Fish & Game

SUSITNA HYDROELECTRIC PROJECT

FERC LICENSE APPLICATION

EXHIBIT E

CHAPTER 3

DRAFT

NOVEMBER 15, 1982

Pages E-3-118 and E-3-119 and tables E.3.22 and E.3.23 do not exist.

Sections 2.5 and 2.6 precede section 2.4.

Prepared by:

ACRES

ALASKA POWER AUTHORITY

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VOLUME 2 CHAPTER 3

FISH, WILDLIFE, AND BOTANICAL RESOURCES

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3 - REPORT ON FISH, WILDLIFE, AND BOTANICAL RESOURCES

1 - INTRODUCTION

This report discusses the fish, vegetation, and wildlife resources of the area that will be affected by the proposed Susitna Hydroelectic Project. Each of the major subsections (2 - Fish, 3 - Botanical Resources, and 4 - Wildlife) provides a baseline description of species and populations of the project area, an assessment of potential project impacts on this biota, and a mitigation plan that explains how preliminary planning, design, and construction have incorporated measures to avoid, minimize, or rectify potentially adverse effects of the project on the biological environment. In appropriate cases, resource management options to reduce or compensate for adverse impacts that cannot otherwise be mitigated are discussed.

1.1 - Baseline Descriptions

These sections describe the distributions and characteristics of biological populations and communities within the project area. The discussions are based on a thorough review of the scientific literature, and emphasize documented studies conducted in preparation for the Susitna Hydroelectric Project by the Alaska Department of Fish and Game (ADF&G) and professional consultants. They provide the most current available information through November 1982 on fish, vegetation, and wildlife of the project area.

Discussions of animals focus on vertebrate species - resident and anadromous fish, big game, furbearers, and birds. The plant descriptions deal with species aggregations that occur in recognizable patterns, such as vegetation communities and successional stages.

The baseline descriptions emphasize functional relationships among habitat components and animal communities. Factors that regulate species distribution and abundance receive particular attention, because knowledge of these regulating mechanisms can suggest where populations are most sensitive to potential disturbance. For example, water temperature and streamflow regimes are discussed as regulators of fish populations, and the role of plant communities in regulating wildlife populations is examined.

1.2 - Impact Assessments

It is expected that the distribution and abundance of fish, plant, and wildlife species in and around the area of the Susitna Hydroelectric Project will change as a result of project construction and operation. The impact assessments presented in this report are based, in part, on the project description presented in Exhibit A, project operations described in Exhibit B, the proposed construction schedule shown in Exhibit C, and an analysis of similar activities associated with large construction and hydroelectric projects in similar habitats. In addition, the Recreation Plan presented in Exhibit E, Section 7, has been reviewed as a proposed project action to determine its potential impacts on fish, vegetation, and wildlife. The impact assessment links predicted physical changes with habitat utilization to provide a qualitative statement of impacts likely to result from the Susitna Hydroelectric Project. Changes potentially resulting from the project are discussed with respect to specific project features and activities, assuming standard engineering design and construction practice without the incorporation of modifications to avoid or minimize the changes. Much of the discussion is based on professional judgment. Data collection and analysis programs currently underway will provide the basis for impact quantification.

Although some project impacts, if not mitigated, will be adverse, other impacts will be innocuous and some will enhance fish or wildlife productivity. Therefore, potentially beneficial impacts are given balanced treatment with those to be mitigated. Each potential effect, together with the action responsible for it, is called an impact issue.

The identification and prioritization of impact issues have followed the procedures established by the Susitna Hydroelectric Project Fish and Wildlife Mitigation Policy (Alaska Power Authority 1982; Appendix EA). This policy was prepared by the Power Authority through a Fisheries Mitigation Core Group, a Wildlife Mitigation Core Group, and a Fish and Wildlife Mitigation Review Group. The core groups, consisting of professional consultants and agency representatives, developed the technical specifics of the mitigation policy. The review group, which consists entirely of state and federal agency representatives, evaluated draft stages of the mitigation policy and provided comments that were incorporated through successive revisions. The review group included representatives of the following resource agencies:

- Alaska Department of Fish and Game (ADF&G);
- Alaska Department of Natural Resources (ADNR);
- National Marine Fisheries Service (NMFS);
- U.S. Bureau of Land Management (USBLM);
- U.S. Environmental Protection Agency (USEPA); and
- U.S. Fish and Wildlife Service (USFWS).

In addition to procedures outlined in the Susitna Project mitigation policy, criteria for assessing the relative importance of biological impact issues have been provided by (1) mitigation policies of the Alaska Department of Fish and Game (ADF&G 1982) and the U.S. Fish and Wildlife Service (Christian 1981); (2) comments and testimony by the Alaska Department of Fish and Game (Skoog, 1982; Schneider 1979, 1982a, b, c), the Alaska Department of Natural Resources (ADNR 1982), the U.S. Fish and Wildlife Service (Sowl, 1982; USFWS 1979, 1980a, b, 1982a, b), and the Susitna Hydro Steering Committee (SHSC 1981, 1982); and (3) discussions of impact issues in workshops (ESSA/WELUT/LGL 1982) and numerous other technical meetings involving Susitna Project personnel and resource agency representatives.

All three mitigation policies imply that project impacts on fish and game species will be of greater concern than changes in the distribution and abundance of non-game wildlife and invertebrate species. The policies and comments also indicate that, for the Susitna Project area, vegetation is considered more important as a component of wildlife habitat than as a botanical resource in itself. Statewide policies and management approaches of resource agencies suggest that fish and wildlife species with commercial, subsistence, and other consumptive uses are more important than species without such value.

