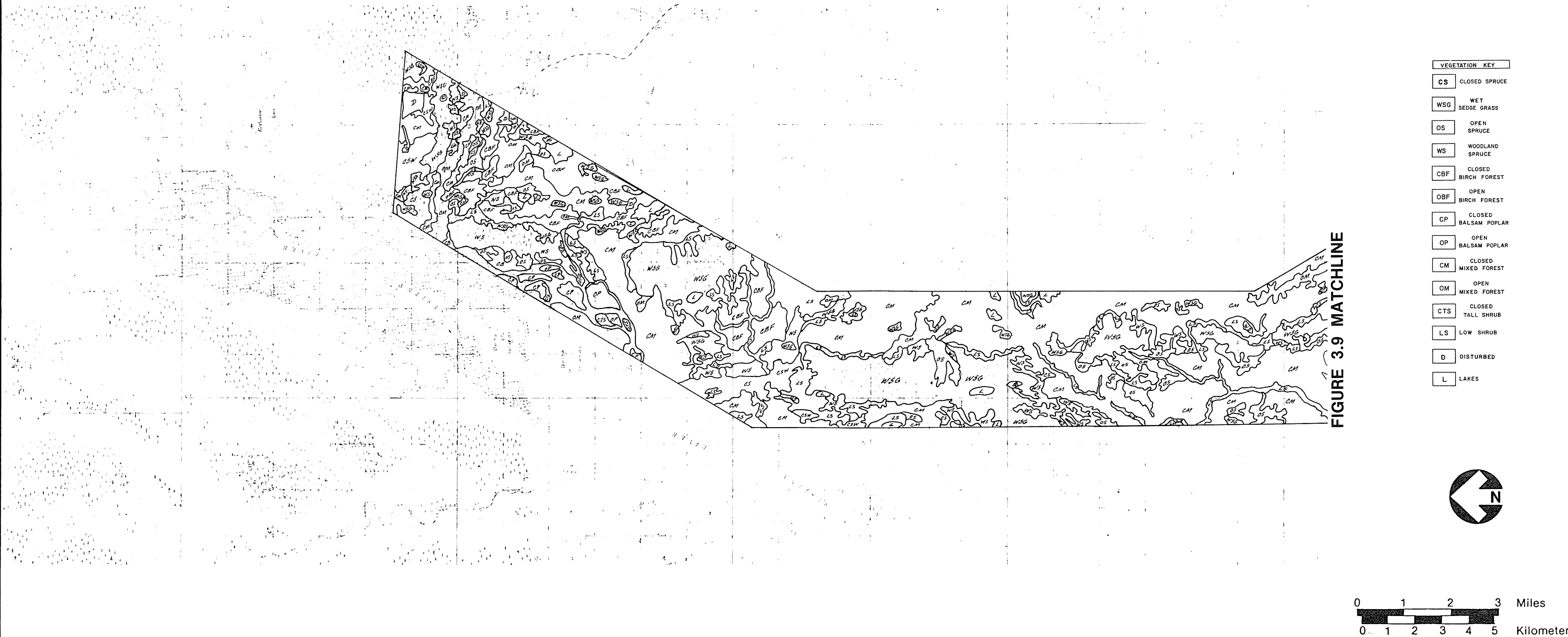


VEGETATION / HABITAT MAP OF HEALY TO FAIRBANKS TRANSMISSION CORRIDOR, SOUTHERN PORTION

PREPARED BY TES / UNIVERSITY OF ALASKA

FIGURE 3.7

ACRES



VEGETATION / HABITAT MAP OF WILLOW TO POINT MACKENZIE TRANSMISSION CORRIDOR, NORTHERN PORTION

PREPARED BY TES / UNIVERSITY OF ALASKA

FIGURE 3.8

VEGETATION / HABITAT MAP OF WILLOW TO POINT MACKENZIE TRANSMISSION CORRIDOR, SOUTHERN PORTION

PREPARED BY TES / UNIVERSITY OF ALASKA

FIGURE 3.9

ACRES

TABLE 3.56: HECTARES OF DIFFERENT VEGETATION TYPES TO BE IMPACTED BY THE WATANA FACILITY COMPARED WITH TOTAL HECTARES OF THAT TYPE IN THE ENTIRE UPPER BASIN AND IN THE AREA WITHIN 16 KM OF THE SUSITNA RIVER

Vegetation/Habitat Type	Facility Components														
	Dam and Spillways	Impound-ment	Camp	Village	Airstrip	Borrow Areas A	D	E	F	H	I	Construction Zone[(a)]	Total [(b)]	% of Upper Basin Total For That Type	% of 16 km Area [(c)] For That Type
Forest	34	10784				181	53	180	81	451	34	7825	18609	5.3	13.1
Woodland spruce-black	8	3870				179	16			224		2564	6434	4.2	10.2
Woodland spruce-white		397						71	69			1133	1530		11.5
Open spruce-black		2864								121	15	1499	4363	4.6	15.4
Open spruce-white		769				2		62	11			303	1072		10.2
Open birch	1	325										286	611	63.1	40.8
Closed birch	13	460					5					38	498[(d)]	154.2[(d)]	21.4
Closed balsam poplar		3											3	(e)	.5
Open conifer-deciduous	5	1337					32			106		453	1790	7.7	18.6
Closed conifer-deciduous	7	759						47	1		19	1549	2308	14.5	17.5
Tundra		84				70	8					502	586	.2	.5
Wet sedge-grass		84					8					91	175	3.6	5.0
Sedge-grass															
Sedge shrub												29	29	(b)	0.1
Mat and cushion						70						382	382	.7	0.7
Shrubland	46	1719	63	62	17	81	224		199	38		4942	6661	1.0	3.8
Open tall shrub	6	227				1							227	.4	1.5
Closed tall shrub	17	287				1	12						287		1.8
Birch shrub	1	443	34	35	13	4	88		195			2915	3358	10.0	7.8
Willow shrub		66							4	17		252	318	3.0	3.7
Mixed low shrub	22	651	29	27	4	75	124			21		1775	2426	0.5	2.6
Herbaceous		45											45		250.0
Grassland															
Disturbed															
Unvegetated	13	2104		8		1	2					456	2560	1.0	9.5
Rock	1	59					2						59	0.05	.36
Snow and ice															
River	12	2007										287	2294	15.6	54.2
Lake		38		8		1						169	207	0.8	3.5
TOTAL	93	14691	63	70	17	333	287	180	280	489	34	13725	28416	1.7	6.2

a. This area encompasses all facility components except the impoundment, with the exception of minor portions of Borrow Areas F and I.

b. Impoundment plus construction zone.

c. An area 16 km on either side of the Susitna River from Gold Creek to the mouth of the Maclaren River (See Figures 3.2 through 3.4).

d. Hectares of closed birch are apparently greater in the impact areas than for the entire basin, because the basin was mapped at a much smaller scale, and many of the closed birch stands did not appear at that scale.

e. Areas of this type were too small to be mapped at the scale of which the upper Susitna River basin was mapped.

TABLE 3.57: HECTARES OF DIFFERENT VEGETATION TYPES TO BE IMPACTED BY THE DEVIL CANYON FACILITY COMPARED WITH TOTAL HECTARES OF THAT TYPE IN THE ENTIRE UPPER BASIN AND IN THE AREA WITHIN 16 KM OF THE SUSITNA RIVER

Vegetation/Habitat Type	Facility Component: Dam and Spillways	Impoundment	Camp	Village	Borrow Area K	Construction Zone[a]	Total[b]	% of Upper Basin Total For That Type	% of 16 km Area[c] For That Type
Forest	16	2289	36	39	119	4504	6793	1.9	4.8
Woodland spruce-black		133				46	179	.36	.3
Woodland spruce-white		20				480	500		3.8
Open spruce-black	4	300			11	785	1085	1.6	3.8
Open spruce-white		329				474	803		7.7
Open birch		57				126	183	18.9	12.2
Closed birch	3	430				156	586[d]	181[d]	25.2
Open balsam poplar		6					6	(e)	
Closed balsam poplar		8				14	22	(e)	3.9
Open conifer-deciduous	7	279					279	1.2	2.9
Closed conifer-deciduous	2	727	36	39	108	2423	3150	19.7	23.8
Tundra		11				211	222	0.06	0.2
Wet sedge-grass		11				192	203	4.2	5.8
Sedge grass						18	18	.01	.07
Sedge shrub						1	1	0	.005
Mat and cushion									
Shrubland		70			18	802	872	0.2	0.5
Open tall shrub		2				125	127	.2	.8
Closed tall shrub		1				165	166		1.0
Birch shrub		49			18	266	315	.9	.7
Willow shrub		14				34	48	.5	.6
Mixed low-shrub		4				212	216	.05	.2
Herbaceous									
Grassland									
Disturbed									
Unvegetated	2	826			11	171	997	.4	3.7
Rock		15				2	17	.02	.1
Snow and ice									
River	1	810				137	947	6.5	22.4
Lake	1	1			11	32	33	0.13	0.6
TOTAL	18	3196	36	39	148	5688	8884	0.5	1.9

a. This area encompasses all facility components except the impoundment.
b. Impoundment plus construction zone.
c. An area 16 km on either side of the Susitna River from Gold Creek to the mouth of the Maclaren River (see Figures 3.2 through 3.4).
d. Hectares of closed birch are apparently greater in the impact areas than for the entire basin, because the basin was mapped at a much smaller scale, and many of the closed birch stands did not appear at that scale.
e. Balsam poplar stands were too small to be mapped at the scale of which the upper Susitna River basin was mapped.

TABLE 3.58: HECTARES OF DIFFERENT VEGETATION TYPES TO BE IMPACTED BY THE ACCESS ROAD WITH TOTAL HECTARES OF THAT TYPE IN THE UPPER BASIN AND THE AREA WITHIN 16 KM OF THE SUSITNA RIVER

VEGETATION/HABITAT TYPE	Facility Component: Right-of-Way (61 m wide)	Facility Component: Borrow Areas	Facility Component: Rail-road Yard	Total	% of Upper Basin of That Type	% of 16 km Area (a) of That Type
Forest						
Woodland spruce	2.0	16.7		18.7	.001	0.02
Open spruce	38.3	35.5		73.8	.06	0.2
Open birch	10.8			10.8	1.0	0.7
Closed birch	4.4	1.8		6.2	2.0	0.3
Closed balsam poplar	14.7	11.0		25.7		4.0
Open conifer-deciduous	68.7	4.0		72.7		0.7
Closed conifer-deciduous	163.8	141.0	7.8	312.6		2.0
Tundra						
Wet sedge-grass	8.8	1.3		10.1	0.2	0.3
Sedge shrub	17.7			17.7		0.09
Mat and cushion	26.5			26.5	0.04	0.04
Shrubland						
Tall shrub	63.0	11.0		74.0	0.06	0.03
Low birch shrub	108.0	32.0		140.0	0.4	0.33
Low mixed shrub	69.0	3.5		72.5	0.01	0.08
Herbaceous-Grassland			14.6	14.6		1.0
Disturbed	2.0	7.5		9.5		39.0
Unvegetated						
Lakes	13.7			13.7	0.05	0.23
River	2.5			2.5	0.02	0.06
Rock		1.5		1.5	0.001	0.01
TOTAL AREA	613.9	266.8	22.4	903.1	0.06 (b)	0.20 (b)

a. An area 16 km on either side of the Susitna River from Gold Creek to the mouth of the Maclaren River.

b. This figure is not a summation of this column, but a percentage determined by dividing the total area to be impacted by the total available area.

TABLE 3.59: HECTARES OF DIFFERENT VEGETATION TYPES TO BE IMPACTED BY THE TRANSMISSION FACILITY COMPARED WITH TOTAL HECTARES OF THAT TYPE IN THE TRANSMISSION CORRIDORS

VEGETATION/HABITAT TYPE	Healy to Fairbanks Right-of-Way (b)	Healy to Fairbanks % of Corridor	Dams to Intertie Right-of-Way (b)	Dams to Intertie % of Corridor	Willow to Cook Inlet (a) Right-of-Way (b)	Willow to Cook Inlet (a) % of Corridor	Total Rights-Of-Way
Forest	1533.7	1.8	587.1	1.7	713.5	2.8	2834.3
Woodland spruce-black	44.4	2.5	2.5	0.1	20.7	0.8	149.6
Woodland spruce - white			82.0	1.7			
Open spruce-black	685.2	2.2	4.9	0.2	98.0	2.9	812.6
Open spruce-white			24.5	0.6			
Closed spruce	74.6	5.5			61.7	1.9	136.3
Open deciduous	149.7	1.2					149.7
Closed deciduous	76.3	0.7					76.3
Open birch			20.4	2.5			20.4
Closed birch			10.8	0.6	114.8	3.2	125.6
Woodland conifer-deciduous	28.8	3.0					28.8
Open conifer-deciduous	251.0	2.0	95.4	1.9	111.8	6.6	458.2
Closed conifer-deciduous	60.2	1.5	346.6	3.0	306.5	2.8	713.3
Open spruce/open deciduous	30.8	3.2					30.8
Open spruce/wet sedge-grass/ open deciduous	43.0	2.2					43.0
Open spruce/low shrub/wet sedge-grass/open deciduous	70.1	1.0					70.1

TABLE 3.60: AREA OF OVERLAP OF BROWN BEAR HOME RANGES AND THE WATANA AND DEVIL CANYON IMPOUNDMENTS

Bear ID (age)	Home Range (km^2)	Area of intersection (km^2) with impoundment: Watana	Devil Canyon	%
MALES				
342a(2)	1774	0	16.3	0.9
293 (3)	4135	155.4	0.8	3.8
214 (4)	975	50.0	0	5.1
280 (5)	743	84.1	0	11.3
294(10)	611	0	13.7	2.2
FEMALES				
335 (2)	179	0	0	0
281 (3)(w/cubs in '81)	330	82.7	0	25.1
340 (3)	613	62.1	0	10.1
308b(5)	191	0	14.4	7.5
344 (5)	246	0	0	0
331 (6)	1136	50.4	0	4.4
341 (6)	536	43.6	0	8.1
313 (9)	218	0	0	0
277(10)	147	0	0	0
312(10)(w/cubs in '81)	280	1.2	0	0.004
334(10)(w/cubs in '81)	111	0	0	0
283(12)	323	0	12.9	4.0
299(13)	585	54.5	0	9.3
337(13)(w/cubs in '81)	270	0	0	0

TABLE 3.61: AREA OF OVERLAP OF BLACK BEAR HOME RANGES AND THE WATANA AND DEVIL CANYON IMPOUNDMENTS

Bear ID (age)	Home Range (km^2)	Area of intersection (km^2) with impoundment: Watana	Devil Canyon	%
MALES				
330 (1)	10	0	0	0
323 (2)	383	1.0	21.7	5.9
319 (3)	146	0	14.1	9.7
291 (4)	20	0	1.6	8.0
322 (4)	10	2.5	0	25.0
324 (5)	400	0.4	9.8	2.6
342B(5)	611	139.9	0	22.9
343B(5)	289	0	11.8	4.1
302 (8)	326	98.9	0	30.3
303 (8)	142	0	3.1	2.2
305 (9)	48	0	0	0
346 (9)	62	13.9	0	22.4
348 (9)	388	34.5	2.0	9.4
287(10)	292	6.3	2.5	3.0
304(10)	51	0	0	0
FEMALES				
329 (1)	15	6.8	0	45.3
349 (4)	36	11.4	0	31.7
318 (5)	1051	112.4	4.3	11.1
327 (5)	32	14.1	0	44.1
328 (6)	30	0	0.9	3.0
301 (7)	26	7.0	0	26.9
317 (7)	19	0	0	0
290 (8)	163	0	10.6	6.5
289 (9)	47	21.4	0	45.5
288(10)	7	0	0	0
321(10)	774	91.8	5.4	12.6
325(11)	146	9.7	3.3	8.9

TABLE 3.62: GENERAL TYPES OF IMPACTS TO RAPTORS

Disturbance
Construction and Operation Activities
- sudden loud noises (e.g., blasting, gas venting, etc.) can lead to panic flights and damage to nest contents
- noise, human presence, etc. can lead to disruption of daily activities
Aircraft Passage
- sudden appearance and noise can lead to panic flights and damage to nest contents
Human Presence Near Nests
- inadvertent - chance occurrence of people (and dogs) near nests; people may be unaware of nest, raptors, or raptor alarm behavior
- deliberate - curious passersby, naturalists, photographers, researchers can have impacts if safeguards are not taken
Direct Impacts
Intentionally Destructive Acts (as a result of increased public access)
- shooting
- legal or illegal removal of eggs, young, or adults
- rolling of rocks off cliff tops
- cutting of nest trees
Man-made Structures and Obstructions
- raptors may be struck on roads where they may perch or feed
- raptors may strike wires, fences, etc.
- raptors may be electrocuted on power poles
- raptors sometimes attack aircraft, or may accidentally strike aircraft
Environmental Contaminants
- deliberate application and accidental release of insecticides, herbicides, petro-chemicals, and toxic industrial materials can affect raptors and prey by affecting hormones, enzymes, shell thickness, bird behavior, egg fertility and viability, and survival rates of nestlings, fledglings, immatures and adults

Source: Roseneau et al. 1981

TABLE 3.62 (continued)

Changes in Prey Availability

- decrease in prey abundance or loss of nearby hunting areas may affect territory size, efficiency of hunting, nest occupancy, nesting success, condition of adults and young

- changes may result from aircraft overflights, construction and maintenance activities, public access, etc.

<u>Habitat Loss</u>

Abandonment of area due to destruction of nest, perch or important hunting habitat

TABLE 3.63: DISTURBANCE OF RAPTORS -- INFLUENCE OF TIMING

Timing	Possible Effects of Disturbance
Winter	Raptor may abandon nest, roosting cliff, or hunting area (e.g., Gyrfalcon)
Arrival and courtship	Migrant raptor may be forced to use alternative nest site (if available), may remain but refuse to breed or may abandon nest site
Egg-laying	Partial clutch may be abandoned and remainder (or full clutch) laid at alternative nest; breeding effort may cease or site may be abandoned
Incubation	Eggs may be chilled, overheated, or preyed upon if parents are kept off nest too long; sudden flushing from nest may destroy eggs; male may cease incubating; clutch or site may be abandoned
Nestling phase	Chilling, overheating, or predation of young may occur if adults are kept off nest; sudden flushing of parent may injure or kill nestlings; malnutrition and death may result from missed feedings; premature flying of nestlings from nest may cause injury or death; adults may abandon nest or site
Fledgling	Missed feedings may result in malnutrition or death; fledglings may become lost if disturbed in high winds; increased chance of injury due to extra moving about; parents may abandon brood or site
Night	Panic flight may occur and birds may become lost or suffer injury or death
General	Undue expense of energy; increased risk of injury to alarmed or defending birds; missed hunting opportunities

Source: Roseneau et al. 1981

TABLE 3.64: LINEAR DISTANCES OF CLIFFS IN VICINITY OF PROPOSED IMPOUNDMENTS, AND DISTANCES THAT WOULD BE INUNDATED

	Type of cliff[a]	Length inundated (km)	Length above waterline (km)
Devil Canyon Reservoir			
	A	27.4	24.9
	B	8.3	7.9
	C	2.4	1.6
Watana Reservoir			
	A	15.1	0.9
	B	5.1	0
	C	1.6	0.3

a. "A" cliff habitat had cliffs large enough to support a nest, had ledges and nooks for nest placement, and had little loose material; "B" cliffs had these same attributes but were smaller and perhaps not large enough to support a nest; and "C" cliffs had loose substrates (dirt and rock banks or loose talus) and probably would not have been used by raptors.

TABLE 3.65: NUMBER OF KNOWN RAPTOR OR RAVEN NEST SITES IN UPPER SUSITNA RIVER BASIN, ALASKA, THAT WOULD BE INUNDATED BY DEVIL CANYON AND WATANA RESERVOIRS

Species	Total no. active nests	Total no. inactive nests	Active nests that would be flooded		Inactive nests that would be flooded		Total flooded nests
			Devil Canyon	Watana	Devil Canyon	Watana	
Golden Eagle	10	9	1	4	2	3	10
Bald Eagle	6	1	0	2	0	1	3
Gyrfalcon	1	0	0	0	0	0	0
Goshawk	1	0	0	0	0	0	0
Common Raven	4	7	1	0	1	2	4
Unknown	1	3	0	0	0	0	0
TOTALS	23	20	2	6	3	6	17

TABLE 3.66: RAPTOR/RAVEN NEST SITES WITHIN 1.6 km OF POTENTIAL BORROW AREAS

Borrow Area	Species	Distance from Borrow Area	Comments
E	golden eagle	0.2 km	
E	raven	0.5 km	two nest sites
H	raven	0.3 km	
H	unknown	0.4 km	
H	raven	0.8 km	three nest sites
H	gyrfalcon	0.0 km	1974 nest (White 1974)
K	goshawk	1.6 km	
K	gyrfalcon	1.6 km	1974 nest (White 1974)

TABLE 3.67: A GENERAL ASSESSMENT OF POTENTIAL FISH ECOLOGY IMPACT ISSUES BY PROJECT STAGE FOR THE ENTIRE SUSITNA RIVER STUDY AREA UNDER POST-PROJECT FLOWS

Project Stages (a)	Potential Impact Issues	General Assessment
CC, CD, RD, O	Changes in the water quality	Decreases in turbidity levels expected above Talkeetna in summer and minor increases above Talkeetna in winter.
CD, O	Alteration of the temperature structure of the stream.	Impact not yet determined. Greatest concern is for salmon egg development, especially during filling and in the Talkeetna to Devil Canyon reach.
CD	Possibility of excessive dissolved gas (nitrogen and oxygen) concentrations caused by plunging flows	No major impacts expected with appropriate dam design and construction procedures, as proposed.
O	Development of new ice-free areas.	Level of impact not known.
O	Change in ice conditions below Talkeetna affecting downstream movement of fish.	Level of impact on downstream fish movement not known.
CD, O	Summer and winter flow changes and the impact on fish reproduction, growth, and predation as well as critical flows for transportation (including access to tributaries and sloughs)	Level of information on impact on fish reproduction and growth not well-known. Access to main tributaries should not be impacted but access to sloughs above Talkeetna by adult salmon eliminated.
O	Effect on present type of fish collection devices in Cook Inlet	No impact expected.
CD	Extension of upstream anadromous fishery	Salmon passage through Devil Canyon possible during filling. After Devil Canyon dam is constructed, limit of migration will revert to present location.

a. Project stages:
CC - Construction of the cofferdam and river diversion
CD - Construction of the dam and reservoir filling time
RD - Development of limnological conditions and fishery management in the reservoir after filling
O - Operational stage including start-up

TABLE 3.67 (continued)

Project Stages[(a)]	Potential Impact Issues	General Assessment
O	Bank scour caused by piping effect of increased flows under the ice	No major impacts predicted above Talkeetna Impact below Talkeetna not known.
CD, O	Bed scour as affected by changing flows and ice	Decreases in scouring due to flood control. Open water year-round above Talkeetna may increase enhancement opportunities if proper flow control utilized.
O	Potential for increased production by the addition of new spawning areas and new rearing areas	Potential for mainstem spawning enhancment as a mitigative measure.
CD, RD, O	Formation (and management) of new lakes (impoundments)	Some tributary and mainstem Susitna habitat eliminated. Impoundment may increase amount of overwintering habitat for grayling and development of a resident fishery possible.
RD, O	Changes in personal use fishery	Major increases in impoundment areas and Indian River possible.
CD, O	Potential stranding of juveniles and exposure of redds due to diel variation	Under present project scheme, no significant impact predicted. Potential problem would occur, however, if there were to be significant power peaking at the Devil Canyon facility.
CD, RD, O	Changes in the habitats of downstream resident fish populations	If power peaking is minimal, overall impact on resident fish downstream is expected to be minimal.
CD, O	Effects on rearing, fish passage and egg incubation in the Susitna River from its mouth upstream to Talkeetna	Detailed predictions as to the level of impacts on fisheries in this reach have not been established with the information presently available.