The mitigation policies all agree that resource vulnerability is an important criterion for impact prioritization. Resources judged most vulnerable to potential project impacts have therefore been given highest priority in impact assessment and mitigation planning. Similarly, impact issues have been considered with regard to probability of occurrence. Where there is a high degree of confidence that an impact will actually occur, it has been ranked above impacts predicted with less certainty. Also, the mitigation policies and agency comments indicate that impacts on productivity and animal population size through changes in habitat availability are of high concern. Behavioral responses that have the potential for producing population-level effects are also important. Adverse impacts that are longer-lasting or irreversible have priority over short-term impacts.

1.3 - Mitigation Plans

Mitigation plans have been developed for identified impact issues in accordance with the sequence of steps defined by 40 CFR 1508.20, pursuant to the National Environmental Policy Act (42 USC 4321 et seq.). The mitigation planning sequence includes, in priority order of implementation, the following steps:

- Avoiding the impact through project design and operation, or by not taking a certain action;

- Minimizing the impact by reducing the degree or magnitude of the action, or by changing its location;

- Rectifying the impact by repairing, rehabilitating, or restoring the affected portion of the environment;

- Reducing or eliminating the impact over time by preservation, monitoring, and maintenance operations during the life of the action; and

- Compensating for the impact by providing replacement or substitute resources that would not otherwise be available.

This sequential strategy for mitigation option analysis is shared by all three mitigation policies applied to the project (Alaska Power Authority, 1982; ADF&G, 1982; USFWS, 1982). The relationships of steps within the sequence are shown in Figure E.3.1 and further compared in Table E.3.1.

The process by which mitigation will be implemented and continually refined throughout the life of the project is shown schematically in Figure E.3.2. The process involves the following steps:

- Impact issue evaluation:

  - Identification of the nature and extent of impacts:
    - Populations
    - Subpopulations
    - Habitat types
    - Geographical areas

  - Ranking importance of resources to be impacted:
    - Ecological value
    - Consumptive value
    - Nonconsumptive value
    - Confidence of impact prediction

- Option Analysis Procedure

  - Identification of practicable mitigation options:
    - Type of mitigation option
    - Sequence of implementation

  - Evaluation of mitigation options:
    - Effectiveness of option
    - Conflicts with project objectives
    - Residual impacts

  - Documentation of option analysis:
    - Impact issues
    - Mitigation options
    - Conflicts (if any) with project objectives

- Mitigation plan implementation:

  - Construction and operating monitoring:
    - Review work accomplished
    - Evaluate degree of impact
    - Evaluate effectiveness of mitigation
    - Identify modifications to the mitigation plan
    - Submit regularly scheduled reports

  - Mitigation plan modifications:
    - Propose modifications
    - Submit modifications for review
    - Implement and monitor approved modifications

Data from the baseline, impact, and monitoring studies will be used throughout the life of the project by the mitigation core and review groups to plan and continually refine the mitigation process in a flexible, adaptive fashion.

Mitigation measures proposed for the Susitna Hydroelectric Project may be classified within two broad categories:

- Modifications to engineering, construction or operation, design and planning; and

- Management strategies.

The first type of mitigation measure is project-specific and emphasizes the avoidance, minimization, rectification or compensation of adverse impacts, as prioritized by the Fish and Wildlife Mitigation Policy established by the Alaska Power Authority (1982) and coordinating agencies (ADF&G, 1982; USFWS, 1982). As shown in Figure E.3.1, these measures must first be implemented to keep adverse impacts to the minimum consistent with project requirements. They involve adjusting or adding project features during design and planning so that mitigation becomes a built-in component of project actions.

When impacts cannot be fully avoided or rectified, reduction or compensation measures are justified. This type of mitigation can involve management of the resource itself, rather than adjustments to the project, and may require concurrence of resource management boards or agencies with jurisdiction over lands or resources within and around the project area.

Mitigation planning for the Susitna Hydroelectric Project has emphasized both approaches. The prioritized sequence of options from avoidance through compensation has been applied to each impact issue. If full mitigation can be achieved at a high priority option, lower options may not be considered. In the resulting Mitigation Plan, measures to avoid, minimize, or rectify potential impacts are treated in greatest detail. Specifications for facility siting and design, special mitigation facilities, construction procedures, and scheduling of project actions to mitigate adverse effects on the biota are presented. These are summarized in Appendix EB. Monitoring and maintenance of mitigation features to reduce impacts over time are recognized as an integral part of the mitigation process.

Long-term management strategies for project mitigation are discussed as potential options. The Alaska Power Authority is committed to evaluate and recommend such resource management options, and is sponsoring continuing research to define their need and application. Final agreement on measures will require interagency coordination.

2 - FISHERY RESOURCES OF THE SUSITNA RIVER DRAINAGE

2.1 - Overview of the Resources

(a) Description of the Study Area for Fishery Resources

The study area for the Susitna Hydroelectric Project fishery studies includes the Susitna River mainstem, side channels, sloughs, and mouths of major tributaries (Figure E.3.3). From the terminus of Susitna Glacier in the Alaska Mountain Range to its mouth in Cook Inlet, the Susitna River flows approximately 300 miles and drains 19,600 square miles. The mainstem and major tributaries of the Susitna River, including the Chulitna, Talkeetna and Yenta Rivers, originate in glaciers and carry a heavy load of glacier flour during the ice-free months. There are many smaller, clear water tributaries that are perennially silt-free, except during flood flows, including Portage Creek, Indian River, Kroto Creek (Deshka River) and Alexander Creek.

Streamflow is characterized by moderate to high flows between May and September and low flows from October to April. High summer discharges result from snowmelt, rainfall and glacial melt. Winter flows consist almost entirely of bank storage and groundwater inflow (see Chapter 2). Freeze-up begins in the higher regions in early October, and most of the river is ice-free by late-May.

Three study reaches have been defined for baseline data gathering and impact analysis based upon stream morphology, flow regime and anticipated impacts. These study reaches are: Cook Inlet (River mile RM 0) to Talkeetna (RM 98); Talkeetna to Devil Canyon RM 152); and the impoundment each from Devil Canyon to a point approximately four miles upstream from the Oshetna River (RM 236.0).

(b) Threatened and Endangered Species

No threatened or endangered species of fish have been identified in Alaska. The U.S. Department of Interior, Fish and Wildlife Service, does not list any fish species in Alaska as being threatened or endangered (USFWS 1982). The State of Alaska Endangered Species Act does not list any fish species as endangered.

(c) Overview of Important Species

Fishery resources in the Susitna River comprise a major portion of the Cook Inlet commercial salmon harvest and provide sport fishing for Anchorage and the surrounding area. Anadromous species that form the base of commercial and recreational fisheries include five species of Pacific salmon: chinook, coho, chum, sockeye and pink. Other anadromous species include eulachon and Bering cisco.

Important resident species found in the Susitna River drainage include Arctic grayling, rainbow trout, lake trout, burbot, Dolly Varden and round whitefish. Scientific and common names for all fish species identified from the Susitna drainage are listed in Table E.3.2.

The Susitna River is a migrational corridor, spawning area and juvenile rearing area for five species of salmon from its point of discharge into Cook Inlet to Devil Canyon, where salmon appear to be prevented from moving upstream by the water velocity at high flow. Preliminary data indicate that the majority of the 1981 Susitna River escapement of sockeye, pink, chum and coho salmon spawned above the Yentna River confluence and below Curry Station (ADF&G, 1981). Preliminary data also show that sloughs between Devil Canyon and Talkeetna provide spawning habitat for pink, sockeye and chum salmon. Field data show that juvenile chinook and coho salmon occur throughout the lower river, concentrating at slough and mainstem habitat during winter and at tributary mouths during summer. The majority of juvenile coho salmon were captured at tributary mouths throughout the year.

Highest catches per unit effort for rainbow trout and Dolly Varden were recorded at mouths of tributary streams. Data regarding geographic and seasonal distribution, relative abundance, length distribution and age distribution for other adult residents are discussed in the following section. Relatively few juvenile resident fish were collected in 1981.

(d) Selection of Project Evaluation Species

Selection of evaluation species is a necessary step in assessing impacts and in developing mitigation plans. Various species and life stages have different critical life requirements and respond differently to habitat alterations. A change in habitat conditions that benefits one species or life stage may adversely affect another and mitigation plans for one species may conflict with those proposed for another. Selection of evaluation species can provide a mechanism to resolve potential conflicts and to focus the resources available for analysis and planning.

The evaluation species can be selected after initial baseline studies and impact assessments have identified the dominant species and potential impacts on available habitats throughout the year. Mitigations can then be developed that will reduce impacts on population controlling habitat parameters.

Fishery resources of the Susitna River and activities associated with the project proposal were reviewed. Evaluation species were selected on the basis of the following criteria:

- High human use value.
- Dominance in the ecosystem.
- Sensitivity to project impacts.

Species with high regional visibility and commercial, sport, subsistence, or aesthetic value were given priority. Within this category, species sensitive to project effects were highly rated. Since the evaluation species play a dominant role in the ecosystem, they may serve as indicator species. By maintaining critical habitats for evaluation species, many of the potential impacts on less sensitive species or species with a lower evaluation priority will be mitigated.

Based on the aquatic studies baseline reports, preliminary impact assessments, and harvest contributions, the five species of Pacific salmon were identified as evaluation species for the Susitna River below Devil Canyon. Arctic grayling was selected as the evaluation species for the impoundment.

Since the greatest changes in physical habitats are expected in the reach between Talkeetna and Devil Canyon, fishery resources using that portion of the river were considered to be the most sensitive to project effects. Because of differences in their seasonal habitat requirements, not all salmon species would be equally affected by the proposed project. Of the five species, chum and sockeye salmon appear to be the most vulnerable in this reach, due to their dependence on slough habitats for spawning, incubation and early rearing (ADF&G 1981a, 1981b, 1982a). Of the two species, chum salmon appear to be the dominant species (ADF&G 1981b and Trent 1982). Chinook and coho salmon, while having a greater commercial and sport value than chum salmon, are less likely to be impacted by the project because most of their critical life stages, such as spawning, incubation, rearing and overwintering, occur in habitats that are less likely to be altered by the project (ADF&G 1981a, 1982a). While some pink salmon spawn in slough habitats in the reach between Talkeetna and Devil Canyon, the majority of these fish utilize tributary habitats (1981b). The mitigations proposed to maintain chum salmon should allow sockeye and pink salmon to be maintained as well. The chinook and coho salmon juveniles rear in the river for one to two years prior to outmigration with much of the rearing apparently occurring in clearwater areas, such as in sloughs and tributary mouths (ADF&G 1981d, 1982a). Improved conditions in the mainstem are expected to provide replacement habitat to mitigate for the potential loss of rearing areas in slough habitats. Juvenile overwintering habitats are not expected to be adversely affected.

In the impoundment zone, Arctic grayling were selected as the evaluation species because of their abundance in the clearwater systems, their sensitivity to impacts during all seasons and life stages and their desireability as a sport fish.

In summary, the evaluation species and life stages selected for the Susitna Hydroelectric Project are:

(i) Talkeetna to Devil Canyon Reach

- Chum Salmon

  - Spawning adults;
  - Embryos and pre-emergent fry;
  - Emergent fry;
  - Returning adults; and
  - Outmigrant juveniles.

- Sockeye Salmon

  - Spawning adults;
  - Embryos and pre-emergent fry;
  - Emergent fry;
  - Returning adults; and
  - Outmigrant juveniles.

- Chinook Salmon

  - Rearing juveniles; and
  - Returning adults.

- Coho Salmon

  - Rearing juveniles; and
  - Returning adults.

- Pink Salmon

  - Spawning adults;
  - Embryos and pre-emergent fry;
  - Emergent fry;
  - Returning adults; and
  - Outmigrant juveniles.