TABLE 3.68: PRIORITY ORGANIZATION OF WILDLIFE MITIGATION IMPACT ISSUES

High Priority Impact Issues	Project Component	Wildlife Resource
W-6	Watana and Devil Canyon Impoundments	Upper Basin Moose
W-8	Watana and Devil Canyon Impoundments	Brown Bear
W-9	Watana and Devil Canyon Impoundments	Wolf
W-20	Access Roads and Construction Camps	All Upstream Furbearer and Big Game Species

Moderate Priority Impact Issues	Project Component	Wildlife Resource
W-2	Watana and Devil Canyon Impoundments	Pine Marten
W-3	Watana and Devil Canyon Impoundments	Cliff-nesting Raptors
W-4	Watana and Devil Canyon Impoundments	Bald Eagle
W-7	Watana and Devil Canyon Impoundments	Black Bear
W-11	Watana Impoundment	Caribou
W-12	Operation of Devil Canyon Dam	Downstream Beavers
W-13	Operation of Devil Canyon Dam	Downstream Moose
W-15	Clearing of Woody Material from the Watana Impoundment	Caribou
W-17	Main Access Road, Borrow Areas, Access Roads to Borrow Areas, and all Construction Camps/Villages	All Furbearer Species, Many Avian and Small Mammal Species, and all Big Game Species except Dall Sheep
W-22	Construction Camps and Access Roads	All Upper Basin Wildlife Species
W-23	Air Traffic	All Big Game Species, Raptors and Trumpeter Swans

TABLE 3.68 (Continued)

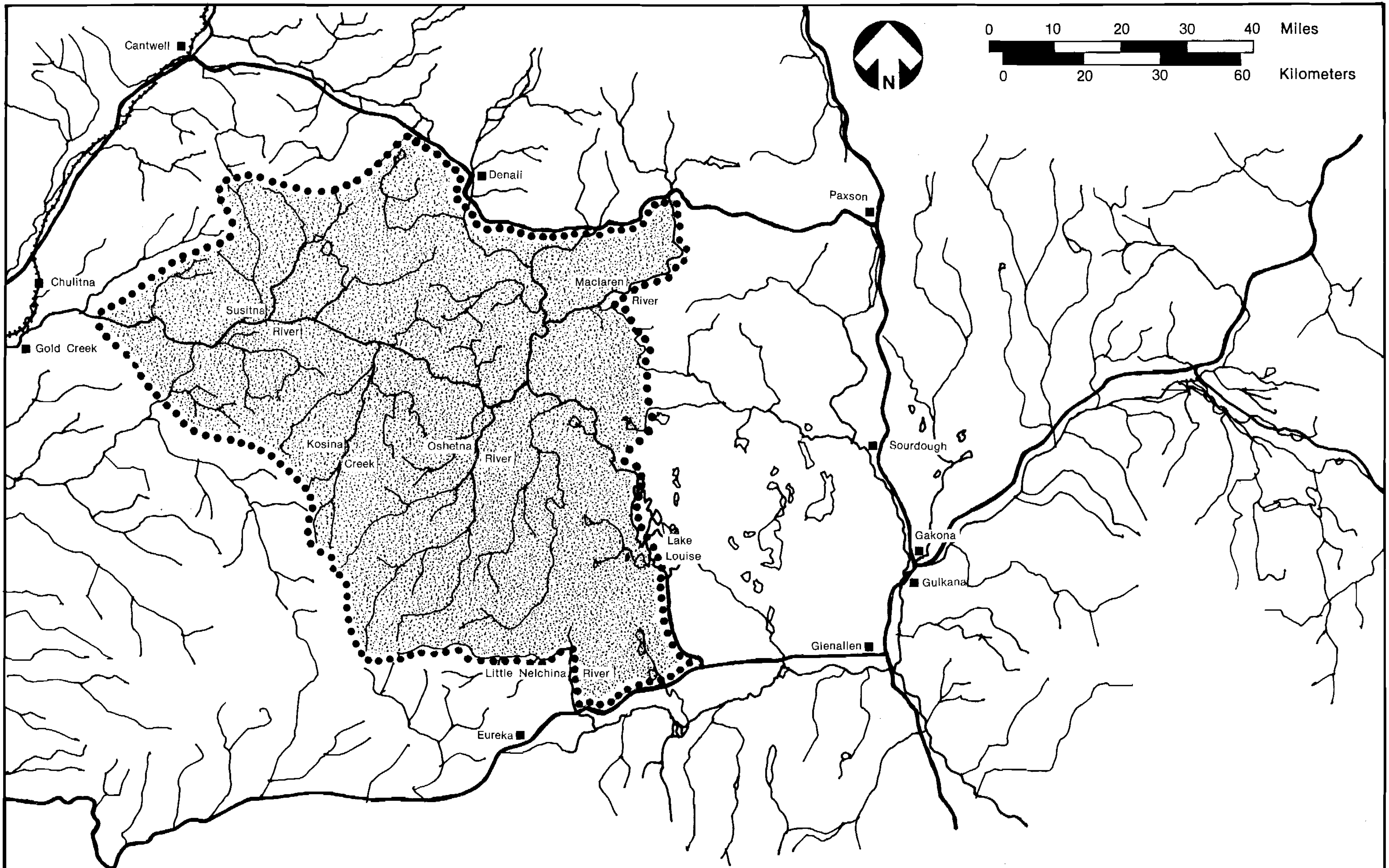
Low Priority Impact Issues	Project Component	Wildlife Resource
W-1	Watana and Devil Canyon Impoundments	Mink and River Otter
W-5	Watana and Devil Canyon Impoundments	Forest-dwelling and Riverine Bird and Small Mammal Species
W-10	Watana Impoundment	Dall Sheep
W-14	Clearing of Woody Material from Impoundments	All Upstream Big Game Species
W-16	Construction Camps/Villages and all Access Roads	Red fox, Wolf, Black and Brown Bear, Ground Squirrel, Gulls and Ravens
W-18	Borrow Areas and Access Roads to Borrow Areas	All Upstream Big Game Species except Dall Sheep
W-19	All Access Roads	Moose and Caribou
W-21	Construction Camps and Villages	Red Fox and Wolf

TABLE 3.69: PREDICTED DOWNSTREAM WATER TEMPERATURES (°C) FOR AN AVERAGE YEAR WITH PROJECT FLOWS[a]

Cross[b] Section	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LRX 68 (Portage Creek)	3.9	3.9	3.9	3.9	5.7	7.1	9.8	9.6	7.6	4.3	3.9	3.9
LRX 61	3.8	3.8	3.9	3.9	5.8	7.1	9.8	9.7	7.6	4.3	3.9	3.8
LRX 54	3.3	3.5	3.7	4.0	6.1	7.5	10.1	10.1	7.7	4.2	3.5	3.5
LRX 47	3.0	3.2	3.6	4.1	6.2	7.8	10.2	10.3	7.8	4.2	3.4	3.3
LRX 41 (Gold Creek)	2.9	3.2	3.6	4.1	6.3	7.9	10.3	10.4	7.8	4.2	3.3	3.2
LRX 34	2.6	2.9	3.4	4.2	6.5	8.2	10.5	10.7	7.9	4.1	3.0	2.9
LRX 27	2.1	2.5	3.3	4.3	6.8	8.6	10.7	11.0	8.0	4.1	2.7	2.5
LRX 21	1.7	2.3	3.2	4.4	7.0	8.9	10.9	11.3	8.1	4.0	2.5	2.2
LRX 15	1.1	1.8	3.0	4.5	7.3	9.4	11.2	11.8	8.2	3.9	2.1	1.7
LRX 9	0.5	1.4	2.8	4.7	7.7	9.9	11.5	12.2	8.3	3.8	1.7	1.3
LRX 3 (Talkeetna)	0.1	1.1	2.6	4.8	7.9	10.3	11.7	12.6	8.4	3.8	1.4	0.9
Discharge Below DC (cfs)	10514	8883	8072	7903	9344	10288	9070	8665	6972	7403	9425	11864

a. Assumes operation for maximum power production, a floating intake at Watana, and a single level intake at 21.3 m (70 ft) at Devil Canyon.

b. LRX refers to R&M river cross sections.