(ii) Impoundment Zone

- Arctic Grayling

  - Spawning adults;
  - Incubating embryos;
  - Rearing; and
  - Overwintering.

(e) Contribution to Commercial, Sport, and Subsistence Fishery

(i) Commercial

With the exception of sockeye salmon, the majority of Upper Cook Inlet Salmon production originates in the Susitna drainage (ADF&G 1982b). The Upper Cook Inlet commercial fishery harvests mixed stocks. The long term average annual catch of 2.8 million fish is worth approximately 17.9 million dollars (ADF&G 1982b). The Susitna River is considered the most important salmon producing system in upper Cook Inlet, however, the quantitative contribution of the Susitna River to the commercial fishery can only be estimated due to:

- The high number of intra-drainage spawning and rearing areas;

- The lack of data on other known and suspected salmon-producing systems in upper Cook Inlet.

- The lack of stock separation programs (except for sockeye salmon); and

- Overlap in migration timing of mixed stocks and species in Cook Inlet harvest areas.

Therefore, the following discussion on the contribution of the Susitna River to the upper Cook Inlet fishery is based on the limitations above. Estimates are based upon:

- Historical sustained harvest in upper Cook Inlet; and

- Available escapement data for the Susitna drainage.

- Sockeye

The commercial sockeye harvest has averaged 1.2 million fish annually in upper Cook Inlet over the last ten years with an ex-vessel value of 6.9 million dollars (Table E.3.3). As a result, the species is considered the most valuable salmon in the commercial fishery. The estimated sockeye escapement in the reach above Talkeetna was 4,800 in 1981 and 3,100 in 1982 (Table E.3.4).

- Chum

Chum salmon are second to sockeye salmon in economic value for upper Cook Inlet, averaging 2.3 million dollars, ex-vessel. The Upper Cook Inlet chum salmon catch has averaged approximately 700,000 fish annually over the past ten years (Table E.3.3). The 1981 and 1982 estimates of chum salmon escapement in the reach above Talkeetna were 20,800 and 49,200 (Table E.3.4.).

- Coho Salmon

Upper Cook Inlet coho salmon rank third in commercial value. Since 1960 the commercial catch has averaged 240,000 fish (Table E.3.3). The 1981 and 1982 estimates of coho salmon escapement in the reach above Talkeetna were 3,300 and 5,100 (Table E.3.4).

- Pink Salmon

The upper Cook Inlet annual average odd-year harvest of pink salmon is about 146,000 with a range of 24,000 to 554,000 while the average even-year harvest is 1,671,000 with a range of 484,000 to 3,232,000 (Table E.3.3).

Estimates of pink salmon escapement in the reach above Talkeetna was about 2,300 in 1981 and 73,100 in 1982 (Table E.3.4).

- Chinook

Since 1960, the commercial catch of Chinook salmon in Upper Cook Inlet has averaged 12,500 (Table E.3.3). The Upper Cook Inlet harvest for 1981 was 11,500. Since 1964, the opening date of the commercial fishery has been June 25, and the Susitna River chinook salmon run begins in late May and peaks in mid-June. Thus, the majority of chinooks have already passed through the area subject to commercial fishing. Estimates of chinook salmon escapement in the reach above Talkeetna were 10,200 in 1982 (Table E.3.4).

(ii) Sport Fishing

Recent increases in population and tourism in Alaska have resulted in a growing demand for recreational fishing. Recreational fishing is now considered a significant factor in total fisheries management, especially in Cook Inlet where sport-commercial-subsistence user conflicts have developed (Mills 1980). The Susitna River and its major salmon and resident fish-producing tributary streams provide a multi-species sport fishery easily accessible from Anchorage and other Cook Inlet communities. In 1980, the Susitna River and its primary tributaries accounted for over one hundred thousand man days of sport fishing effort and about 9 percent of the total angler days in Alaska (Mills 1980).

Based upon 1980 mailing surveys to a sample of licenses (Mills 1980), the following sport fish harvest was reported for important anadromous and resident fish in the Susitna River and its primary tributaries:

Salmon

Pink	54,244
Coho	13,657
Chinook	6,493
Chum	4,673
Sockeye	925

Other Anadromous and Resident

Arctic Grayling	13,921
Rainbow Trout	12,965
Dolly Varden	3,024
Burbot	591
Lake Trout	267

The figures represent the sport fishing harvest in an area that is larger than that which could be affected by the proposed project.

The estimated catch of Arctic grayling represents about 20 percent of the estimated harvest in southcentral Alaska in 1980 and the estimated catch of rainbow trout represents about 17 percent of the entire state harvest in 1980. The Susitna harvest of pink salmon represents about 33 percent of the total estimated harvest for southcentral Alaska, whereas the harvest of coho represents about 11 percent of the estimated harvest for southcentral Alaska and the harvest of chinook represents about 27 percent of the estimated harvest for southcentral Alaska.

(iii) Subsistence Harvest

Although salmon form an important resource for many Susitna Basin residents, subsistence fishing within the Susitna Basin is not a recognized harvest by the state. The Tyonek Village subsistence salmon fishery, approximately 30 mi southeast of the mouth of the Susitna River, is supported at least in part by Susitna River stocks.

2.2 - Species Biology and Habitat Utilization in the Susitna River Drainage

(a) Species Biology

(i) Salmon

- Chinook

In the Susitna River below Talkeetna the adult chinook salmon migration begins in late May and ends in early to mid-July. Historically, by 1 July, 90 percent or more of the escapement have migrated past the Susitna Station (ADF&G 1972). Sonar counters and fishwheels installed to monitor escapements for pink, chum, sockeye and coho salmon provided some incidental information regarding the timing of chinook runs. Fishwheel catches indicate that the migration ended by July 9 at the Susitna and Yentna stations. Initial sonar counts made at Sunshine Station also suggested that a significant segment of the escapement had migrated past this location prior to the June 23 sonar counter installation. Similarly, a sizable portion of escapement had already passed the Talkeetna site before June 23, when the sonar counters became operational. Fishwheel catches and sonar counter data indicated that the peak of upstream migration at Sunshine Station occurred on June 23 and that migration ceased about July 10. At Curry Station, the fish wheels were in place early enough to clearly define the beginning of migration on June 16, the peak of migration on June 23 and the end of migration on July 4.

At four of five mainstem sampling stations in 1981, an undetermined portion of the early escapement was not recorded, rendering it impossible to estimate total escapement through either sonar counts or tagging studies. However, stream escapement surveys (Table E.3.5) made from helicopters, fixed-wing aircraft and from the ground (ADF&G 1978, 1981b) indicate that total escapement within the drainage is in the range of 100,000 with a minimum annual escapement of 60,000 needed to maintain stocks at historic levels. Without repeated spawning ground counts and knowledge of average stream life expectancy of chinook salmon in each stream surveyed, the escapement counts cannot be considered an absolute measure of total escapement; however, they can be considered an index of abundance.

Radio telemetry studies during June, July and August of 1981 (ADF&G 1981b) indicated that the confluence of the Talkeetna, Chulitna and Susitna Rivers is a probable milling area for migrating adult chinook salmon. The four fish tagged at the Talkeetna site moved downstream and remained either at the confluence or downstream from this area for several days or weeks before moving back upstream. This downstream movement was seen in two of the twelve fish that were radio tagged at the Curry Site. Eleven of the thirteen tagged fish that moved upstream after being tagged at Talkeetna or Curry Stations entered a single tributary and remained there. Two of the remaining tagged fish entered a different tributary, one moved downstream and held near Chase Creek, and two were lost because of technical difficulties with the transmitters.

Four-year old individuals were dominant at Sunshine and Curry Stations while at Talkeetna, six- and four-year olds were equally abundant. There was a higher percentage of younger fish, mainly three-year olds, at Sunshine Station than at either the Talkeetna or Curry Stations. Seven-year old fish were relatively scarce at Sunshine and Talkeetna and none were identified from the Curry Station sample.

Surveys of chinook salmon spawning areas were performed by helicopter, single-engine fixed-wing aircraft and by foot during the 1981 and 1982 investigations. Chinook appear to spawn in the tributaries rather than the mainstem of the Susitna River. Some of the more important spawning tributaries include Alexander Creek, Krotȯ Creek, (Deshka River), Willow Creek, Clear Creek (in the Talkeetna Drainage), Chulitna River, Peters Creek, Lake Creek, Talachulitna River, Prairie Creek, Montana Creek, Indian River and Portage Creek (Table E.3.5 and Table E.3.6).

In the Susitna River system chinook spawn in July and early August (ADF&G 1981b). In Alaska each female deposits from 4,200 to 13,000 eggs, which incubate in the gravel through winter and hatch the following spring (Morrow 1980). The alevins generally remain in the redd for two to three weeks until the yolk sac is absorbed and then emerge from the gravel and become free-swimming, feeding fry (Morrow 1980).

The chinook fry school after emerging from the gravel but become territorial as they grow. Aquatic insect larvae, including chironomids and caddis flies, as well as small crustaceans, are the major food sources for juvenile chinook salmon (ADF&G 1978). Analysis of adult chinook salmon scales show that most Susitna River salmon appear to remain in freshwater for one year before smolting (ADF&G 1981b).

The geographical and seasonal distribution, relative abundance, age composition and smolt migration timing of juvenile chinook salmon reared in the Susitna drainage are summarized below based upon studies by ADF&G (1981d), Delaney et. al. (1981), and ADF&G (1978).

Juvenile chinook salmon were captured throughout the study area from Alexander Creek (RM 10.1) upstream to Portage Creek (RM 148.8). Collection techniques and data summaries for juvenile collections are detailed in ADF&G (1981d). Populations varied in abundance and distribution by river habitat type and seasonal period. During winter, most juveniles were captured in mainstem and slough sites. All juvenile chinook salmon captured at the mainstem and slough sites are believed to have migrated from associated streams since no chinook salmon spawning has been recorded in the mainstem or sloughs. The migration to mainstem and slough sites during late fall is apparently the result of icing and lowered flow in tributaries (ADF&G 1981d).

During summer, juvenile chinook were also captured throughout the study area below Devil Canyon from Alexander Creek to Portage Creek. A total of 6,579 juvenile chinook were captured during the summer surveys between Cook Inlet and Devil Canyon. The reach between Talkeetna and Devil Canyon accounted for 34 percent of the total captures and the remainder were captured between Cook Inlet and Talkeetna (ADF&G 1981d). Tributary mouths appear to provide important rearing habitat during summer months. Clearwater sloughs may also supply summer rearing habitat and may be important year-round rearing habitat.

Two age groups of juvenile chinook salmon, representing brood years 1979 (1+) and 1980 (0+), were identified from scale analysis and length distribution. Age 1+ were observed between Talkeetna and Devil Canyon at 45 percent of sites surveyed during the first two weeks of June. Captures decreased and terminated in July. Age 1+ were not captured after August in the Cook Inlet to Talkeetna reach. It was concluded that the decreasing numbers of age 1+ chinook salmon was a result of smolt out-migration (ADF&G 1981d). The peak smolt movement apparently occurred prior to early June sampling.

Catches of age 0+ in mainstem and slough habitats increased from late June to a high in early September for the Talkeetna to Devil Canyon reach. This was interpreted as an indication that juvenile distribution expanded from tributary streams and stream mouth sites into mainstem and slough sites as summer progressed (ADF&G 1981d).

Interpretation of present and past surveys of the Susitna River and its tributaries have resulted in the following conclusions relating to abundance, distribution and outmigration (ADF&G 1981d).

- Juvenile chinook salmon populations are not static but vary in abundance and distribution by river habitat and season.