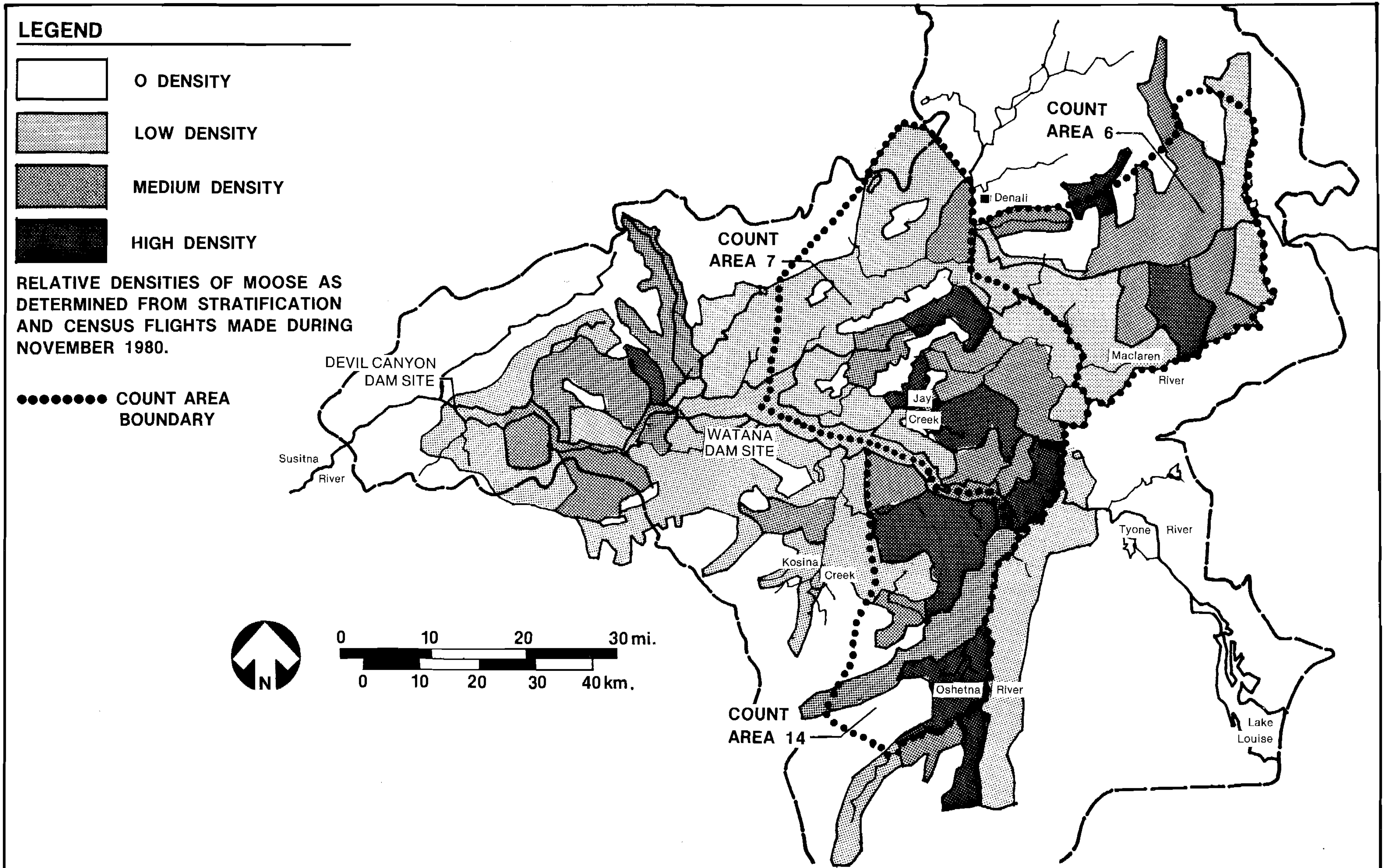


BOUNDARIES OF THE SUSITNA MOOSE STUDY AREA - UPSTREAM

PREPARED BY TES / ADF&G

FIGURE 3.10

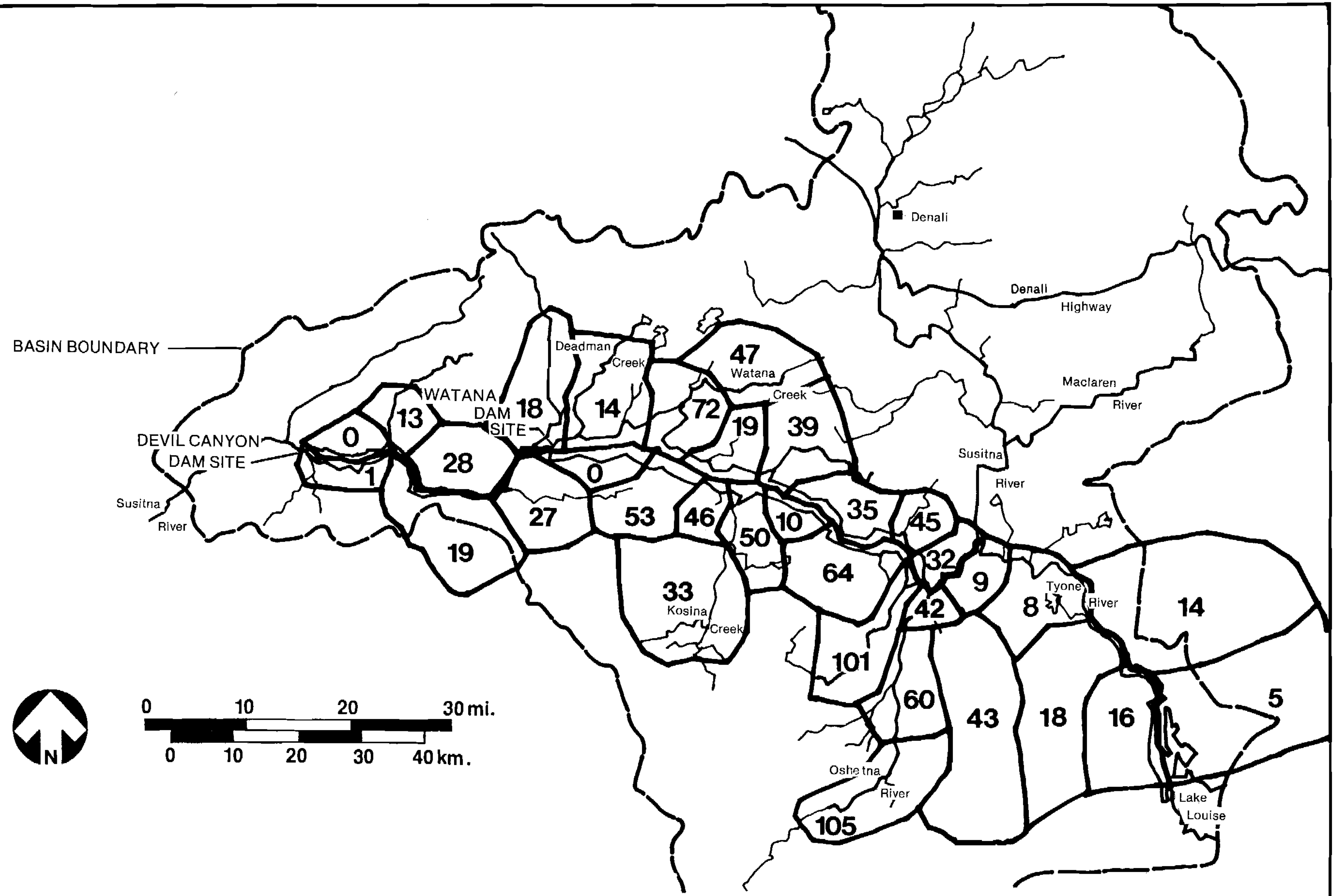
ACRES



BOUNDARIES OF ESTABLISHED MOOSE COUNT AREAS

PREPARED BY TES / ADF&G

FIGURE 3.11

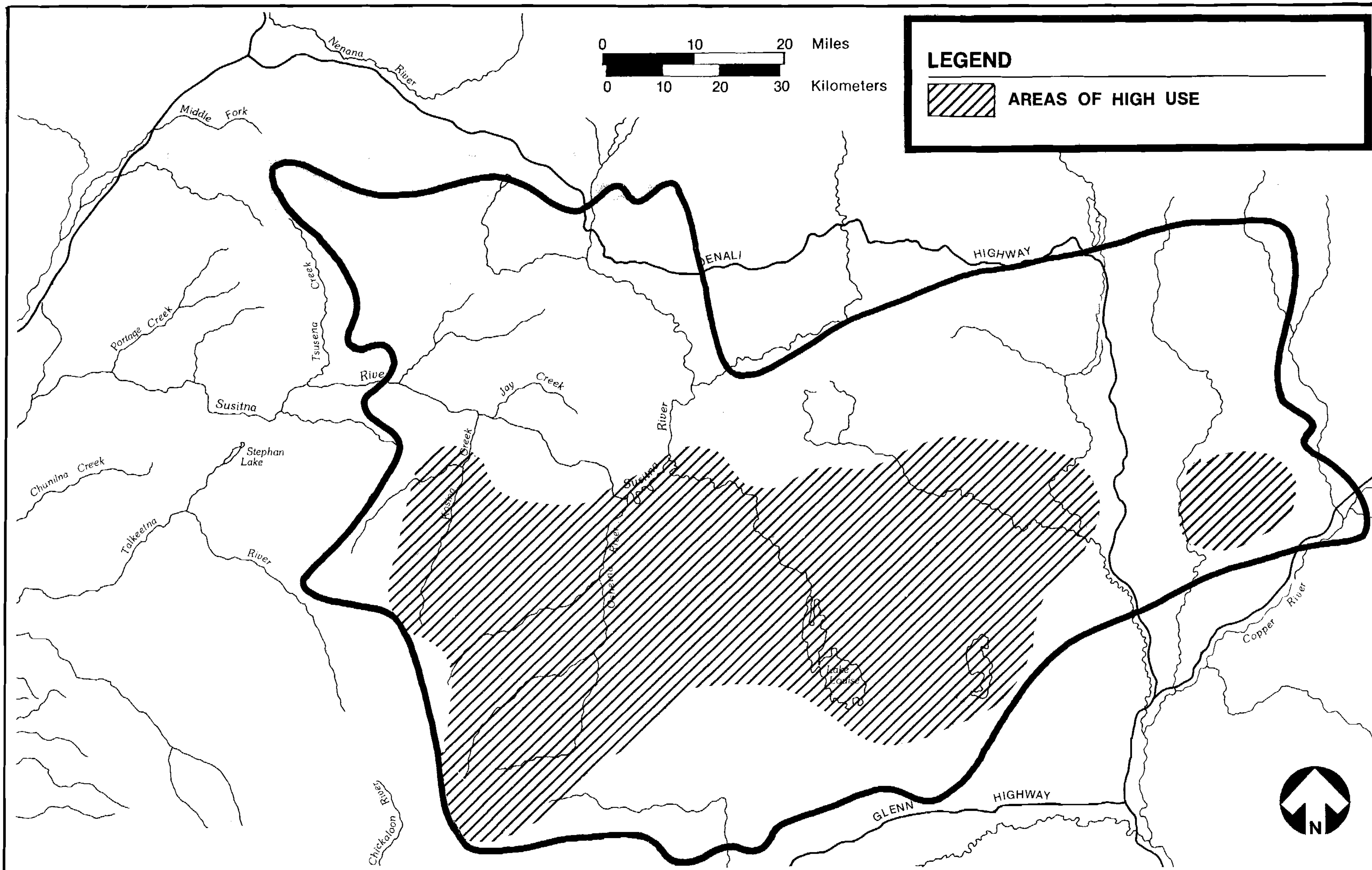


RELATIVE DISTRIBUTION OF MOOSE OBSERVED DURING A WINTER DISTRIBUTION SURVEY CONDUCTED FROM 4 THROUGH 25 MARCH 1980

PREPARED BY TES / ADF&G

FIGURE 3.12

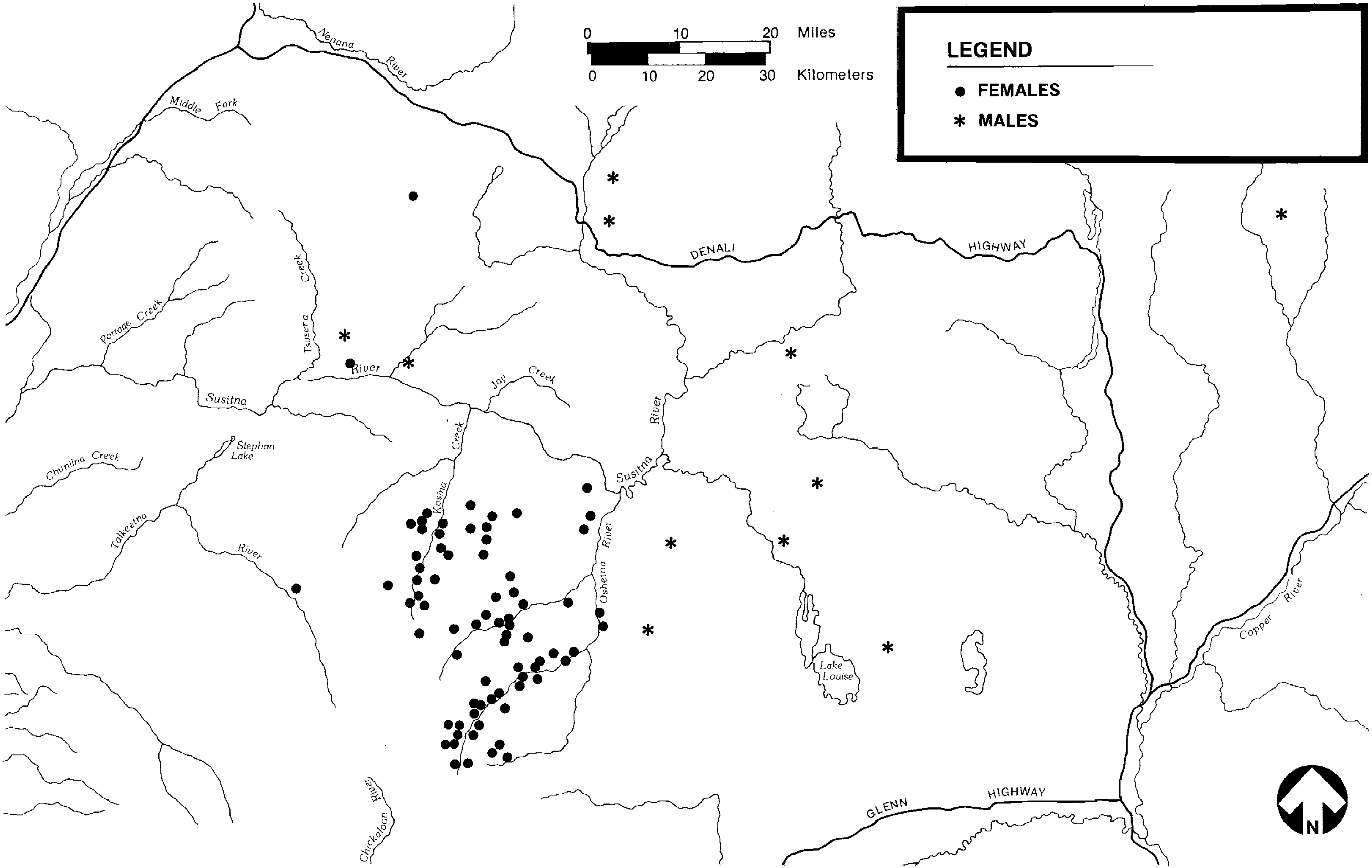
ACRES



DISTRIBUTION OF MAIN NELCHINA RADIO-COLLARED CARIBOU,
14 APRIL 1980 THROUGH 29 SEPTEMBER 1981

PREPARED BY TES / ADF&G

FIGURE 3.13

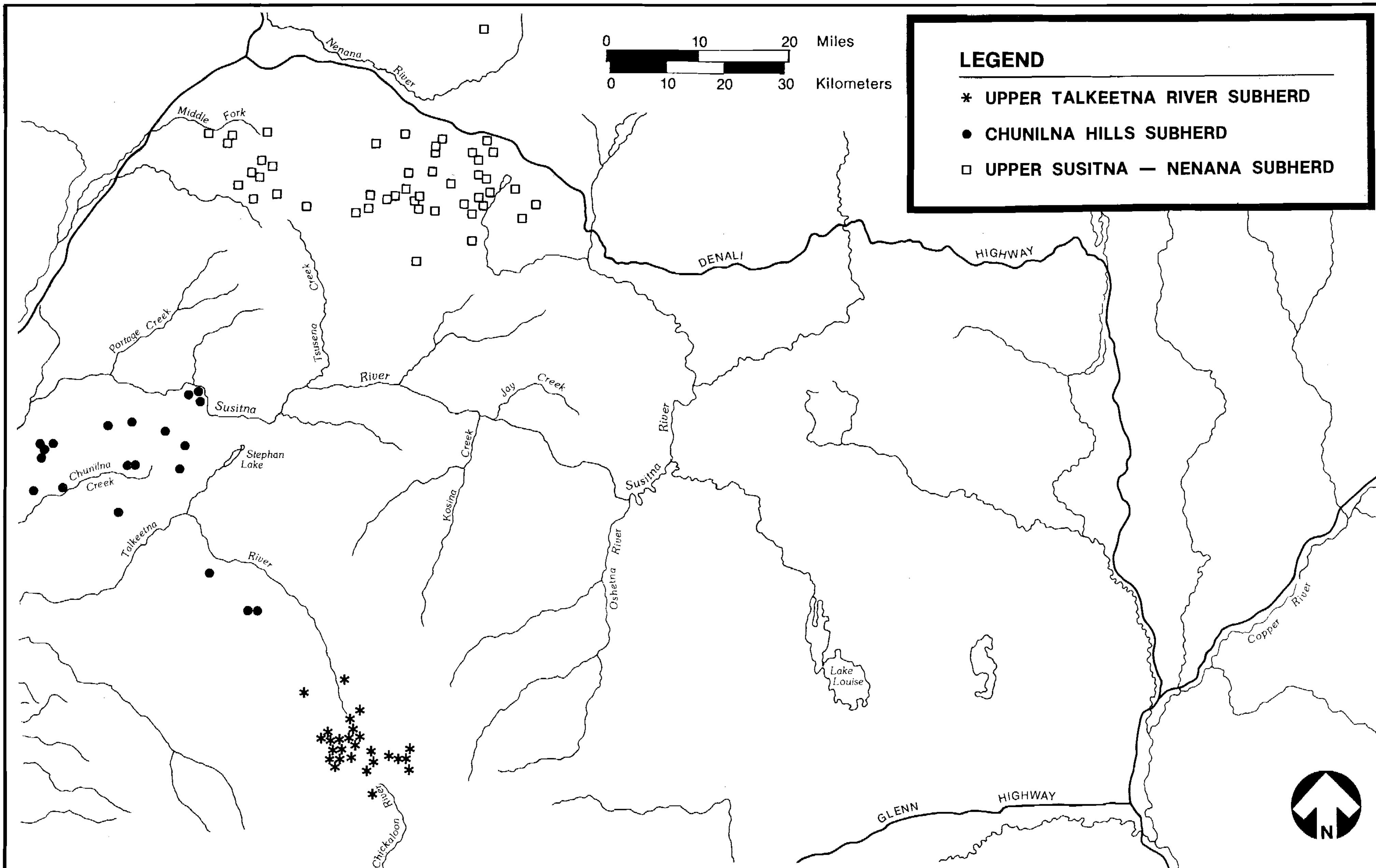


DISTRIBUTION OF NELCHINA RADIO-COLLARED CARIBOU
DURING THE CALVING PERIOD, 15 MAY THROUGH 10 JUNE, 1980 AND 1981

PREPARED BY TES/ADF&G

FIGURE 3.14

ACRES

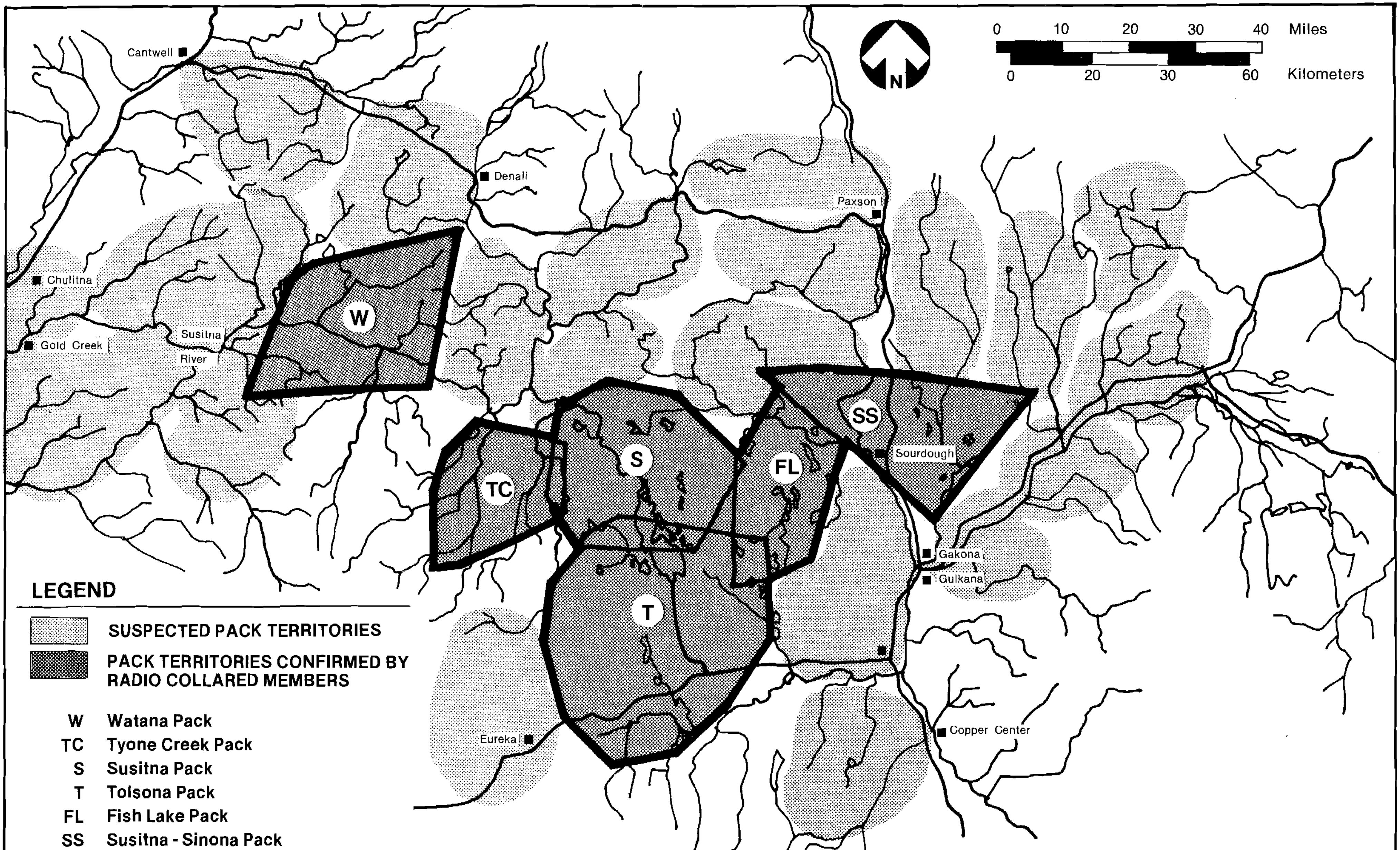


LOCATION OF RADIO-COLLARED CARIBOU IN SUBHERDS,
9 MAY 1980 THROUGH 22 SEPTEMBER 1981

PREPARED BY TES / ADF&G

FIGURE 3.15

ACRES

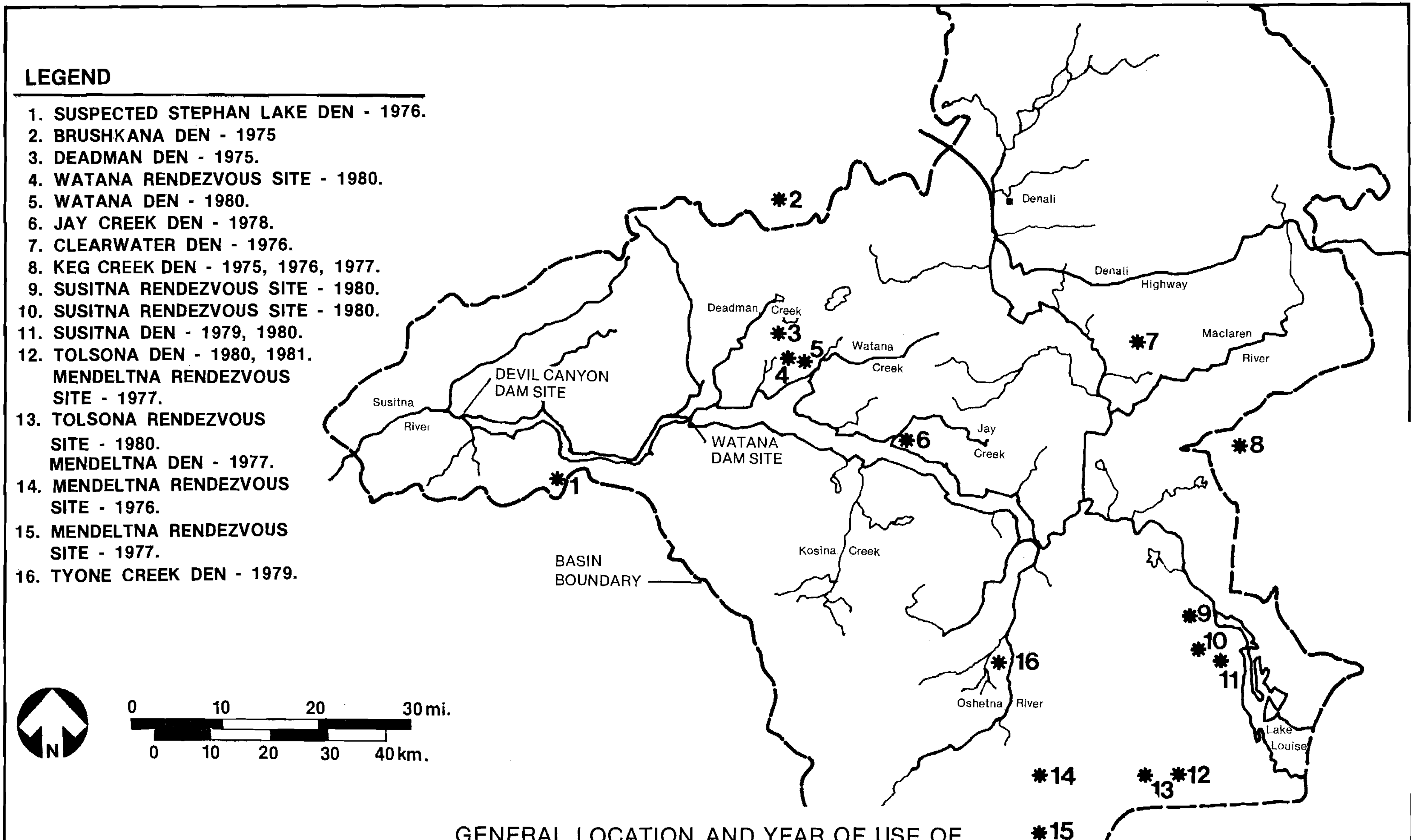


SUSPECTED LOCATIONS AND TERRITORIAL BOUNDARIES
OF WOLF PACKS DURING 1980 and 1981

PREPARED BY TES / ADF&G

FIGURE 3.16

ACRES

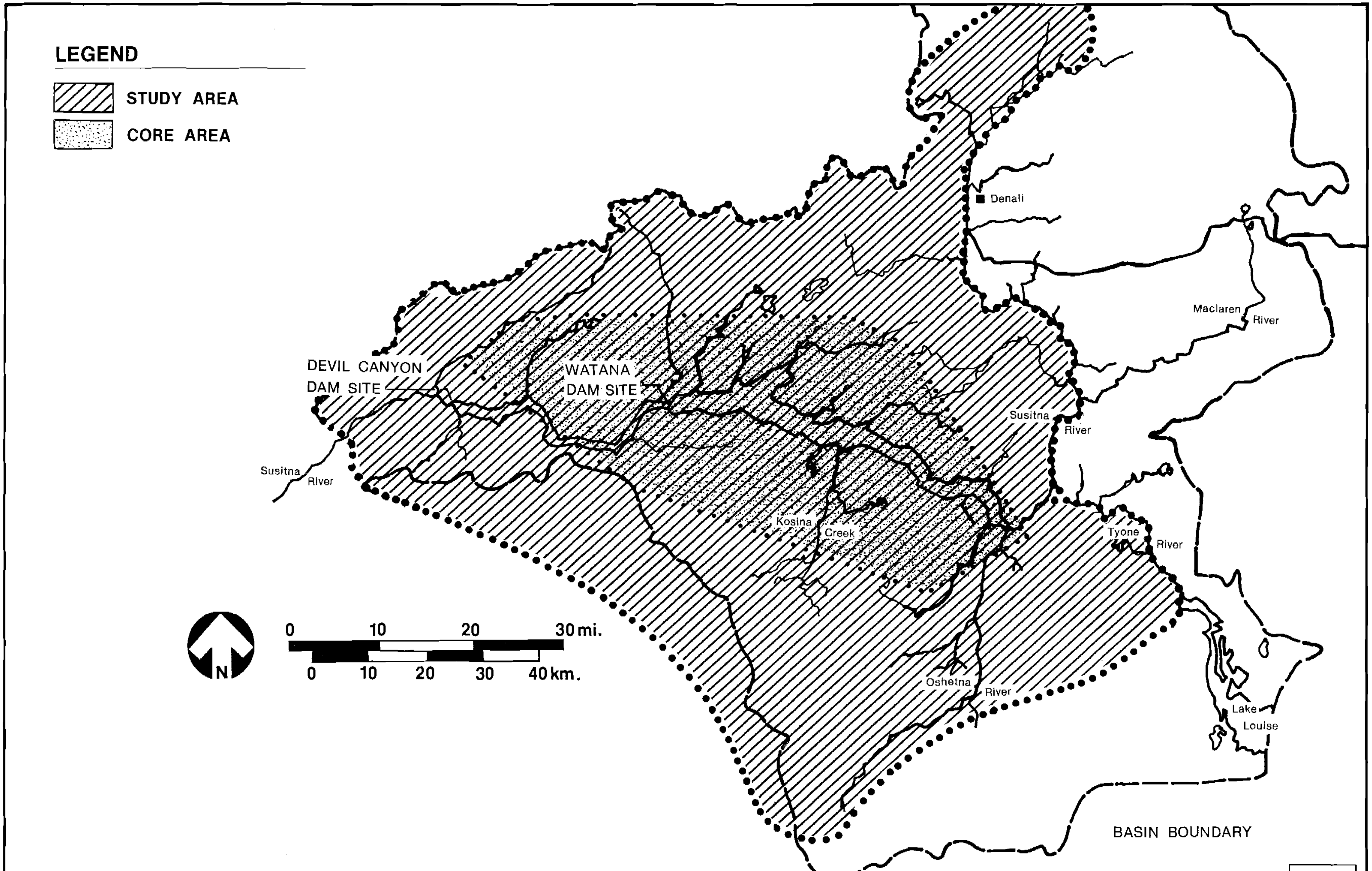


GENERAL LOCATION AND YEAR OF USE OF OBSERVED WOLF DEN AND RENDEZVOUS SITES DISCOVERED IN THE SUSITNA HYDROELECTRIC PROJECT AREA FROM 1975 THROUGH 1981

PREPARED BY TES/ADF&G

FIGURE 3.17

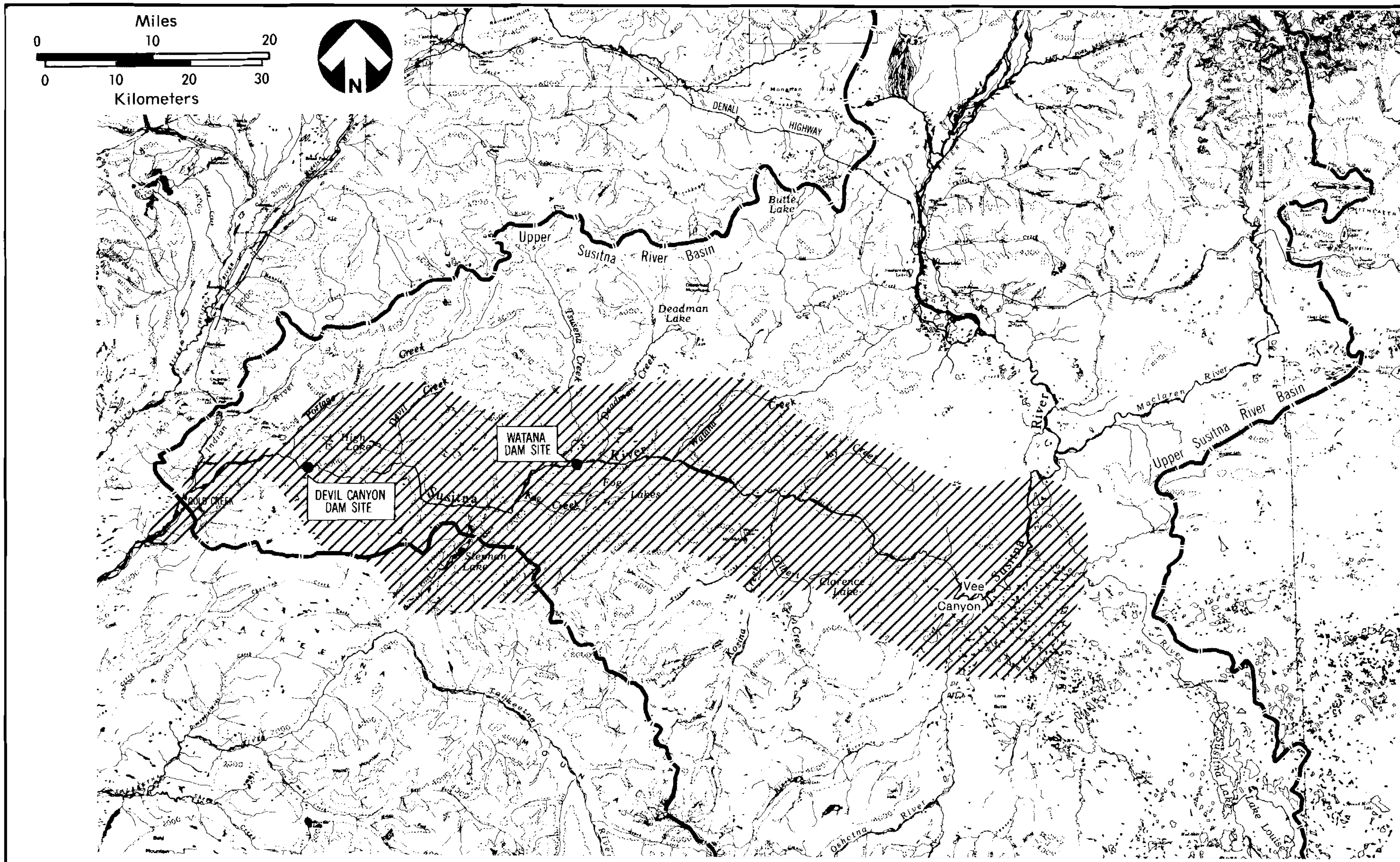
ACRES



WOLVERINE STUDY AREA

PREPARED BY TES / ADF&G

FIGURE 3.18

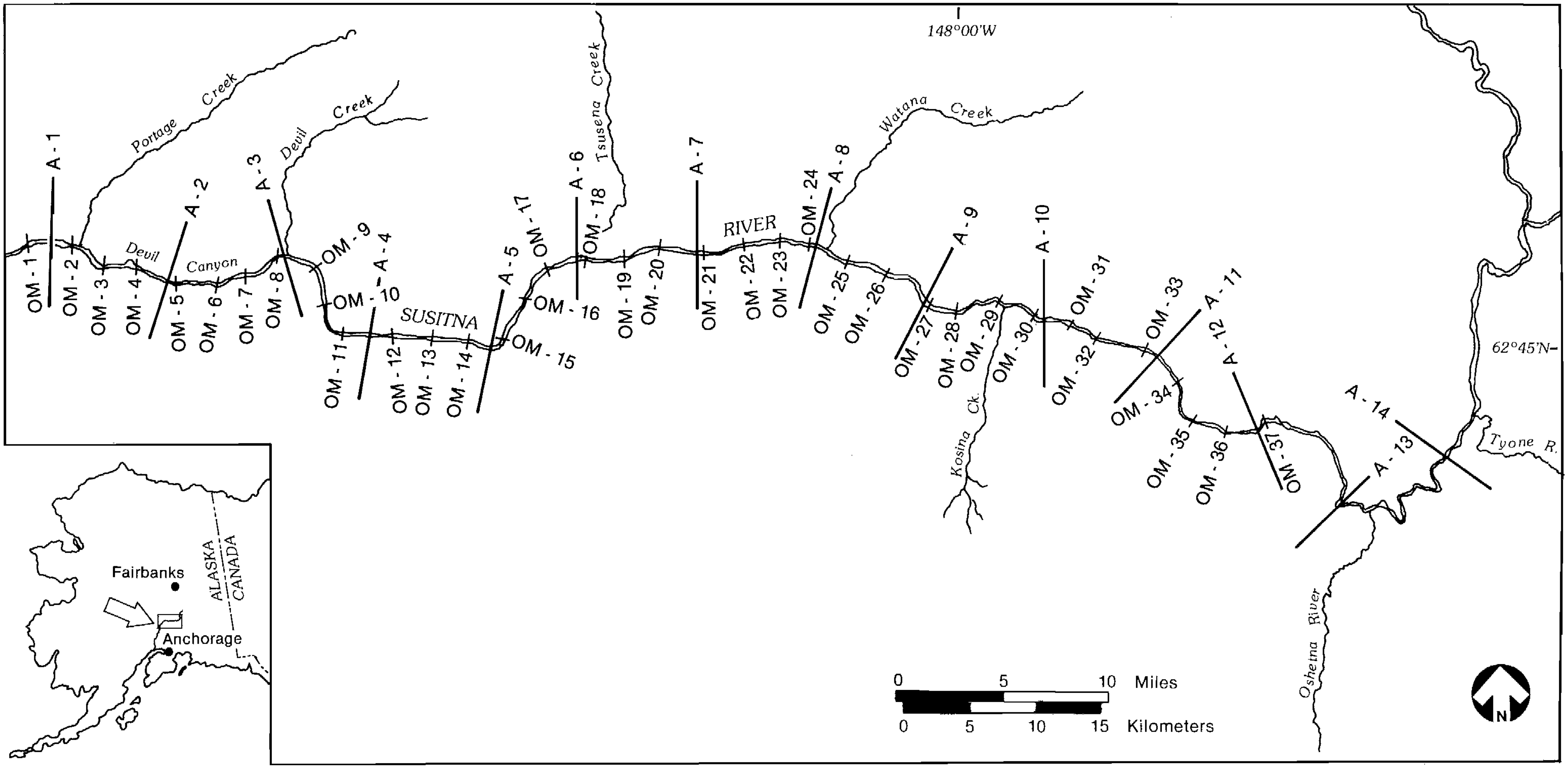


FURBEARER STUDY AREA - UPSTREAM

PREPARED BY TES

ACRES

FIGURE 3.19

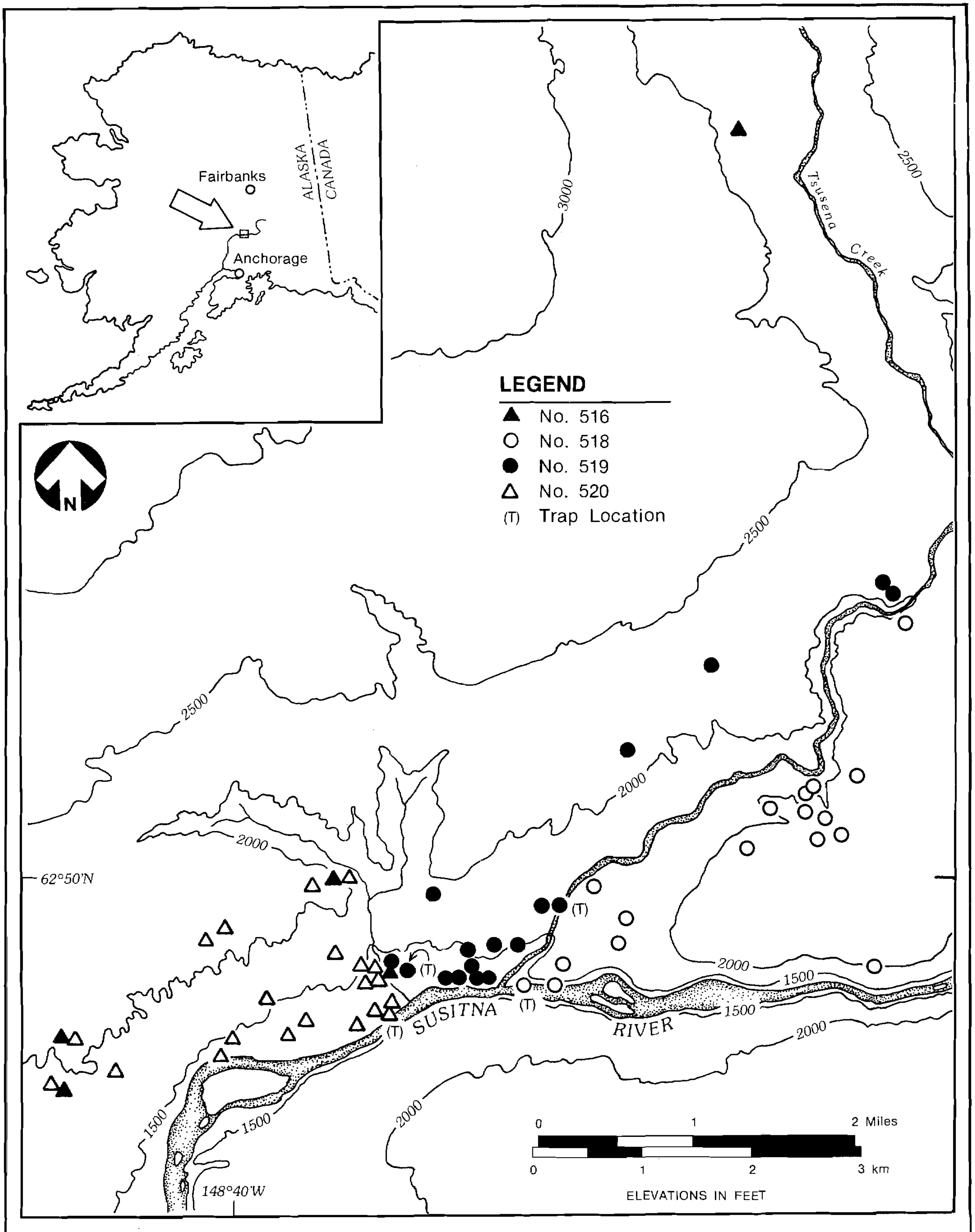


AERIAL TRANSECTS FOR FURBEARERS (A) AND CHECKPOINTS FOR SIGNS OF OTTER AND MINK (OM)