- Redistribution of juvenile chinook from areas of emergence (tributaries) to more favorable habitat at the mouths of tributaries and sloughs begins as the fish reach a mobile state.

- Tributary mouths appear to provide important milling and rearing areas for juveniles during summer months.

- During late fall, lowered flow conditions develop in the tributary systems and juveniles move into the mainstem and slough habitats to overwinter.

- The majority of juvenile chinook spend one winter in fresh water before migrating to the sea. Out-migration in the reach from Talkeetna to Devil Canyon peaks prior to early June and terminates by the end of July throughout the drainage.

- Sockeye

The escapement, migrational timing, and population estimates of adult sockeye moving up the Susitna River to spawning grounds were measured in 1981 and 1982 by side-scan sonar, fishwheel catches, and tag/recapture studies. Five escapement monitoring stations were established in early June 1981 at locations identified in Figure E.3.4. Operating dates, equipment used and methodology are described in detail in ADF&G 1981b. Sonar counts and tag/-recapture population estimates (Tables E.3.4 and E.3.7) for sockeye salmon are discussed below.

At Susitna Station, the sockeye salmon migration extended from June 29 to August 24, with the midpoint of the run occurring on July 17. A total of 340,000 individuals were counted by side-scan sonar counters. From July 11 to July 23, 75 percent of the escapement passed Susitna Station. Fishwheel catch per hour indicated that the peak migration occurred between July 10 and 19.

A total of 139,000 sockeye were counted by sonar at the Yentna Station. The migration began on July 1, the midpoint occurred on July 16 and the run ended by August 3. Between July 12 and 23, 75 percent of the total fish escapement had passed Yentna Station. Fishwheel catches indicated that the migration peak was between July 13 and 15.

Sonar counts at Sunshine Station totaled 89,900. The migration began on approximately July 16, reached a midpoint on July 23, and ended on August 20. Between July 19 and 28, 75 percent of the sockeye migrated past this location. Based upon fishwheel catch records, the peak of the migration occurred between July 18 and 23.

At Talkeetna Station, 3,500 sockeye were counted. The migration commenced on July 23 and was completed by August 8. The midpoint occurred on July 31. A majority of the total count was made between July 23 and August 6. It appeared from fishwheel catch data that the migration peak occurred between July 27 and August 1.

The Curry Station fishwheel caught 470 sockeye. Results indicate that the migration commenced on July 18, reached a midpoint on August 5, and was not over until September 29.

From the sonar data, the migration chronology of sockeye salmon indicates that those fish passing Susitna Station enroute to the Yentna River made the 6.2 mile trip in one day or less. Individuals migrating past Susitna Station toward Sunshine Station covered this distance in an average of 8 days (6.8 miles) and reached Talkeetna Station in an average time of 13 days (4.6 miles). Tag/recapture data indicated that the minimum travel time between Sunshine and Talkeetna Stations and Curry Station was approximately five days or a travel speed of approximately 3.5 miles/day.

Population estimates were calculated based upon tagging operations. Sockeye estimates indicated that approximately 133,000 sockeye migrated past Sunshine, 4,800 passed Talkeetna, and 2,800 passed Curry Station in 1981, in 1982 152,000, 3,100, and 1,300 passed the same stations respectively (Table E.3.4). The 95 percent confidence limits on the 1981 estimates and components used to calculate them are discussed in ADF&G (1981b). There are discrepancies between population estimates from sonar counts and estimates from tag and recapture studies (Tables E.3.4 and E.3.7). These discrepancies reflect limitations inherent in both techniques (ADF&G 1981b), which nonetheless represent the state-of-the-art for estimating population sizes in glacial river systems.

Sockeye salmon age composition analyses indicate that a majority of the fish sampled at each station were age 5_2, (i.e. five years old with two years in fresh water). The second most abundant age group was 4_2 followed by age 6_2. Five-year old fish comprised approximately 86 percent of the return at Susitna Station and Yentna Station, 73 percent at Sunshine and Talkeetna Station, and 70 percent at Curry Station. Further age composition data are given by ADF&G (1981a).

Surveys of sockeye spawning areas were conducted in the mainstem Susitna River between Cook Inlet and Devil Canyon from late July through September using drift gill nets, electroshocking equipment and egg deposition pumps. Susitna River tributary streams and sloughs between the Talkeetna River confluence and Devil Canyon were surveyed on foot for spawning salmon from late July through September. Detailed methodology is given in ADF&G (1981b). No mainstem spawning was observed for sockeye salmon; sockeye spawning areas were documented in several sloughs and one tributary. In the Talkeetna to Devil Canyon reach, adult sockeye were observed in Sloughs 3B, 3A, 6A, 8A, 9A, 9B, 11, 17, 19, 10 20 and 21 and in lower McKenzie Creek (Figures E.3.5 - E.3.8). Peak spawning occurred during the last week of August and the first three weeks of September. Of the locations listed, sockeye were most numerous in Sloughs 8A, 9B and 11, where peak spawning ground counts were 177, 81 and 893, respectively.

Although a limited number of juvenile sockeye salmon were captured during ADF&G 1980-81 investigations, the techniques utilized did not result in the data necessary to determine early life histories and freshwater rearing of the species in the Susitna River (ADF&G 1981d). Sockeye salmon are normally found in river system with lakes which provide nursey areas for juveniles. The Susitna River does not contain lake habitat usually associated with sockeye salmon. Results of smolt trapping during Spring 1982 will lead to an increased understanding of the life history phases of Susitna River sockeye.

Based upon information from other sockeye producing spawning areas, mature females typically produce from 2,500 to 5,300 eggs (Morrow 1980). Hatching normally occurs during the period January-March. Fry remain in the gravel for several weeks and then emerge during the period April through June. Fry move into lakes or other rearing areas after emerging from the gravel. After spending 1 to 3 years in fresh water, the fish migrate in schools to feeding grounds in the Pacific Ocean (Morrow 1980).

- Coho

The escapement, migrational timing and population estimates of adult coho salmon migrating up the Susitna River to spawning grounds were determined (ADF&G 1981b). The results of apportioned side-scan sonar counts and tag/-recapture estimates are shown in Tables E.3.4 and E.3.7 and discussed below.

The peak of the coho salmon migration into the Susitna River drainage occurs in mid-July and early August, but can extend from late June into September. Side-scan sonar counts and migration periods for each sampling station are summarized below.

- A total of 33,500 coho salmon were enumerated by the sonar counters at Susitna Sation. The migration began, reached a midpoint and ended on July 20, July 28 and August 25, respectively. Approximately 75 percent of the fish passed this station between July 23 and August 16. Fishwheel catches indicated a migration peak occurring between July 25 and July 30.

- At the Yentna Station, 17,000 coho were enumerated by the sonar counters. The migration began on July 22, reached a midpoint on July 31 and ended on August 20. The major portion of the run passed this location between July 23 and August 16. The peak of migration occurred between July 23 and August 6.

- The count at Sunshine Station was 22,800 coho salmon. The beginning of the migrational period was July 29, the midpoint was reached on August 18 and the run ended on September 5. Between August 4 and August 24, 75 percent of the migration run occurred. The peak migration period was between August 18 and August 25.

- At Talkeenta, 3,500 coho were enumerated by sonar counters. The beginning of the migration was July 30, August 24 was the midpoint, and September 11 was the termination. The majority of coho were counted between August 11 and September 1. The migrational peak period occurred between August 19 and August 30.

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

The average travel time for coho salmon migrating between Susitna Station and Yentna Station was two days, a travel rate of approximately 3.1 miles/day. An average of fourteen days was required to reach Sunshine from Susitna Station. Total travel time from Susitna Station to Talkeetna Station was approximately 24 days. These travel times can be equated to a migration rate of 3.9 miles/day to Sunshine Station from Susitna Station and 3.1 miles/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 fifteen days with an average travel time of 4.5 days. This was a migrational rate of approximately 3.7 miles/day.

Population estimates derived from tagging and recapture operations indicated that approximately 19,000 coho salmon migrated past Sunshine Station, 3,300 past Talkeetna Station and 1,100 past Curry Station in 1981, while 45,800, 5,100 and 2,500 passed the same stations in 1982 (Table E.3.4). The majority of individuals sampled for age analyses in 1981 were 4_2, from the 1977 brood year, followed by age 3_2, for the 1978 brood year. Less than 10 percent of the 1981 coho escapement consisted of other age groups.

Surveys of spawning areas were conducted in the mainstem, sloughs, and tributaries of the Susitna River (ADF&G 1981b). Of twelve mainstem spawning sites identified, coho salmon were the only species observed at one site and coho and chum salmon shared spawning sites in two mainstem areas. Coho salmon were not observed spawning in any of the sloughs surveyed but were observed in Whiskers Creek, Chase Creek, Lane Creek, Gash Creek, Lower McKenzie Creek, Fourth of July Creek, Indian River and Portage Creek. The highest densities, based upon peak index counts, were in Whiskers Creek, Chase Creek, Gash Creek and Indian River, where 70, 80, 141 and 85 coho, 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.

Based upon general information on coho salmon life history in Alaska (Hartman 1971), each female deposits an average of 3,500 eggs, which incubate in the gravel through winter. Upon emergence in March and April, fry generally occupy areas with adequate cover, low water velocities and moderate water temperature for optimum growth (Gray et. al. 1978; Delaney and Wadman 1979; Watsjold and Engel 1978). Drifting aquatic insect larvae are the major diet items of juvenile coho salmon in spring; adult stages of these insects are major feed items during summer and fall (ADF&G 1978). Juvenile pink, chum and sockeye salmon can also be an important supplemental food source to age 1 or older coho salmon (Roos 1960; Scott and Crossman 1973).

The geographical and seasonal distribution, relative abundance, age composition and smolt migration timing of coho salmon reared in the Susitna drainage is summarized below based on studies by ADF&G (1981d).

Juvenile coho salmon were captured throughout the study area between Alexander Creek (RM. 10.1) and Slough 21 (RM 141.8) at 55 out of 99 sample sites from November 1980 to October 1981. Collection techniques and data summaries for juvenile collections are detailed in ADF&G (1981d).

During the winter and spring (November-May), juvenile coho salmon frequently occurred (measured by percent incidence) at tributary mouth sites between Cook Inlet and Talkeetna, and at a mainstem and slough sites between Talkeetna and Devil Canyon (Table E.3.8). A total of 337 juvenile coho salmon were collected from Cook Inlet to Devil Canyon. The maximum catch rate for juvenile coho salmon was 8.0 fish per trap at Slough 6A in March. Length frequency and scale analysis indicated that two age groups, brood years 1978 (2+) and 1979 (1+) were captured between Cook Inlet and Devil Canyon.

During June-September 1981, juvenile coho salmon occurred most frequently at tributary mouths in the Cook Inlet to Talkeetna reach (Table E.3.9). A total of 3,605 juvenile coho salmon (combined age groups 0+ and 1+) were captured between Cook Inlet and Talkeetna. During the same summer sampling period (June through September 1981), a total of 1,216 juvenile coho salmon were captured between Talkeetna and Devil Canyon. (Table E.3.8). Occurrence of age 0+ (1980 brood year) was consistently higher at tributary mouth locations than at mainstem or slough locations throughout the summer. The frequency of occurrence in tributary mouths increased during the summer. This indicates that age 0 coho were moving out of the tributaries during late summer. Maximum catch rate for juvenile coho salmon recorded during summer was 41.0 fish per trap at Caswell Creek (RM 63.0) in late August.