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 3.20

ACRES

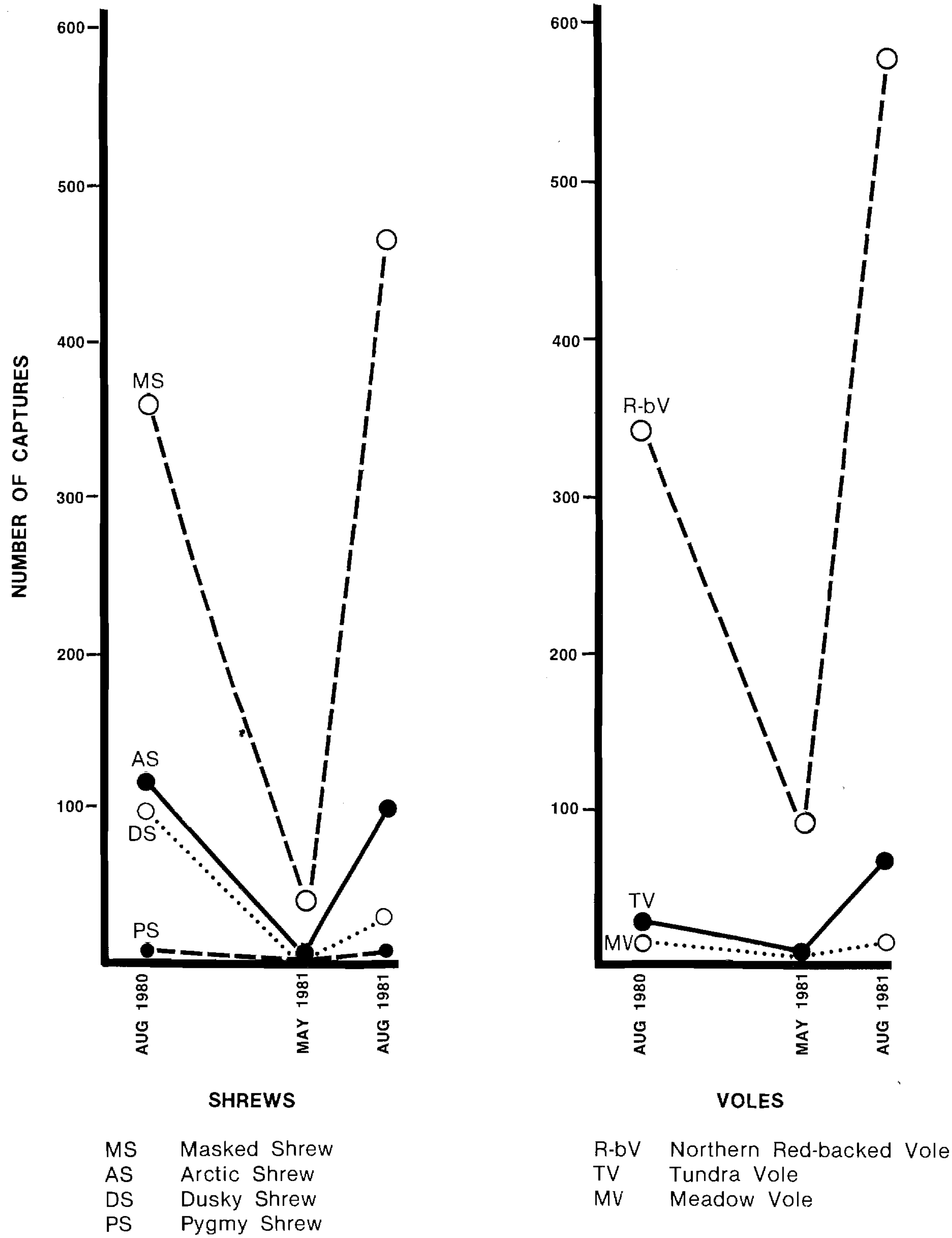


TRACKING LOCATIONS FOR FOUR RADIO-COLLARED MALE MARTEN, 1980

PREPARED BY TES/UNIVERSITY OF ALASKA

ACRES

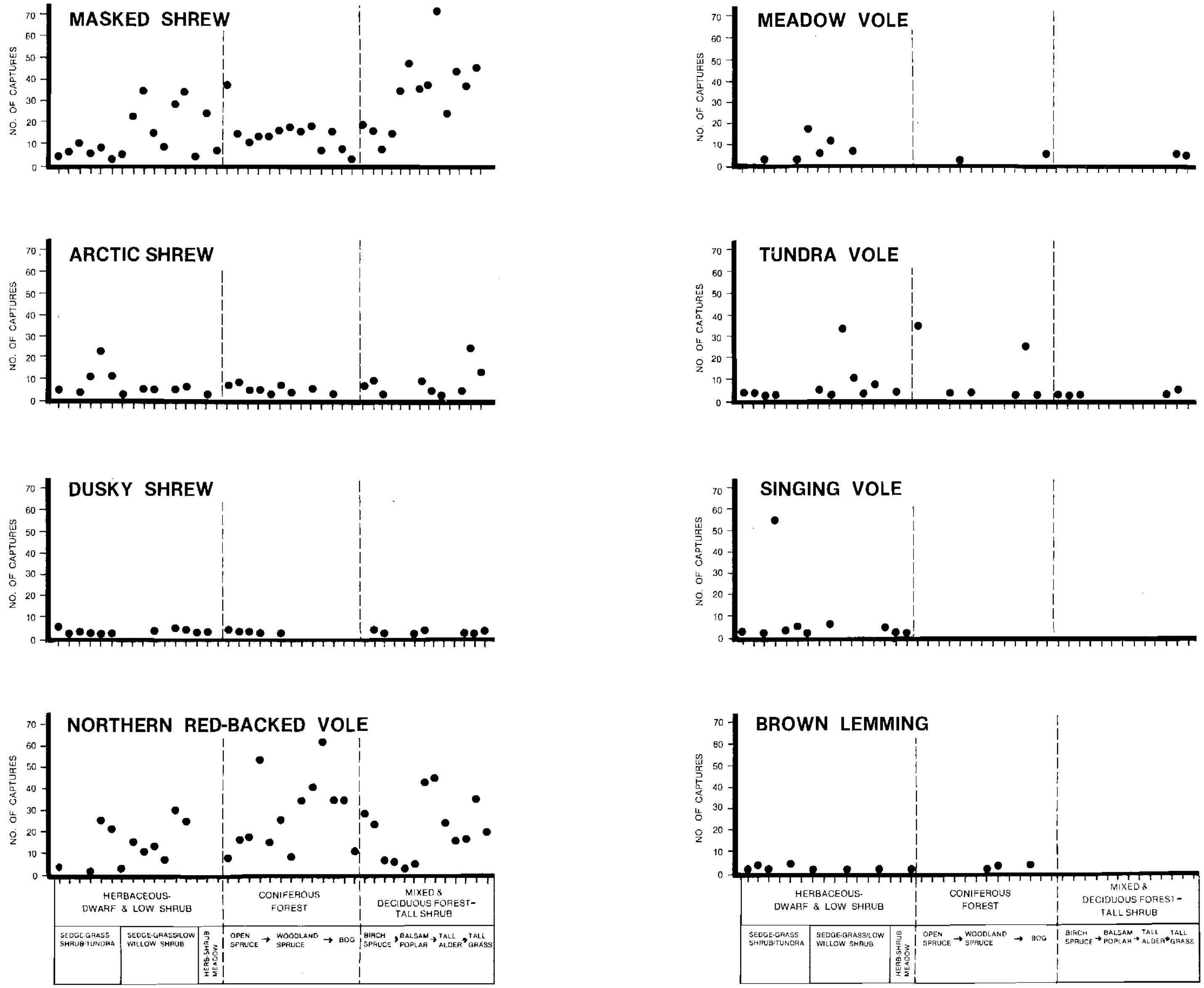
FIGURE 3.21



TEMPORAL VARIATION IN NUMBERS OF SMALL MAMMAL CAPTURES AT 12 SITES IN THE UPPER SUSITNA RIVER BASIN, ALASKA

PREPARED BY TES/UNIVERSITY OF ALASKA

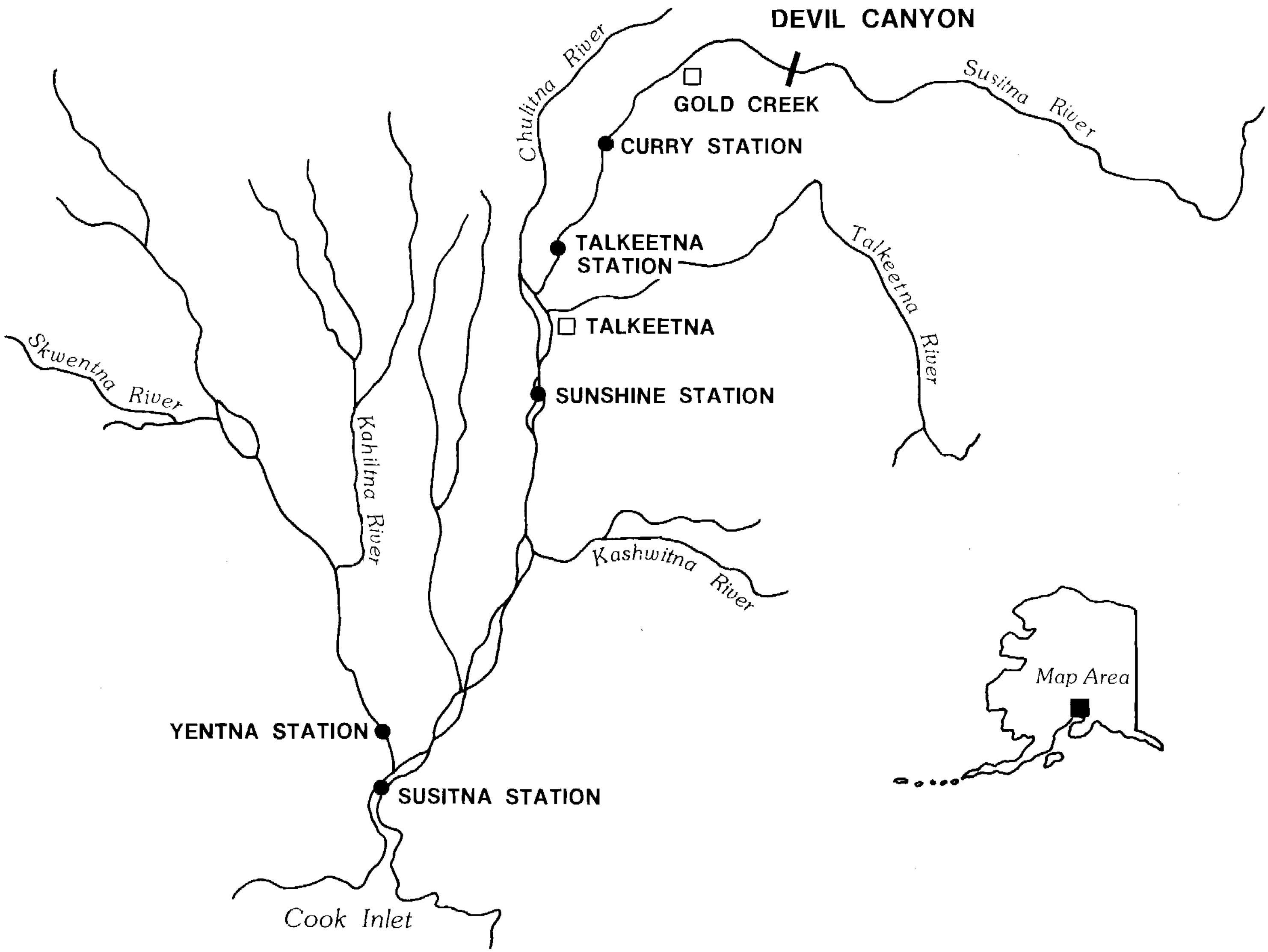
FIGURE 3.22



ABUNDANCE PATTERNS OF EIGHT SMALL MAMMAL SPECIES
RELATIVE TO VEGETATION TYPES AT 42 SITES IN THE
UPPER SUSITNA RIVER BASIN, ALASKA 29 JULY - 30 AUGUST 1981

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 3.23

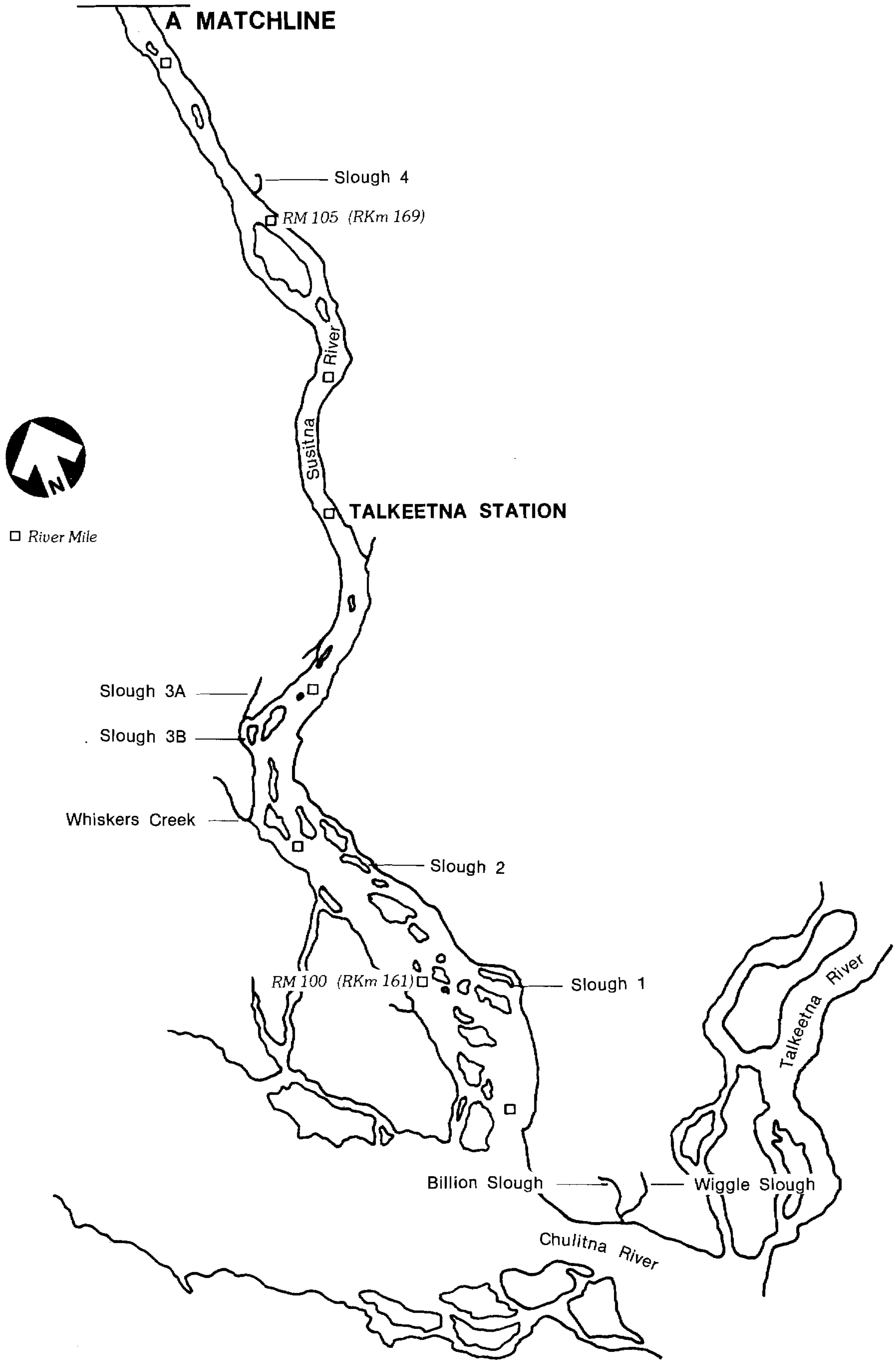


FIELD STATIONS, ADULT ANADROMOUS INVESTIGATIONS, ADF&G SUSITNA HYDROELECTRIC STUDIES, 1981

PREPARED BY TES/ADF&G

FIGURE 3.24

ACRES

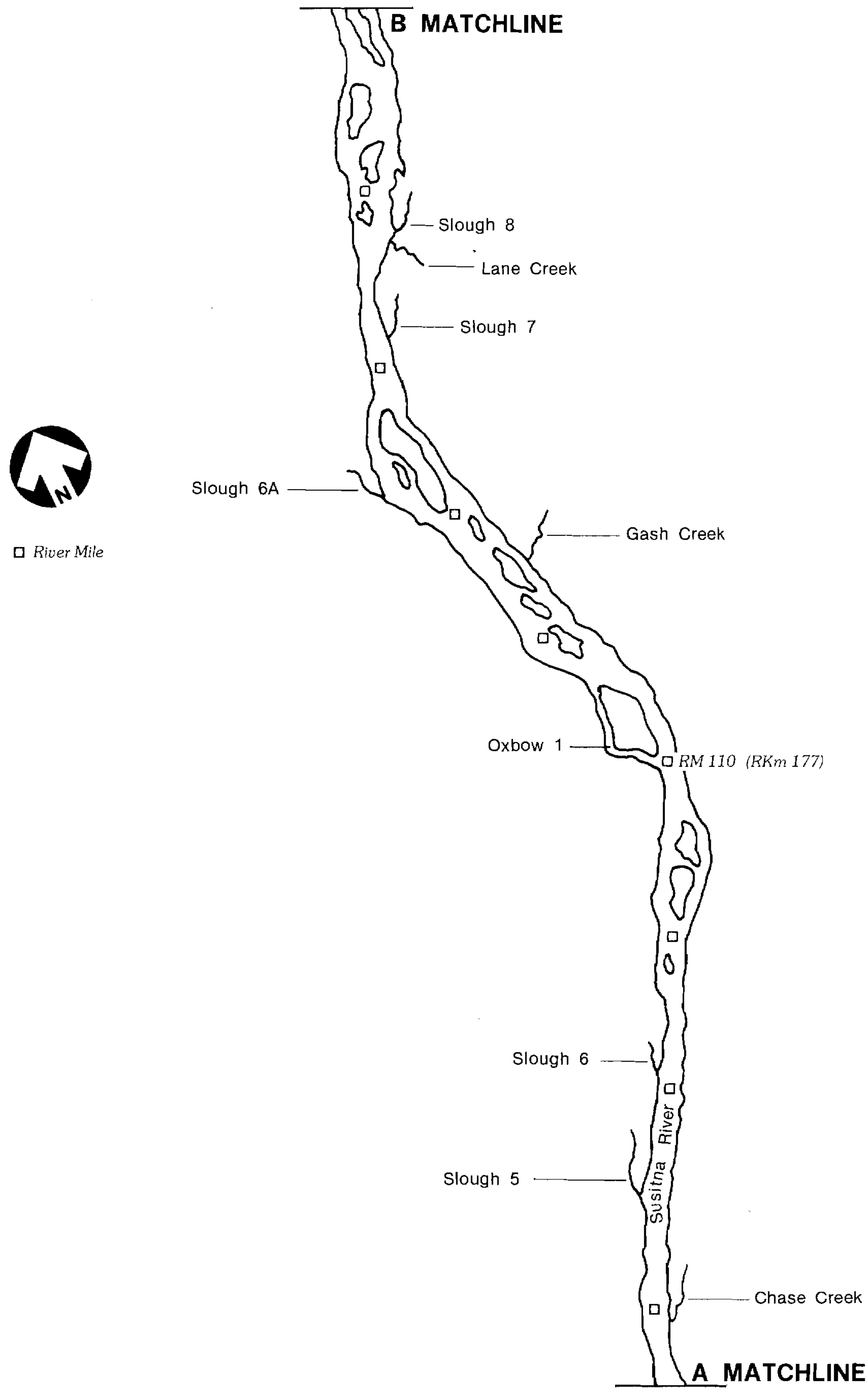


SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES OF THE SUSITNA RIVER FROM ABOVE THE CHULITNA RIVER CONFLUENCE TO SLOUGH 4 (RKm 168)

PREPARED BY TES / ADF&G

FIGURE 3.25

ACRES

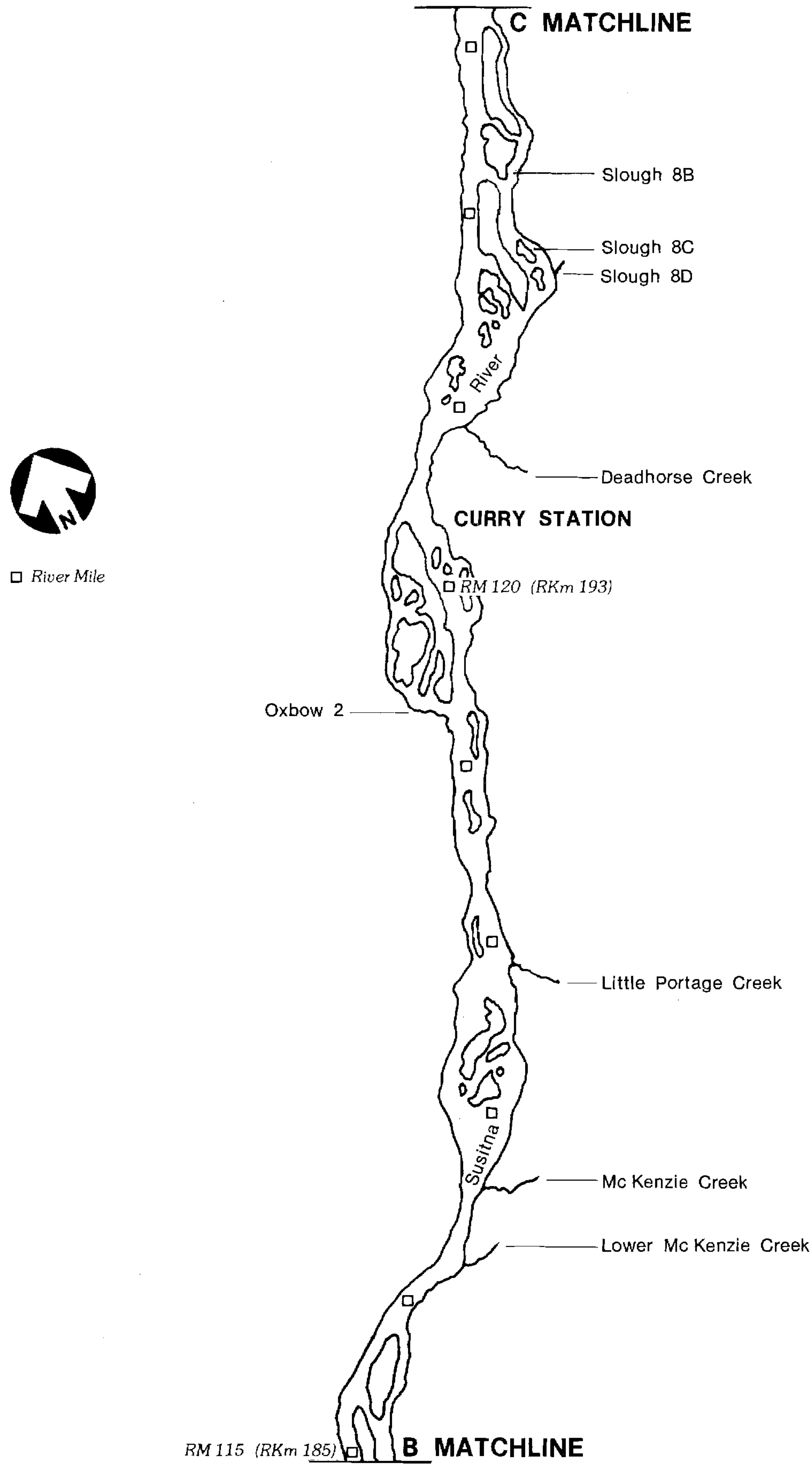


SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES
OF THE SUSITNA RIVER BETWEEN
CHASE CREEK AND SLOUGH 8

PREPARED BY TES/ADF&G

FIGURE 3.26

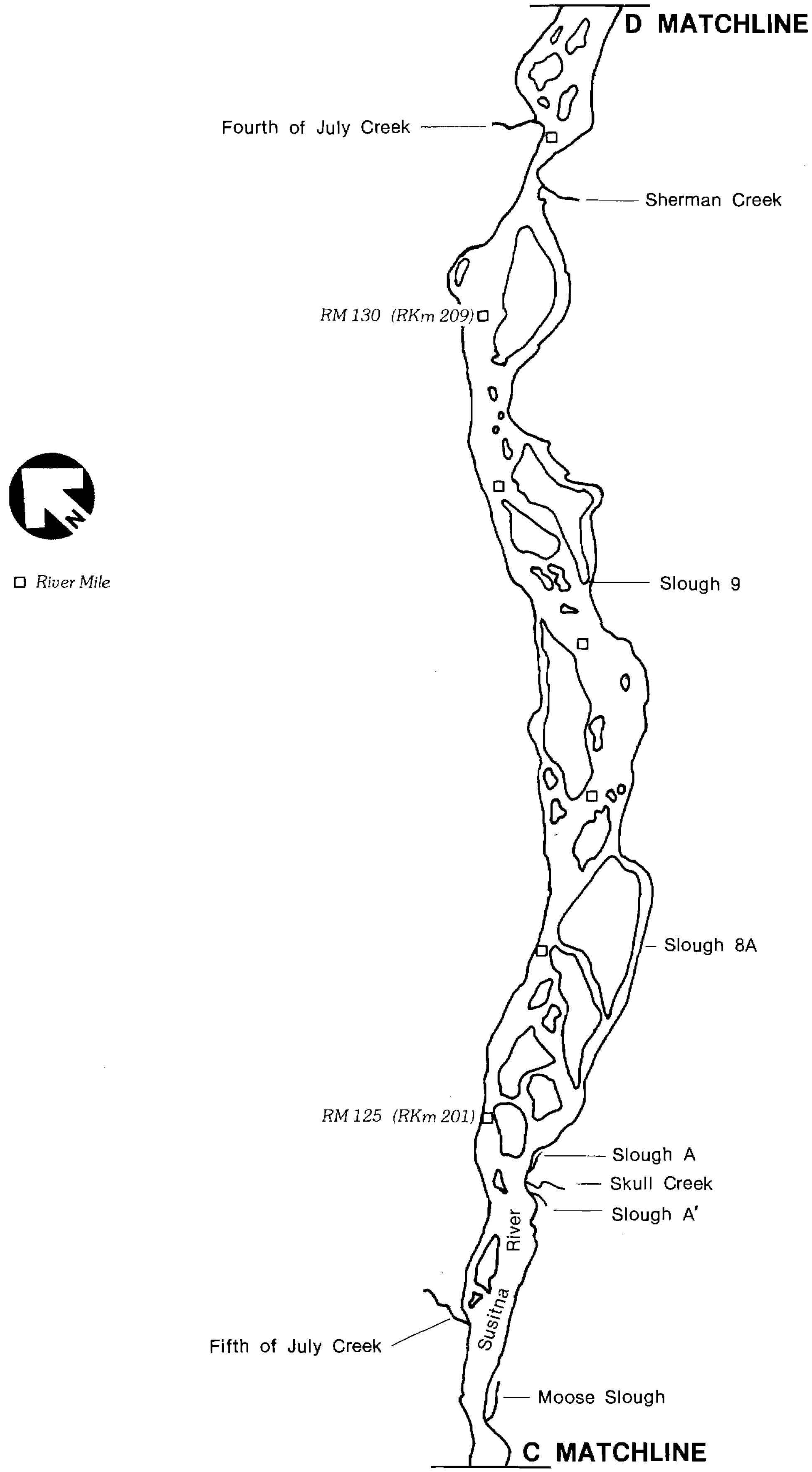
ACRES



SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES OF THE SUSITNA RIVER BETWEEN LOWER MCKENZIE CREEK AND SLOUGH 8B

PREPARED BY TES / ADF&G

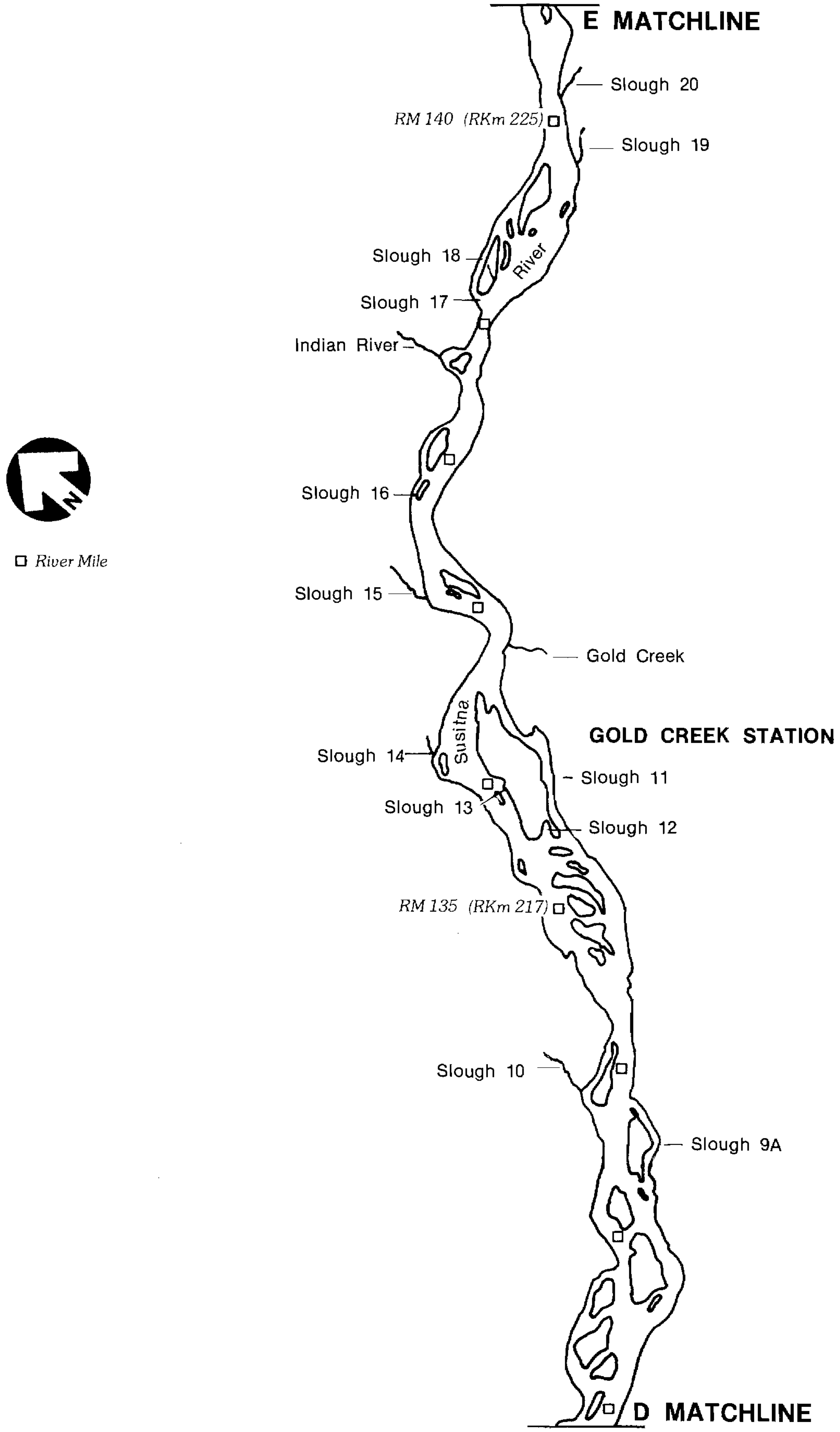
FIGURE 3.27



SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES OF THE SUSITNA RIVER BETWEEN MOOSE SLOUGH AND FOURTH OF JULY CREEK

PREPARED BY TES / ADF&G

FIGURE 3.28

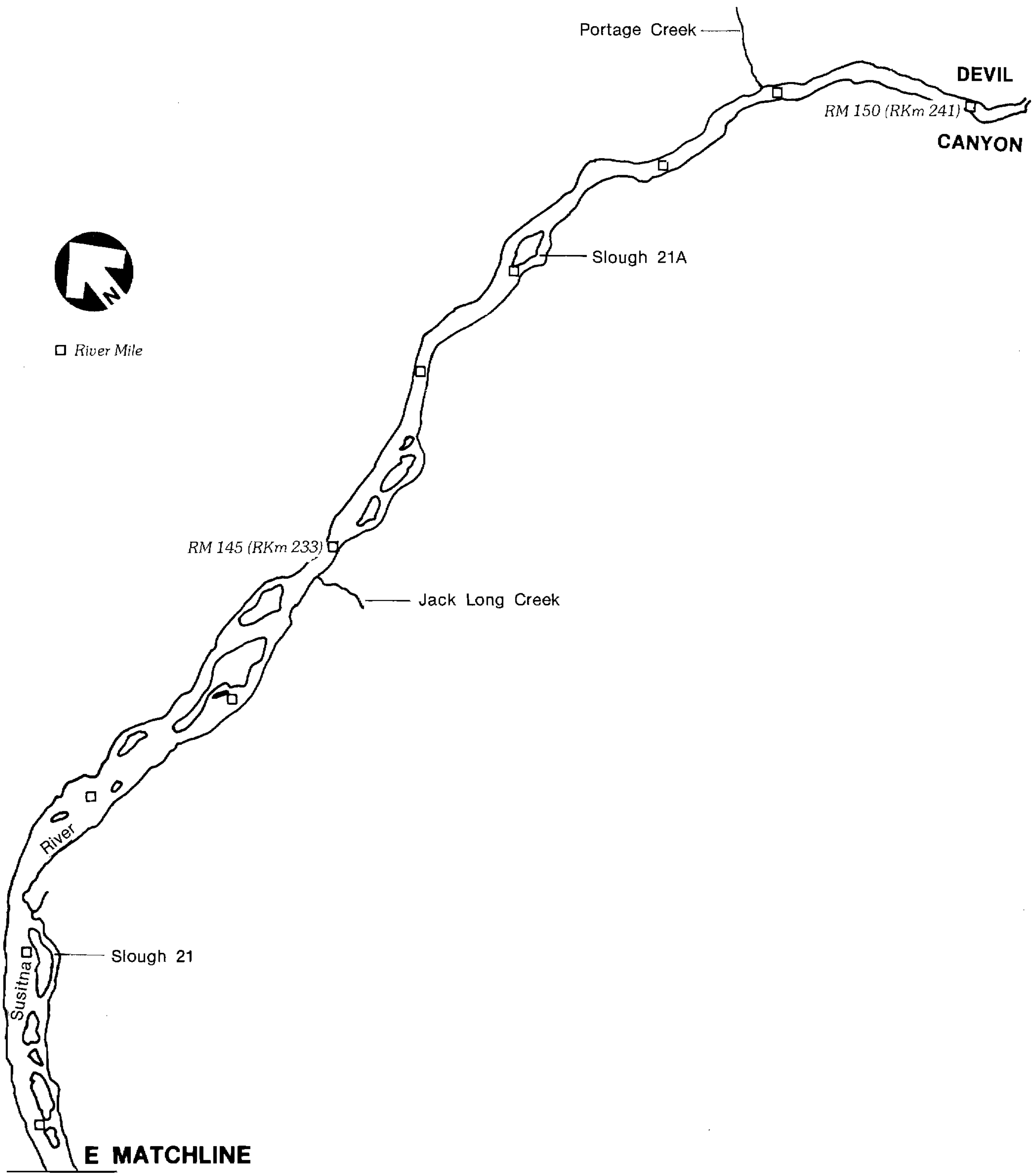


SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES
OF THE SUSITNA RIVER BETWEEN
SLOUGH 9A (RKm 214) AND SLOUGH 20 (RKm 225)

PREPARED BY TES / ADF&G

FIGURE 3.29

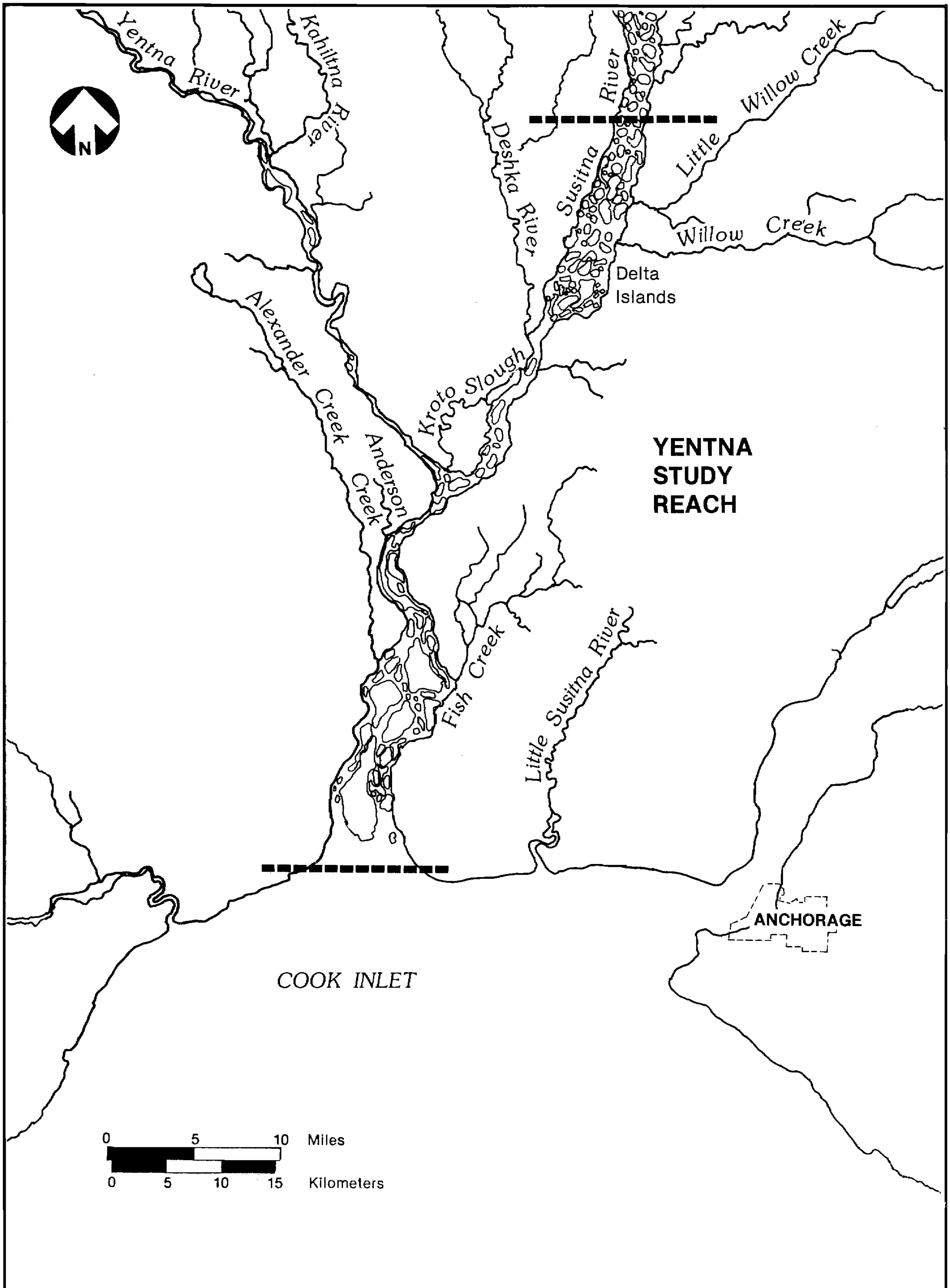
ACRES



SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES
OF THE SUSITNA RIVER BETWEEN
SLOUGH 21 (RKm 227) AND DEVIL CANYON

PREPARED BY TES / ADF&G

FIGURE 3.30

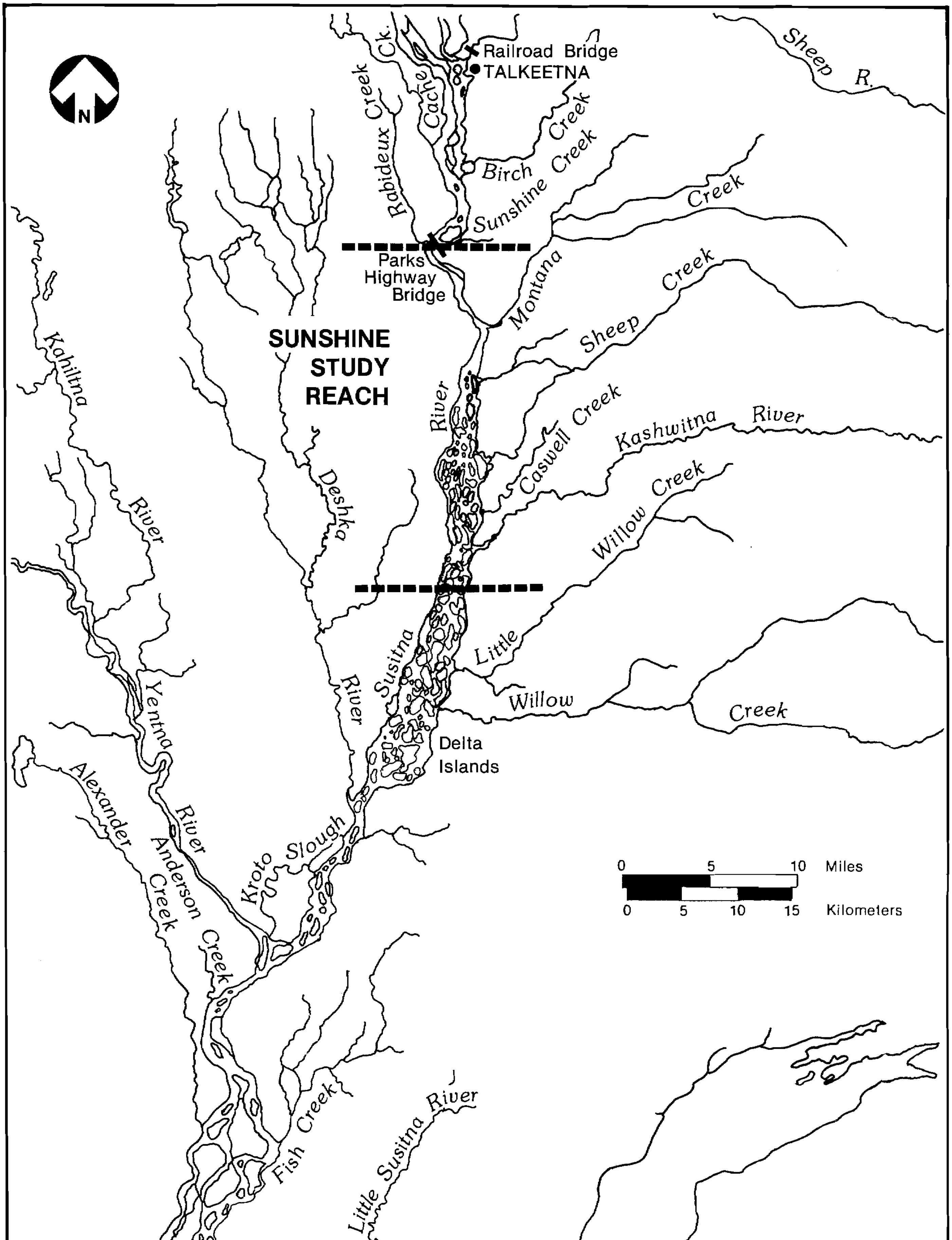


YENTNA STUDY REACH

PREPARED BY TES / ADF&G

FIGURE 3.31

ACRES

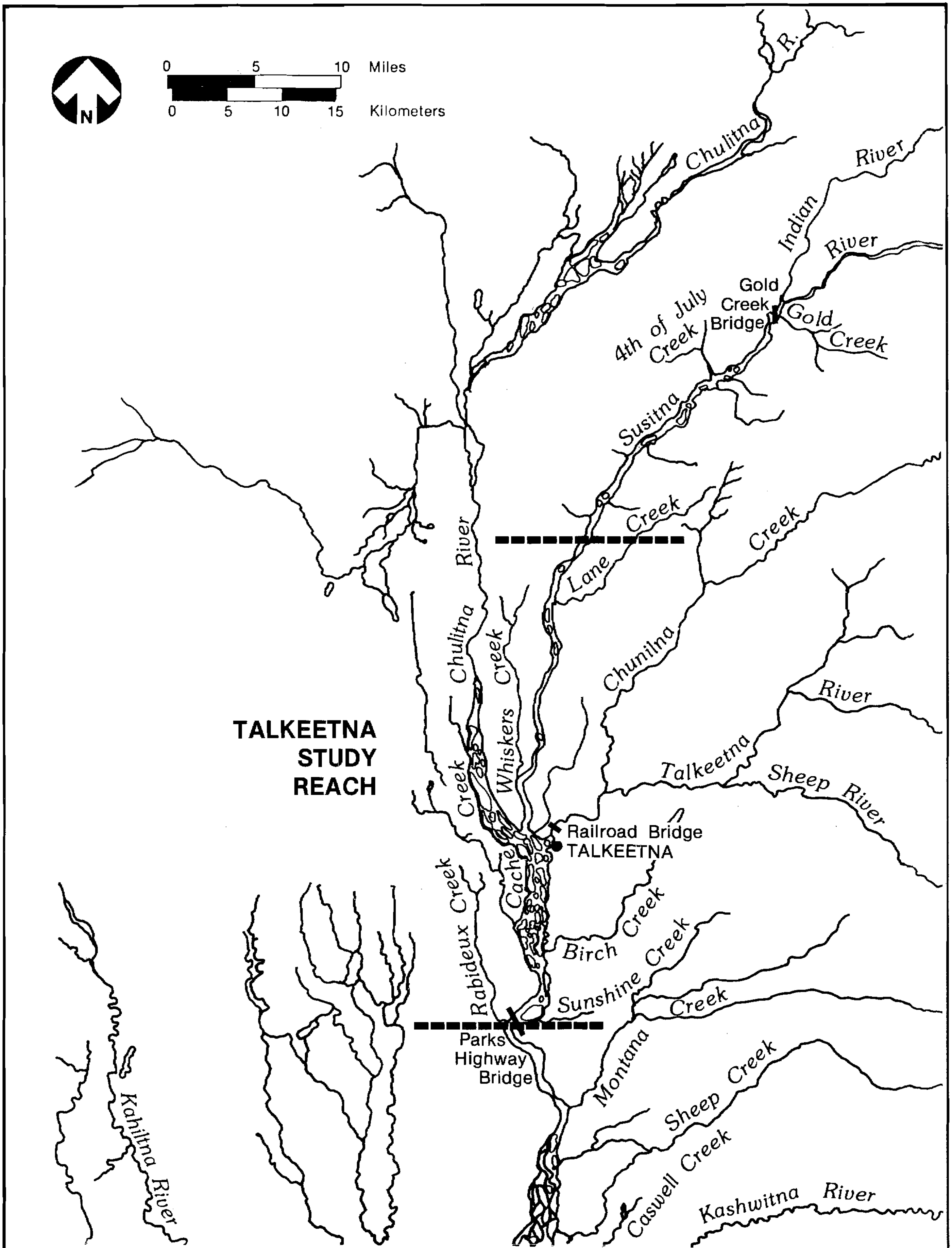


SUNSHINE STUDY REACH

PREPARED BY TES/ADF&G

FIGURE 3.32

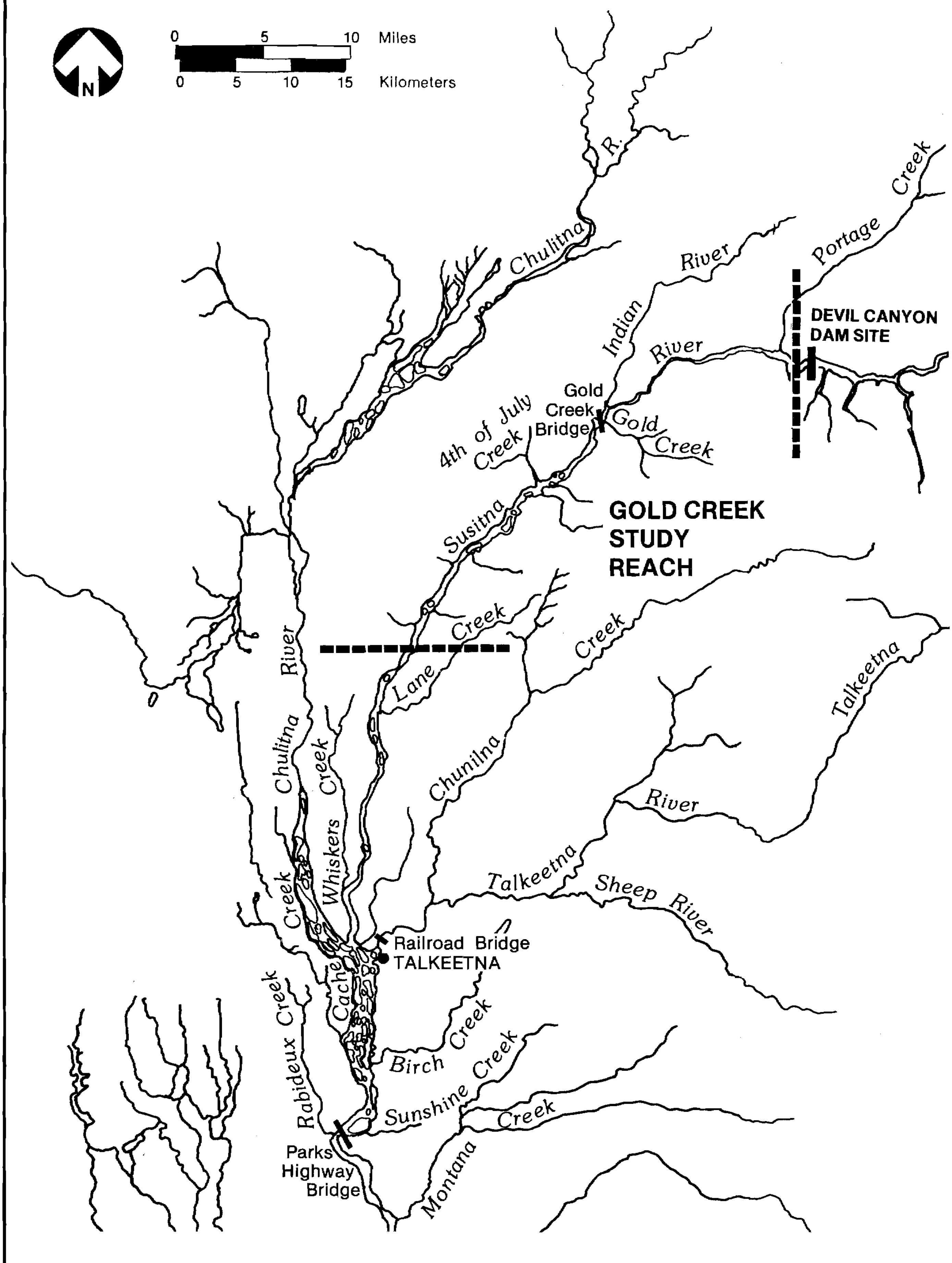
ACRES



TALKEETNA STUDY REACH

PREPARED BY TES / ADF&G

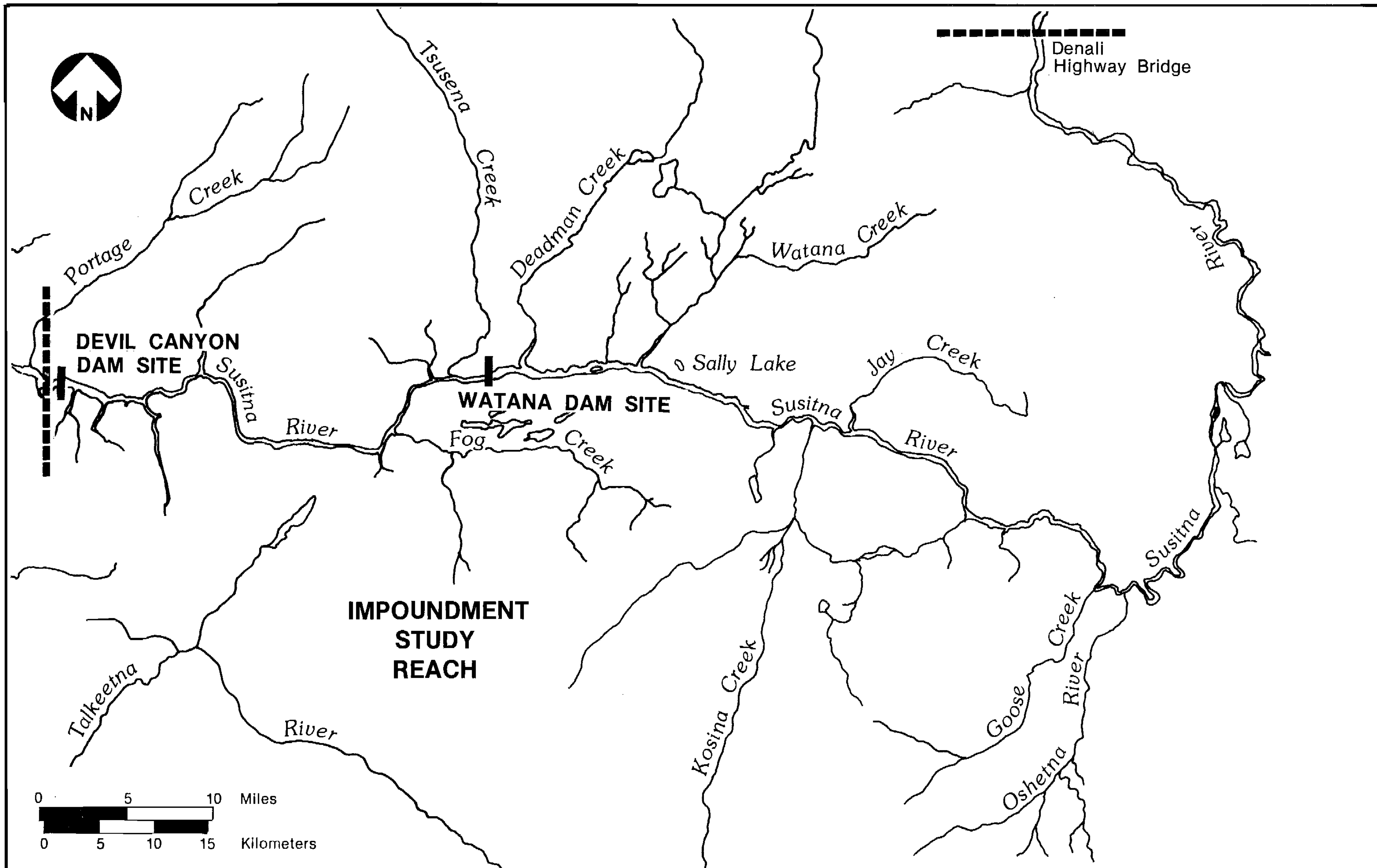
FIGURE 3.33



GOLD CREEK STUDY REACH

PREPARED BY TES/ADF&G

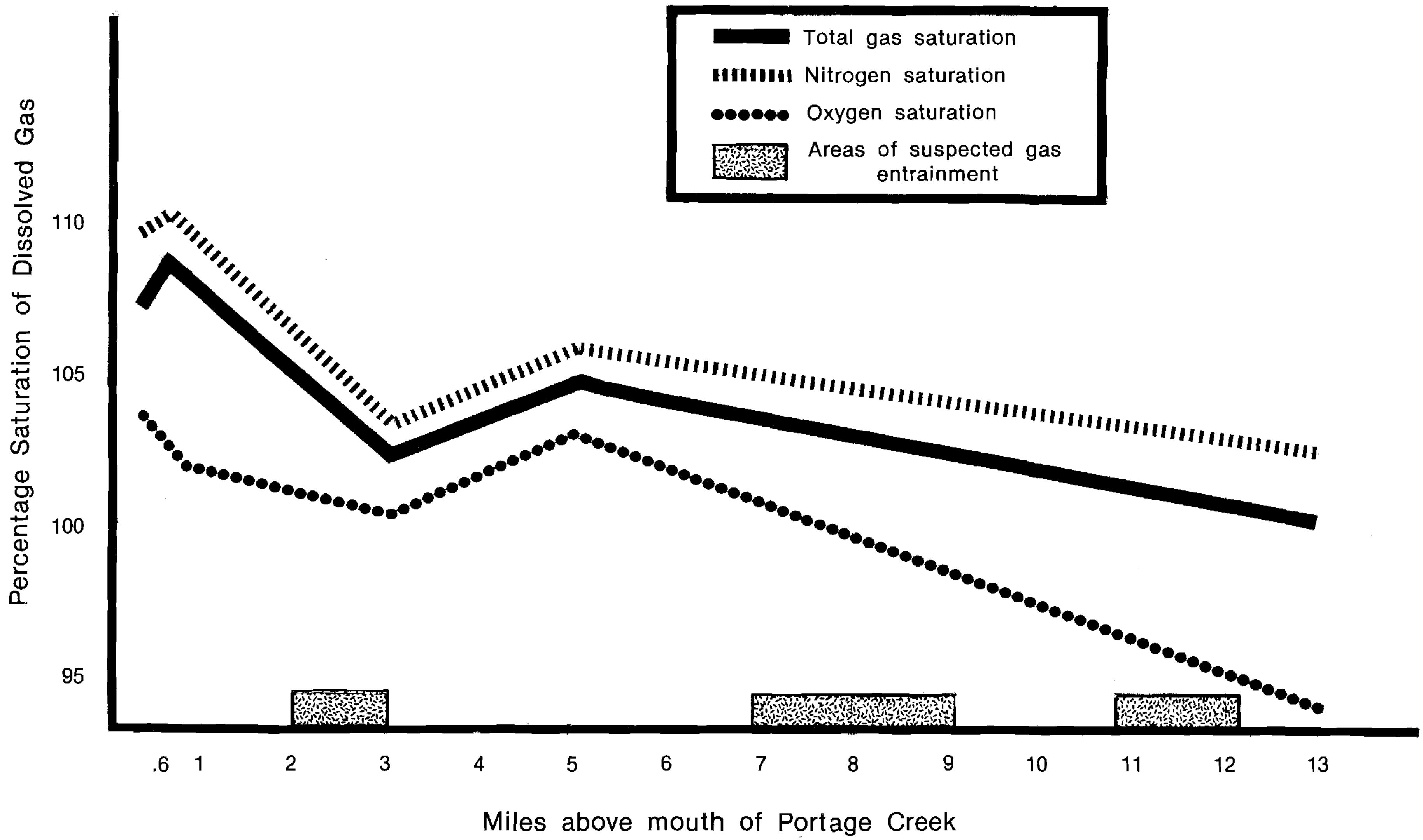
FIGURE 3.34



IMPOUNDMENT STUDY REACH

PREPARED BY TES/ADF&G

FIGURE 3.35

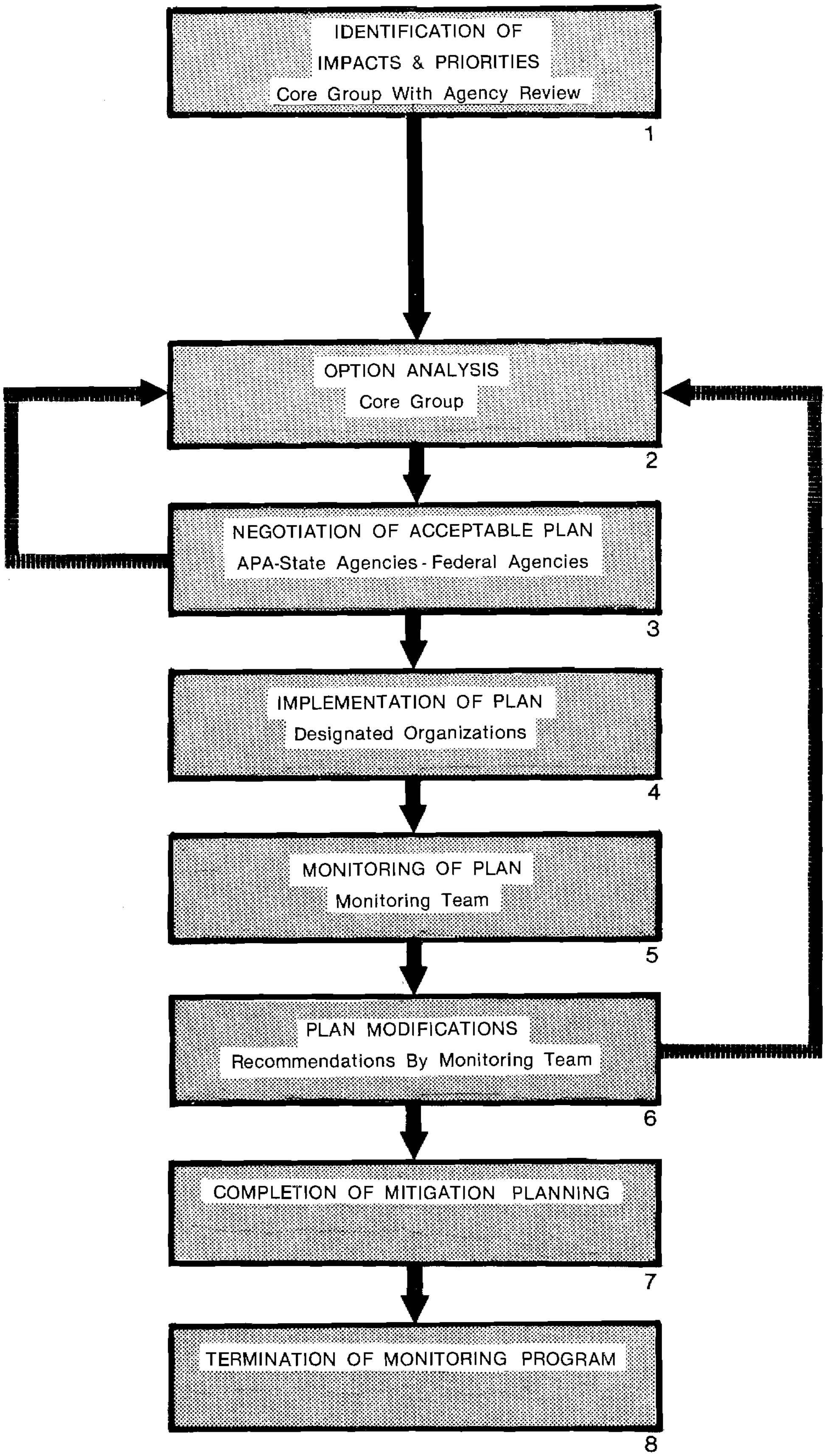


DISSOLVED GAS SATURATION IN VICINITY OF DEVIL CANYON,
12 JUNE 1981

PREPARED BY TES

FIGURE 3.36

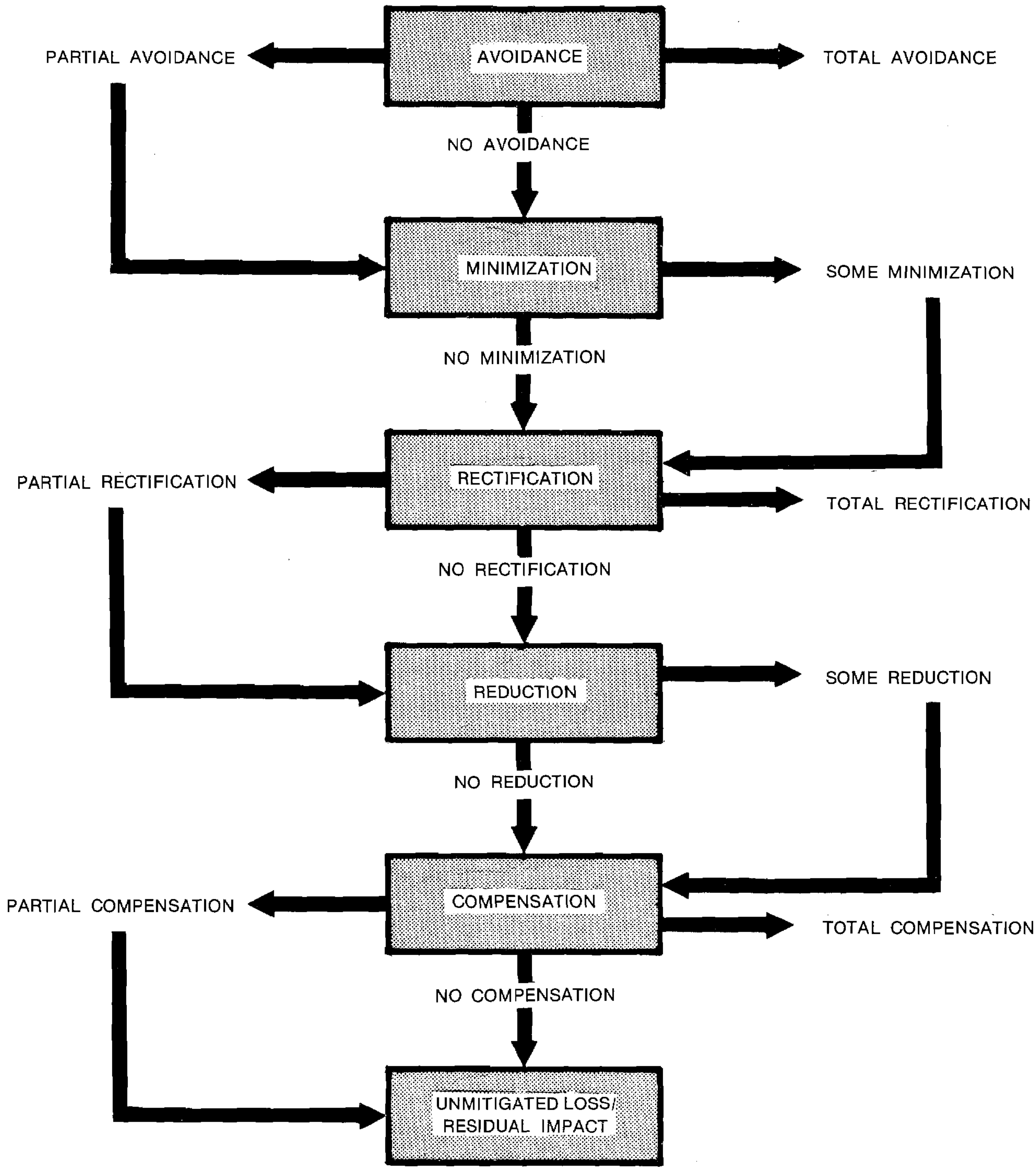
ACRES



FISH AND WILDLIFE MITIGATION PLAN
DEVELOPMENT AND IMPLEMENTATION

PREPARED BY TES / ACRES

FIGURE 3.37



OPTION ANALYSIS

PREPARED BY TES

FIGURE 3.38

ACRES

4 - REPORT ON HISTORIC AND ARCHEOLOGICAL RESOURCES

4.1 - Agency Consultation

(a) Consultation Methods

Archeological and historical resources must be identified for federally funded or licensed projects such as the Susitna Hydroelectric Project (FERC 1981). Before any archeological testing can be conducted, appropriate federal and state permits must be obtained. Moreover, no other project-related ground-disturbing activities (e.g. geotechnical) can be performed until the sites are cleared for cultural resources by an archeologist with the appropriate federal and state archeological permits.

The University of Alaska Museum obtained a Federal Antiquities Permit. Formal application, including vitae of support and supervisory individuals, was made to the National Park Service and the necessary permits received for 1980-81. In addition to the Federal Antiquities Permit, a State Antiquities Permit was obtained for land within the study area, designated "State Selected", that is, lands chosen by the State of Alaska as part of the Alaska Native Claims Settlement Act of 1971.

Through both oral and written communications, the State Historic Preservation Officer and State Archeologist have been advised of cultural resource investigations associated with the Susitna project. Copies of the Procedures Manual (APA 1980), Plan of Study (Acres 1980), and the 1980 Annual Report for the Cultural Resources Investigation (APA 1981a) were submitted for their review and comment and to document compliance with appropriate state and federal legislation.

(b) Summary of Comments

Comments concerning the Federal Antiquities Permit applications were in the form of stipulations to the permits by the National Park Service, the Bureau of Land Management, and the U.S. Fish and Wildlife Service. These comments specified the conditions of the permit.

The research design (Plan of Study, Procedures Manual) and the 1980 Cultural Resources Investigation Annual Report were reviewed by Mr. Robert Shaw, State Historic Preservation Officer (SHPO), and by Mr. Douglas Reger, State Archeologist. They concluded that the Annual Report documents the survey activities conducted during 1980 and adequately accomplished the tasks outlined in the proposed work plan. The SHPO considers the work to date, however, to be preliminary; reconnaissance and testing should continue for areas not yet examined. In addition, specific areas of disturbance and ancillary facilities must still receive archeological clearance. Access roads and material sites must still be examined in detail for cultural resources, and a mitigation plan must be formulated. Both authorities feel that FERC should, and probably will, include mitigation provisions when a permit is issued. Finally, the SHPO and the State Archeologist must review the final report when it becomes available.

4.2 - Survey Methods

(a) Objectives

The cultural resource program [see 4.2 (b) (ii)] had two objectives. The first was to identify and document archeological and historical sites in the Susitna study area. An archeological site is any area or structure dating prior to 1897 and important to native Alaskan cultures. An historical site dates from 1897, with the first native contact with western culture, to 1949. The sites examined to meet this first objective were in the impoundment zones, along portions of transmission line corridors, along the routes of proposed access roads, in borrow areas, and in any other areas with the potential for experiencing ground disturbance.

The second objective of the cultural resource program was to test and evaluate resources found in any of these areas, to address site significance, assess impact, and propose mitigation measures.

(b) Methods

(i) Study Areas

The cultural resources investigation involved three geographic sections: the central, southern, and northern study areas. The central study area, in which most of the efforts were concentrated, included an area from approximately 3 km below Devil Canyon on the west to the Tyone River on the east and extended approximately 2 km outside of the proposed Devil Canyon and Watana impoundments on the Susitna River. Areas affected by the other subtasks' ongoing studies were also included in this study area (APA 1981a).

This central study area for cultural resources also includes the transmission line alternatives from the dam sites to Gold Creek and parts of some of the access road corridor alternatives. The transmission line study areas also included northern and southern sections. Descriptions of the alternative corridors can be found in the Transmission Line Subtask 8.01 Close Out Report (Acres 1981). In brief, the northern section, approximately 8 km wide, is a corridor from Healy to Ester; the southern section is an approximately 8-km-wide corridor from Willow to Knik Arm; and the central study area is from Watana dam west to the intertie.

The access road study area consisted of a number of alternative corridors. One commenced on the Parks Highway near Hurricane; another enters the study area from the Denali Highway; and the last alternative provides access from Gold Creek. The Access Route Selection Report, Subtask 2.10 (R&M 1981), and the Environmental Analysis of Access Road Alternatives (APA 1981b) provide detailed descriptions of the access route alternatives.

(ii) The Five-Step Program

In order to comply with regulations pertaining to cultural resources and to provide the data necessary for preparation of the

Feasibility Report and the Federal Energy Regulatory Commission license application, a five-step program was implemented.

Prefield Tasks -- Step 1: Federal and state permits were applied for and received. Federal Antiquities Permits (#80AK-23, #81AK-209) and State of Alaska Permits (#80-1, #81-11) were obtained for the project [see Section 4.1 (a), Consultation Methods]. A literature review of available documents pertaining to the history, prehistory, ethnology, geology, flora, and fauna of the study area was conducted (APA 1981a, Appendix A and B). Using this information, a research design and strategy was formulated. The research design integrated current data into a tentative cultural chronology, which explicated hypotheses that could aid in the evaluation of sites located during survey and testing (APA 1980, 1981a). The research strategy was structured to predict, within the limits of contemporary archeological method and theory, archeological site locations in relation to physical and topographic features (APA 1981a).

Archeological sites occur in direct relation to associated physical, topographic, and ecological features. Based on the analysis of site locational data from regions adjacent to the study area, the features characteristically associated with archeological site occurrence are: areas of high topographic relief; natural constrictions that would tend to concentrate game animals; well-drained, relatively level areas; and lake, stream, and river margins. Such areas were included in the survey locales selected for examination.

Based on the delineated cultural chronology, documented topography, ecological settings for sites within each culture period, and geological evaluation of the study area, 119 survey locales were identified within the central study area as having relatively high potential for archeological site occurrence. Aerial photography interpretation was also conducted to delineate regional geology and survey locales and to assess archeological potential.

Reconnaissance Testing -- Step 2: Reconnaissance-level archeological testing consists of searches for cultural resources on and below ground surface. Surface testing usually involves the visual examination of areas where the soil is exposed, deflated, or eroded. Sub-surface testing generally includes digging a hole approximately 30 cm by 30 cm (a shovel test) and examining the excavated soil for artifacts.

Archeological and historical sites within the central study area were located and documented by using this technique. Detailed site-specific information was recorded, including the geomorphic feature on which the site was located, topographic setting, elevation, slope, exposure, view, and stratigraphy as well as details concerning the surrounding terrain. Survey forms were used to record data on each site located as well as on each survey locale investigated (APA 1980, 1981a).

As specified in 36 CFR 66, a reconnaissance-level survey should be used only as a preliminary to intensive survey, since a reconnaissance level survey and testing program is not intended to cover 100% of the area. With this in mind and based upon the standard cultural resource research strategy, a limited but representative portion of the study area, considered as having high probability for archeological sites, was tested for cultural resources. In addition, locales associated with proposed borrow sources, access routes, transmission corridors, and areas affected by geotechnical and other preconstruction studies were also examined at various levels of intensity for cultural resources.

Reconnaissance-level testing, in and immediately surrounding the proposed Devil Canyon and Watana impoundment zone, in proposed borrow areas, and in other areas affected by geotechnical and other preconstruction studies, consisted of surface and subsurface tests as described above (APA 1980). For the proposed access corridors, testing and surveys consisted of the identification of potential cultural resource sites through the analysis of aerial photographs and topographic maps and through limited, on-the-ground examination of natural exposures.

For the proposed southern and northern transmission corridors, a cursory, four-hour fly-over was conducted to identify areas with potential for cultural resource sites; on-the-ground examination of natural exposures was limited to a few sites here. Data from the reconnaissance-level testing in and around the impoundment zone and from the access road routing analysis was used to evaluate the cultural resources probability of transmission corridors in the central study region. Also used in this analysis was information from the State Archeologist's Office files regarding the locations of known archeological sites in the central, southern, and northern transmission corridors (Acres 1981).

Systematic Testing -- Step 3: After a site is located by reconnaissance-level testing, a few selected square meters of the site are intensively excavated. All artifacts and features are recorded, using standard archeological field methods. Systematic testing was used to collect data to address site significance and impact prior to developing individual mitigation measures and a general mitigation plan (see Sections 4.4 and 4.5). Systematic testing required transit surveys of sites, topographic mapping, and excavation of selected units using standard archeological methods. Since the number of sites that could be tested was limited, those sites were given precedence that had the greatest potential for producing data that would assist in developing an overall cultural chronology for the upper Susitna River valley. This method enabled extrapolation to other sites not subject to this level of testing.

Analysis and Report Preparation -- Step 4: This process entailed compiling the individual reports for each phase of the cultural resources investigation as well as synthesizing and evaluating all data gathered. Part of the evaluation included dating carbon samples gathered from sites, using radiocarbon analysis. Step 4 also involved preparing and submitting reports on the progress and results of the cultural resource studies.

As part of the process of analysis and prior to recommending mitigation measures, it is first necessary to determine if the site or group of sites is significant. Determination of significance is based on the application of National Register of Historic Places criteria (36 CFR 60.6), which define significant sites as follows:

> "The quality of significance in American history, architecture, archeology, and culture is present in districts, sites, buildings, structures, and objects of State and local importance that possess integrity of location, design, setting, materials, workmanship, feeling and association and:
> (a) That are associated with events that have made a significant contribution to the broad patterns of our history; or
> (b) That are associated with the lives of persons significant in our past; or
> (c) That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
> (d) That have yielded, or may be likely to yield, information important in prehistory or history."

A site or group of sites is eligible for inclusion in the National Register of Historic Places if it is determined to be significant. FERC regulations require a description of impacts on sites or properties either listed in, or recommended as eligible for, the National Register of Historic Places. The management plan for the mitigation (including avoidance) of impacts on historical and archeological sites and resources is to be based upon recommendations from the SHPO and the National Park Service. The applicant may include an explanation of variations from those recommendations (FERC 1981).

To locate and document sites for this project, a program of reconnaissance-level testing was implemented. In order to gather sufficient data on which to base an evaluation of significance, systematic testing was employed. In most cases (a notable exception being historic cabins), systematic testing is necessary to assess significance. To date, relatively few of the known archeological sites have been systematically tested; therefore, a determination of significance for most sites is not possible.

Significance implies a frame of reference; a problem orientation; a geographic, temporal, or other context against which significance is evaluated. Sites can be significant on several levels. Through application of National Register criteria, a site may be evaluated either as a single entity or in terms of its relationship to a group of sites; that is, it may have relative significance. If all of the sites within a drainage system such as the upper Susitna were known and the region itself well studied (which it is not), relative significance of sites or groups of sites could be established with some degree of confidence. When a site or group of sites is located, however, in an area like the Susitna basin, which is relatively unknown archeologically, it is difficult to establish relative significance.

Significance itself is also a relative term, used in an historic context dependent on the current state of knowledge, on the method and theory employed, and on research questions asked. New techniques and methods have enabled archeologists to collect new and different types of data, which, in turn, allow new questions to be formulated and addressed. Currently, National Register criteria for significance pertaining to archeological sites generally emphasize research potential, site integrity, and/or public appreciation; however, these criteria are subject to ongoing modification.

Although all the sites located as a result of this study are related geographically and many, no doubt, temporally, determination of the exact relationships awaits further study. Most of the sites were found associated with one or more of three tephras, which will provide limiting dates for most of the sites in a restricted geographic context. Those dated sites will, in turn, provide a unique and scientifically important opportunity to construct the first cultural chronology for the upper Susitna River basin. It may be appropriate to state that all sites are significant and collectively hold the potential for defining the prehistory for this region of Alaska, a task which has not yet been accomplished. All the sites may, therefore, be eligible for inclusion in the National Register.

Curation -- Step 5: As required by federal law, all cultural material was catalogued and accessioned to the University of Alaska Museum along with all supporting documentation. The University of Alaska Museum was designated on the Federal Antiquities Permit as the repository for cultural material and documentation resulting from this study. All artifactual material and supporting documentation is, therefore, housed at the University of Alaska Museum, Fairbanks, Alaska.

4.3 - Historical and Archeological Sites in the Project Area

(a) Central Study Area

During the summers of 1980 and 1981, in an effort to examine as much of the study area as possible, 111 of the 119 possible survey areas were surveyed and tested, employing both surface and subsurface testing techniques. Examined were areas associated with the Watana and Devil Canyon dams and impoundments, proposed borrow sources and associated facilities, geotechnical areas, access routes and transmission line, and areas containing archeological sites as reported by project personnel. A total of 116 sites were actually located and documented during the two field seasons (Figures 4.1 through 4.3). Because of the large area covered and the number of sites located, however, it was only possible to systematically test 18 of those 116 sites.

Analysis of the field data presented is preliminary. As confirmed by the SHPO, the number of sites found in the upper Susitna basin was unexpectedly large (Shaw 1981 pers. comm.). Preliminary analysis of faunal material from both reconnaissance and systematic testing indicates that the majority identified represent caribou. Three volcanic ash layers (tephras) were found in the study area. Radiocarbon testing has produced preliminary limiting dates for these three layers. Although not all the dates from similar stratigraphic units correspond, the radiocarbon dates suggest that the upper layer is between 1800 and 2300 radiocarbon years B.P.; the middle layer, 2800 to 3200 radiocarbon years B.P.; and the lower layer, older than 4700 radiocarbon years B.P. The ability to correlate most archeological sites and individual components within sites with the volcanic ash layers is highly significant, because it is virtually unprecedented that so many sites could be accurately dated without the uniform presence of carbon. Thus, all sites collectively can provide information concerning the history and prehistory of the upper Susitna valley (see Section 4.4). Preliminary analysis of the data indicates that collectively, at least, all of the archeological sites may be eligible for listing in the National Register of Historic Places. Impacts on these sites are identified in Section 4.4 and a preliminary mitigation plan is presented in Section 4.5.

As described above, prior to any field work and as part of the overall research design, a tentative cultural chronology for the upper Susitna basin was developed. This cultural chronology which was based upon a literature search, appears in the Cultural Resources Procedures Manual (APA 1980) and 1980 Annual Report (APA 1981a). The chronology suggested that sites spanning the past ca. 10,000 years would be found in the study area. Preliminary analysis of cultural resources located during the two field seasons of this project indicates that sites representing all culture periods outlined in the tentative chronology occur in the study area. A literature review of the archeology of central Alaska is also presented in these reports.

Historical sites consist mostly of trappers' cabins. One collapsed cabin might have been a line cabin used by Oscar Vogel in the 1930's and 1940's. Another site, consisting of a cabin, kennels, and an outhouse, was the trapping headquarters of Elmer Simco. The cabin was built in the early 1930's. At the mouth of Portage Creek is an inscription carved in the rock and dated 1897, with the names of William Dickey and three other individuals. Dickey was one of the first white men in the region. These sites may meet some of the National Register criteria. The Simco cabin, for example, may be considered to "embody the distinctive characteristics of a type, period, or method of construction." The Dickey inscription, if genuine, may perhaps be considered to be "associated with the lives of persons significant in our past". None of the historical sites in the area, however, have yet been determined to be eligible for the National Register.

(b) Southern and Northern Study Areas

Results from the southern and northern portions of the transmission line route are presented in Figures 4.4, 4.5, and 4.6. The cultural resource sites indicated on these figures were determined from the files of the State Archeologist. One site, located on the edge of a northeast-southwest trending terrace overlooking the Nenana River near Alaska Railroad Mile Number 383, was discovered during a helicopter review of the proposed transmission line routes. Areas of high potential for the discovery of cultural resources are also illustrated in these figures.

4.4 - Impacts on Historic and Archeological Sites

To define the levels of impact that the Susitna Hydroelectric Project will have on specific sites or groups of sites, the definition of the Advisory Council on Historic Preservation was used. That [36 CRF 800.3 (a)] definition states:

> "Direct effects are caused by the undertaking and occur at the same time and place. Indirect effects include those caused by the undertaking that are later in time or farther removed in distance, but are still reasonably forseeable. Such effects may include changes in the pattern of land use, population or growth rate that may affect on properties of historical, architectural, archeological, or cultural significance."

In terms of the Susitna Project, sites directly affected are those which will experience ground disturbing activities associated with preconstruction, construction, operation, overall land modification, and ancillary development of the project. These include dam construction sites, spillways, access roads, borrow areas, camps, villages, transmission line rights-of-way, staging areas and railroad yard, airstrip, and reservoirs behind the Devil Canyon and Watana dams (Figure 9.7). A further consideration is the types of activities that will take place in these areas.

Indirect impact will occur on sites affected by altered tributary hydrology (erosion and soil saturation) brought about by the filling and lowering of the reservoirs, by greater access to remote areas, by increased population in the area during and after construction, by some project maintenance and related activities, and by ancillary development expected to occur as a result of the project. While some indirect results of the project on surrounding sites are virtually assured, others are more difficult to predict. An impact to sites or groups of sites can be predicted to occur, for example, as a result of expected recreational development or activity.

The archeological profession has a third level of impacts called potential. Potential impact is connected with possible future development resulting from the project but which can not at present be predicted. Potential impact could become direct or indirect depending on how these activities affect the areas containing cultural resources.

(a) Central Study Area

Cultural resouce sites found in the central study area are located on Figures 4.1 through 4.3. Those sites to be either directly or indirectly affected by the project are distinguishable on these figures.

(i) Watana Dam and Impoundment

Two historic sites and 24 archeological sites will be directly affected. One historic site and 23 archeological sites may be indirectly affected.

(ii) Devil Canyon Dam and Impoundment

One historical and seven archeological sites will be directly impacted. Three sites (one archeological, two historical) including the Dickey inscription may be indirectly affected.

(iii) Borrow Areas, Associated Facilities, and Areas Disturbed by Geotechnical Testing

One historic site and 10 archeological sites will be directly affected by activities associated with these areas. Three archeological sites may receive indirect impact. In any case, many of these sites will have been directly or indirectly affected by the Watana dam and reservoir.

(iv) Access Route

Although no historic sites are known to occur in the access road corridor, eight archeological sites will be directly impacted unless mitigative actions are taken. Six archeological sites may be indirectly affected. Sites spared direct impact by minor realignment of the route would still be subject to indirect impact.

(v) Transmission Lines

Currently proposed transmission line routes contain seven known archeological sites that could be directly impacted. An additional seven sites may be indirectly impacted. Direct impacts (but not necessarily indirect impacts) can be avoided by the actual routing of the right-of-way.

(vi) Other Areas

The category "other areas" includes archeological sites identified outside of the study area in addition to those sites within the study area that will not be directly or indirectly affected by the project. There are 42 such sites. They are placed in the potential impact category since future impacts cannot at present be predicted. As required by the FERC license application guidelines, these sites are identified so that early in the planning stages of the Susitna Hydroelectric Project all current data on cultural resources are available to project planners. For example, if Borrow Area F (along Tsusena Creek) were to be further enlarged to the north, a number of cultural resource sites would likely be directly or indirectly impacted. Other sites near Big Bones Ridge (east of the Oshetna River), have a much more remote possibility of being directly or indirectly impacted.

(b) Southern and Northern Transmission Corridors

Figures 4.4 through 4.6 illustrate known archeological sites along the proposed transmission corridors in the southern and northern study areas. The information regarding these sites was obtained from the files of the State Archeologist. Known sites were a consideration in the transmission line routing. These figures also illustrate areas with a high potential for containing cultural resources, which were also a consideration in the routing.

As discussed previously [see Section 4.2 (b)], no reconnaissance-level testing for cultural resources was conducted. Therefore, undiscovered sites may occur in the route. Although a potential does exist for impacts on such sites, it may be possible to avoid at least the direct impacts during alignment of the actual right-of-way.

4.5 - Mitigation of Impacts on Historic and Archeological Sites

(a) Mitigation Policy and Approach

It is mandated by federal law (FERC 1981, United States 1974) that the effect of any federal project or federally licensed project on cultural resources must be assessed and mitigation measures developed to lessen or avoid the impact on these resources. Mitigation is a basic management tool, providing options for either preserving, avoiding, or excavating cultural resources. Although the concept of mitigation continues to be refined, it clearly consists of three options: avoidance, preservation, and investigation.

(i) Avoidance

Avoidance consists of any measures that avoid adverse effects of a project on cultural resources. Avoidance in and of itself may not be totally effective if not coupled with a preservation program. The program should ensure that an historic or archeological site is protected from the immediate adverse effect of the project (direct impacts) and is not inadvertently damaged in the future as a result of the project (indirect impacts). For the Susitna Hydroelectric Project, potential damage may result from, but is not limited to, operation of the facilities, increased access to remote areas, recreational activities, induced private development, and the induced transfer of lands from federal and state governments to corporate or private parties (and vice versa). Therefore, avoidance must be considered in terms of both short and long-range goals, the latter aimed at protecting cultural resources beyond the immediate construction phase of the dam and its ancillary facilities.

(ii) Preservation

Preservation is any protective measure that results in the reduction or avoidance of impacts on cultural resources through physical maintenance or that prevents their further deterioration or destruction. Preservation, as with avoidance, implies both short-term and long-term measures. Preservation may consist of such techniques as stabilization, reconstruction, construction of a barrier around the site, patrolling and monitoring the site, public education, or the establishment of an archeological preserve. Of all the preservation options available for the Susitna project, public education may have the greatest potential for long-term preservation not only of a particular site or group of sites but also of all cultural resources in general.

(iii) Investigation

Investigation (systematic excavation) aims at collecting and conserving archeological data in a scientific manner that addresses significant questions about the past (USDI 1980b). A program of this type means that data recovery procedures are developed for each site or group of sites, analyses of materials collected are undertaken, and the results are disseminated to professional and public audiences. In addition to investigation as a method of avoiding adverse effects, a site could be investigated, either partially or in whole if it appears to fit the research needs of the overall cultural resource management program; it contains information critical to the larger mitigation program; or it cannot be protected from indirect impacts that may result from an increase of off-the-road traffic, recreational use, the number of people in the area, or site visibility.

(b) Mitigation Plan

Any mitigation plan must be based on an evaluation of project consequences to the total resource, including both known and undiscovered sites. Therefore, because only a portion of the area to be affected by the Susitna Hydroelectric Project has been surveyed and investigated, any mitigation plan must include a program to examine the entire area and to mitigate adverse effects on all significant sites.

FERC regulations (FERC 1981) require that final recommendations be submitted to the Alaska State Historic Preservation Officer for review and comment. Following this step, a mitigation plan will be submitted as part of the Susitna project's application. Prior to actually implementing any mitigation plan, however, project managers must permit the Advisory Council on Historic Preservation to comment on the plan's efficacy. Compliance with recommendations to mitigate the effect of the Susitna Hydroelectric Project on cultural resources is the responsibility of the Alaska Power Authority.

(i) Details of Plan (Preliminary)

Mitigation of the impact on all sites that will be adversely affected by the dams, impoundments, and ancillary facilities of the Susitna Hydroelectric Project, either directly or indirectly, can be accomplished by investigation as described above. Avoidance and preservation may be a viable option for minimizing some indirect impacts. Mitigation of potential impacts on sites in the Other Areas category [Section 4.4 (a) (iii)], as well as impacts of the access road and the transmission routes, can likely be achieved by avoidance with an accompanying protection plan as described above.

- Impoundment Zones and Ancillary Facilities

  Mitigation of the direct impact on eight sites and the indirect impact on two sites in the Devil Canyon dam and impoundment area can be accomplished by investigation; the Dickey inscription can be avoided and preserved. Likewise, mitigation of the direct impact on 26 sites and indirect impact on 24 sites in the Watana dam and impoundment zone can also be achieved by investigation. Finally, mitigation of the direct effects to 11 borrow area sites and indirect impact on three other such sites can be accomplished by investigation. Avoidance and preservation may also be a viable alternative for mitigating indirect impacts to some sites.

- Access Route

  Mitigation of the direct impact of the project on eight sites and indirect effects on six sites along the access route can be accomplished by investigation. If realignment of the route can be accomplished in certain areas, mitigation of direct impacts by avoidance is possible; preservation or investigation could then mitigate indirect impacts.

- Transmission Route

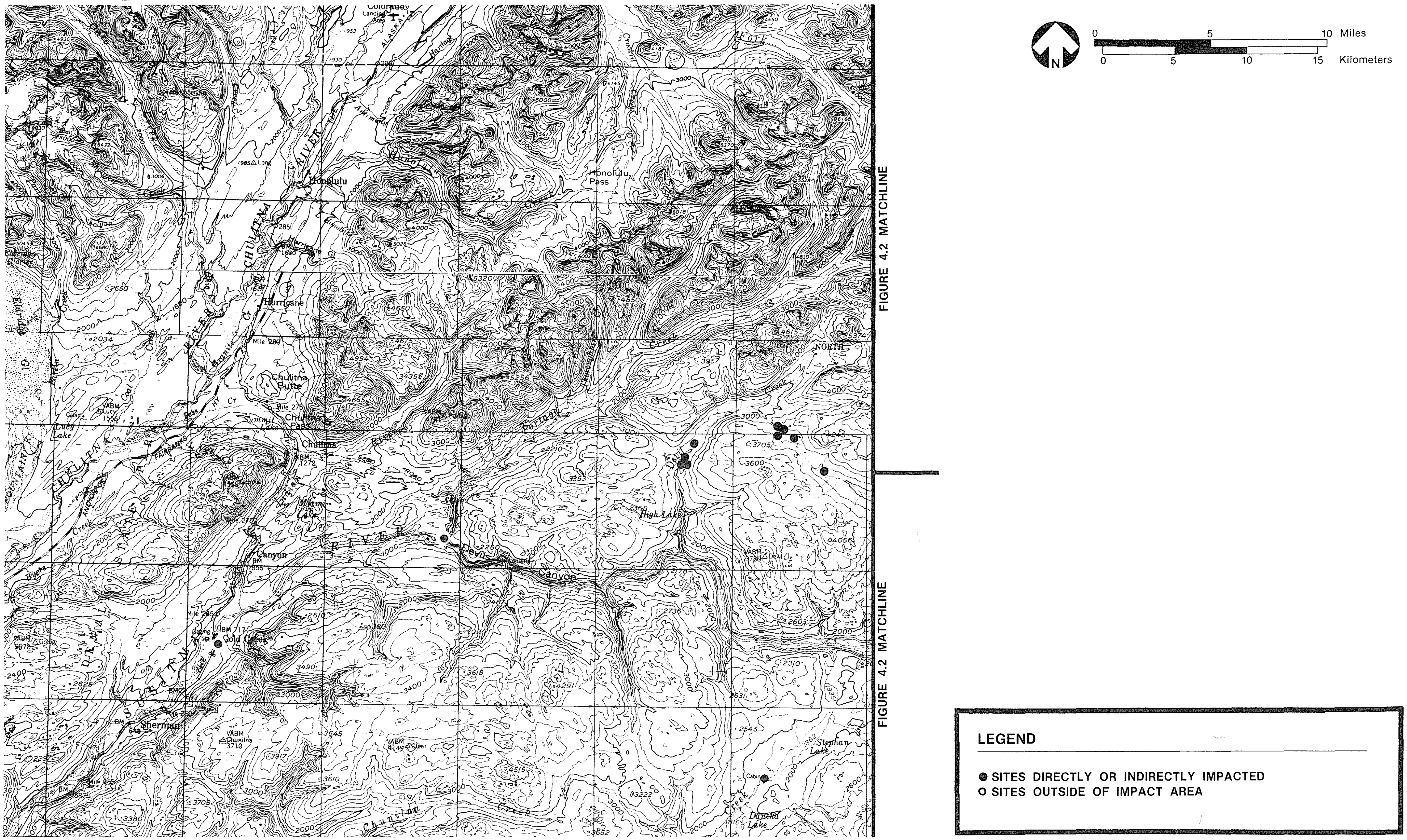
  In the central study area, investigation, avoidance, and/or preservation would mitigate the direct impact on seven sites and indirect impact on seven sites; avoidance may mitigate the direct impacts, but not necessarily the indirect impacts, so preservation (or even investigation) would likely still be needed. Currently, available data do not enumerate the sites that may be directly or indirectly affected by the transmission line in the southern and northern study area. It is assumed that once a transmission route is surveyed, a reconnaissance-level survey will be conducted. Since the transmission line right-of-way can, in most cases, be aligned to skirt any cultural resources located, mitigation of known sites can be accomplished primarily by avoidance and preservation. The effects on those sites that cannot be avoided by aligning tower locations and/or access roads can be mitigated by investigation.

- Other Areas

The 42 cultural resource sites included in "Other Areas" are in the category of potential impacts. One reason for including them in any mitigation plan is that if either the proposed project or future land use changes in any way, then a site previously deemed unaffected may, in fact, experience some consequences. In that event, impacts would then be direct or indirect. Thus, the existence of these areas should be recognized, and mitigation should involve avoidance or preservation. If these measures do not appear likely to be effective, investigation is possible.

(ii) State and Federal Agency Recommendations and Applicant's Variation from these Recommendations

Final mitigation recommendations and the mitigation plan itself will be submitted to the State Historic Preservation Officer and the National Park Service for review and comment. Their comments and recommendations will be included in the FERC license application.



KNOWN CULTURAL RESOURCES SITES, CENTRAL STUDY AREA - MAP I

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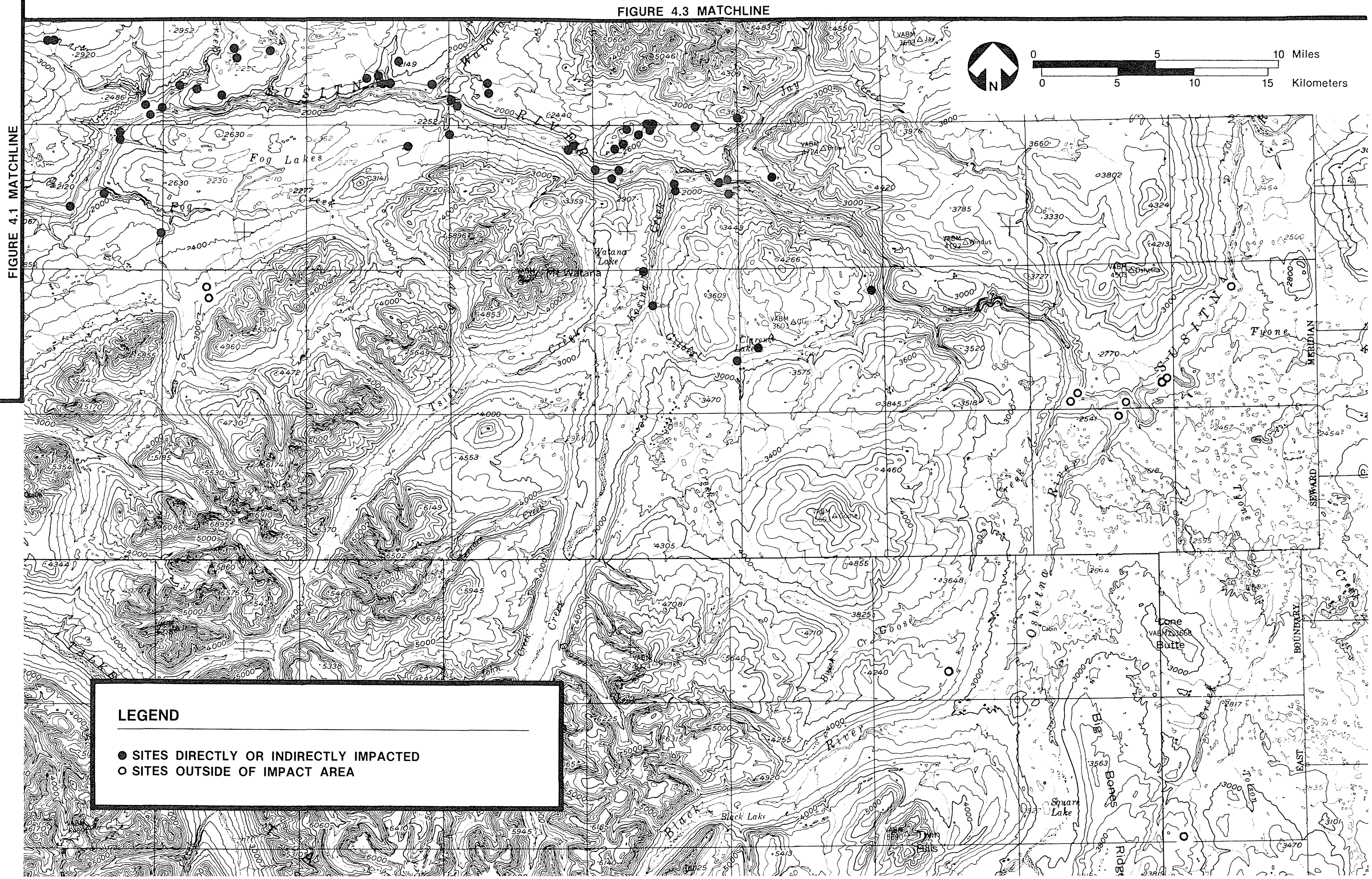
FIGURE 4.1

ACRES



KNOWN CULTURAL RESOURCES SITES, CENTRAL STUDY AREA - MAP II.

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 4.2

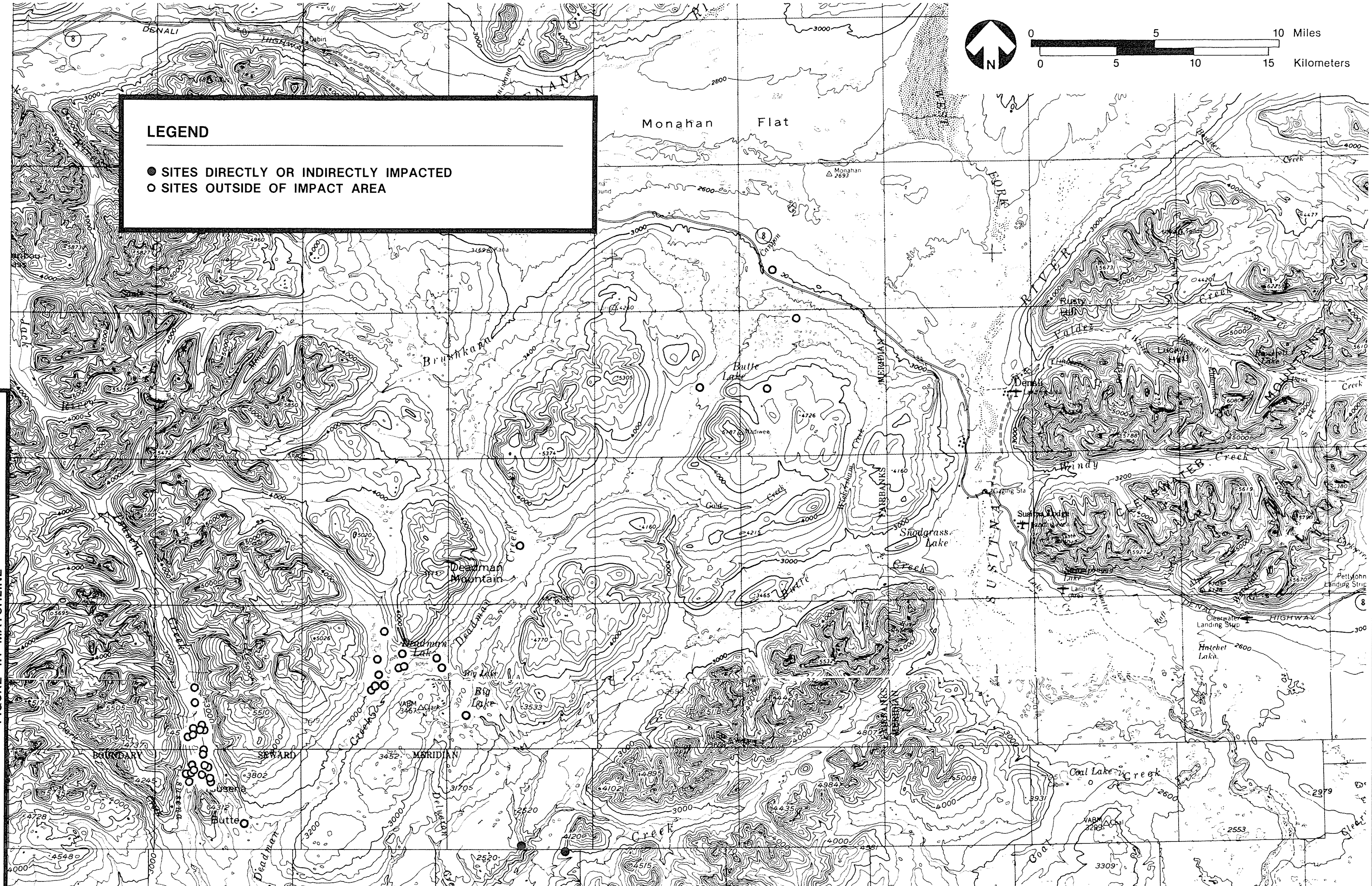


FIGURE 4.1 MATCHLINE

FIGURE 4.2 MATCHLINE

KNOWN CULTURAL RESOURCES SITES, CENTRAL STUDY AREA - MAP III.

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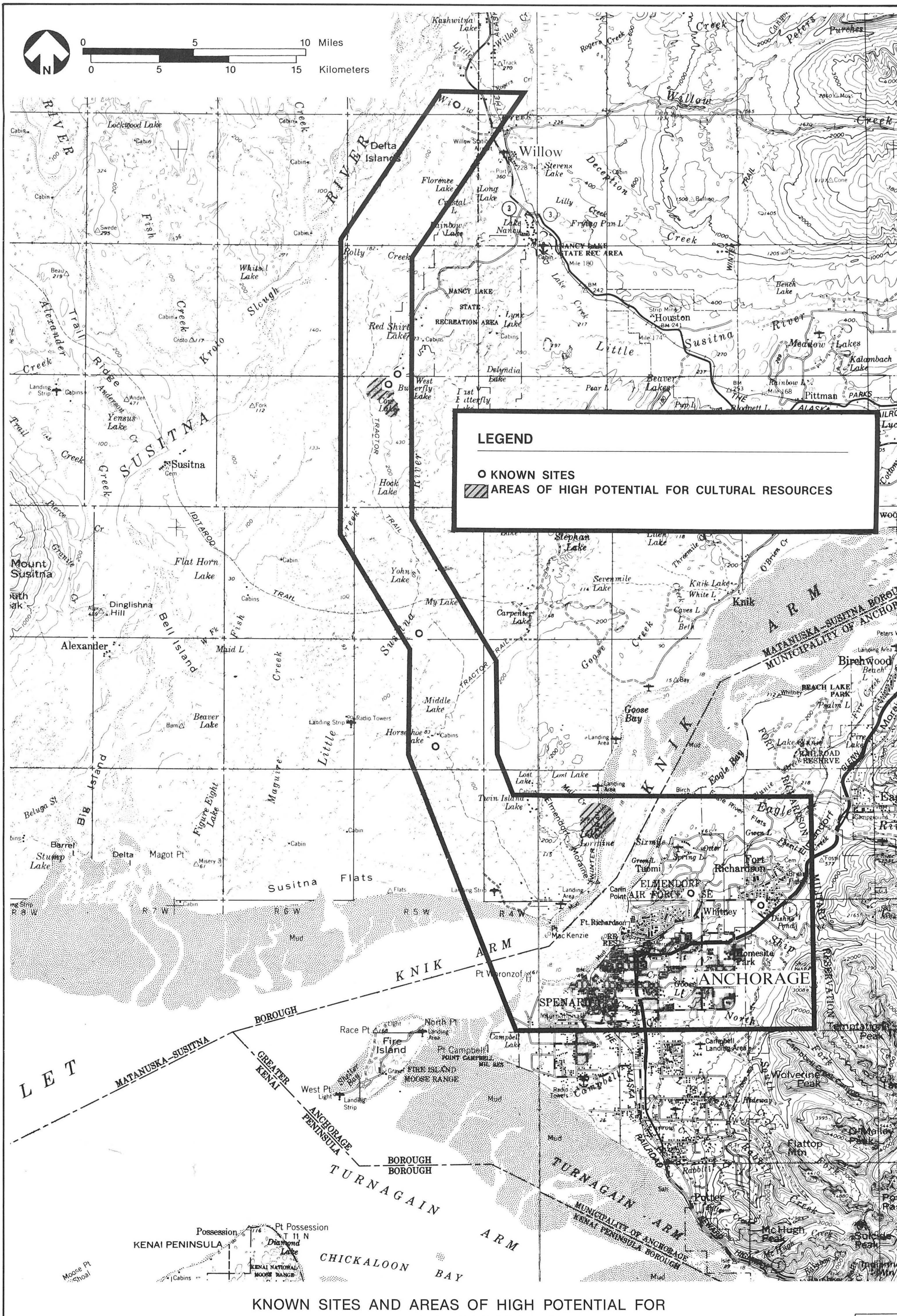
FIGURE 4.3

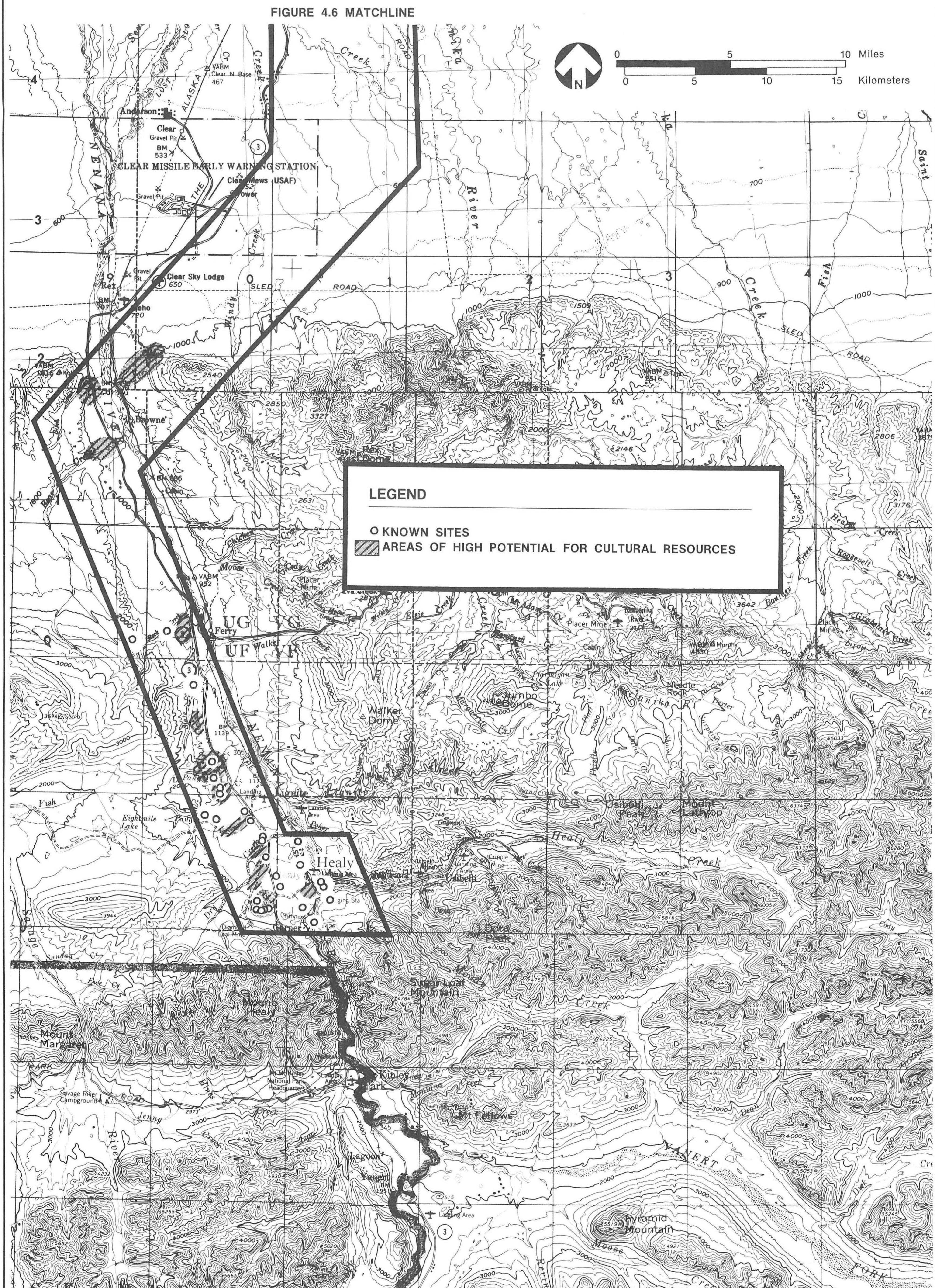
ACRES



KNOWN SITES AND AREAS OF HIGH POTENTIAL FOR CULTURAL RESOURCES, SOUTHERN STUDY AREA

PREPARED BY TES

ACRES



KNOWN SITES AND AREAS OF HIGH POTENTIAL FOR
CULTURAL RESOURCES, NORTHERN STUDY AREA - MAP I

PREPARED BY TES

FIGURE 4.5

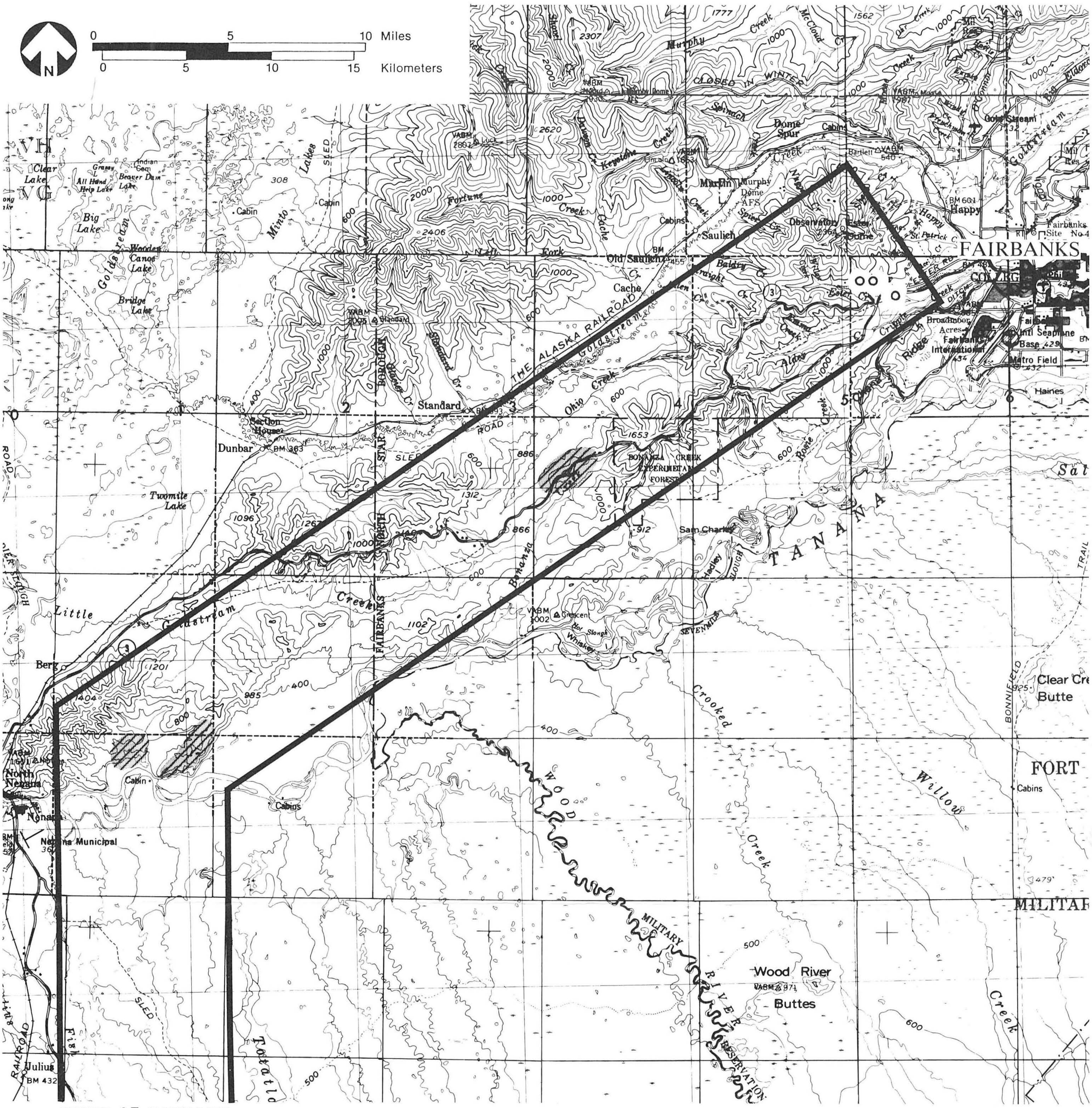


FIGURE 4.7 MATCHLINE

LEGEND

O KNOWN SITES

▨ AREAS OF HIGH POTENTIAL FOR CULTURAL RESOURCES

KNOWN SITES AND AREAS OF HIGH POTENTIAL FOR CULTURAL RESOURCES, NORTHERN STUDY AREA - MAP II

PREPARED BY TES

FIGURE 4.6