Three age groups of juvenile coho salmon were collected at various habitat locations in the Cook Inlet to Devil Canyon reaches of the lower Susitna River from November 1980 to October 1981. These fish represented brood years 1978 (2+), 1979 (1+) and 1980 (0+). Distribution of 0+ fish progressively increased from June when they were first captured through September. The incidence of 1+ coho salmon in catches of all habitat locations between Talkeetna and Devil Canyon also increased from late July to September. Between Cook Inlet and Talkeetna, a similar pattern was observed. Catch rates then decreased in late September for 0+ and 1+ throughout the lower Susitna (Cook Inlet to Devil Canyon) (ADF&G 1981d).

Age 2+ individuals were captured during the winter sampling period, November 1980 to May 1981, but were not captured after May in the Talkeetna to Devil Canyon reach and after mid-June in the Cook Inlet to Talkeetna reach. This finding indicates that the predominate age group for smolts in the Susitna River is age 2+ and that in the Talkeetna to Devil Canyon reach the majority of smolting took place prior to 1 June 1981 and between Cook Inlet to Talkeetna by June 15.

- Chum

The escapement, migrational timing, and population estimates of adult chum salmon migrating up the Susitna River to spawning grounds were measured by side-scan sonar and fishwheel catches in combination with tag-recapture estimates. Apportioned sonar counts and fishwheel catches show that the chum salmon migration began during the second week in July and ended during early September. The peak migration period in the Susitna River upstream of Talkeetna was from late July until late August. Side-scan sonar counts and population estimates based on tag/recapture data are summarized in Tables E.3.4 and E.3.7. Migration periods for each sampling station are summarized below.

- A total of 46,500 chums were counted at Susitna Station by the sonar counters. The migration began at Susitna Station on July 10, reached a midpoint on July 27 and ended on August 25. Between July 15 and August 6, 75 percent of the escapement occurred. Fishwheel catches indicated that the migration peak occurred between August August 3 and 7.

- The Yentna Station enumerated 19,800 individuals. The migration run began at Yentna Station on July 13, reached its midpoint on July 29 and ended on August 24. A 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 July 20 and 23.

- Counts at the Sunshine Station totaled 59,600 chums. The migration at this location commenced on 22 July, reached a midpoint on August 6 and ended on approximately September 6. Seventy-five percent of the fish were counted between July 27 and August 24. The peak of chum migration at Sunshine Station, as indicated by fishwheel catches, occurred between August 17 and 19.

- A total of 10,000 chum salmon were counted at Talkeetna Station. The beginning of the migration was approximately July 28, the midpoint was reached on August 8 and the migration ended on August 29.

- Fishwheel catches at Curry Station indicated that the chum migration began around July 29. The midpoint of the run was August and the migration terminated on September 2.

Chum salmon averaged four days travel time between Susitna Station and Yentna Station, which corresponds to a travel rate of 1.6 miles/day. Average travel time between Susitna Station and Sunshine Station was 10 days, which is a travel rate of 5.6 miles/day. The migration period between Susitna Station and Talkeetna Station averaged 14 days or approximately 5.6 miles/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 1 to 24 days with an average travel time of approximately 4.5 days and a travel rate of approximately 3.7 miles/day.

Population estimates derived from tag and recapture data indicated that approximately 263,000 salmon migrated passed Sunshine, 20,400 past Talkeetna Station and 13,000 passed Curry Station in 1981, while 431,000, 49,200 and 29,500 passed the same stations in 1982. At each sampling site, age 4 chum salmon from the 1977 brood year dominated the catch in 1981, comprising, on the average, 86 percent of the sample. Second in abundance were age 5 fish followed by age 3 individuals.

Spawning surveys conducted in the mainstem of the Susitna River from Cook Inlet to Devil Canyon during 1981 revealed that 10 of 12 mainstem spawning locations identified were occupied by chum salmon. Spawning surveys conducted in sloughs and tributaries between Talkeetna and Devil Canyon also documented the presence of chum salmon in Sloughs 1, 2, 6A, 8 8B, Moose, A1, A, 8A, 9, 9A, 9B, 11, 13, 15, 17, 19, 20, 21 and 21A (Figures E.3.5 and E.3.8). 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 in streams than observed in slough spawning areas. The highest peak count in an index area was registered in Fourth of July Creek, where 90 chums were counted on August 7.

Based on general information from other chum salmon-producing areas in Alaska, females produce an average of 3,000 eggs (Harman 1971). Limited sampling of pre-emergent chum fry conducted April 11 in the area of Gold Creek revealed that yolk sac absorption was 95-100 percent complete. Following emergence, usually during April or May, chum fry remain in the river for only a short period before out-migrating. Limited beach seine sampling resulted in the capture of 1,650 chum fry on June 19 in Slough 11. Although juvenile chum were captured during ADF&G 1981 investigations, the techniques utilized did not result in the data necessary to determine early life histories in the Susitna River (ADF&G 1981d). Because of this, the 1982 field program utilized smolt traps to obtain more accurate information on juvenile chum salmon. Specific timing of out-migration for the Susitna River system is being addressed in the analysis of 1982 data.

- <u>Pink</u>

Pink salmon have a 2-year life cycle that results in two genetically distinct stocks occurring in each stream. The stocks are called "odd-" or "even-year" on the basis of the year in which adults spawn. In the Susitna drainage, the even year runs are numerically dominant. The escapement migrational timing and population estimates of pink salmon migrating up the Susitna River to spawning grounds as measured by side-scan sonar and tag-recapture are shown in Tables E.3.4 and E.3.7. The adult migration for pink salmon in the Susitna River system began about 10 July and terminated during the third week in August. Side-scan sonar counts and migration periods for each sampling station are summarized below.

- Sonar counts at Susitna Station totaled 113,000 pinks. The migration period started around July 10, with the midpoint occurring on July 25. The migration at Susitna Station terminated on August 21. Seventy-five percent of the escapement passed this region between July 15 and July 29. Fishwheel catches indicated that the migration peak had occurred between July 21 and August 3.

- At the Yentna Station, 36,000 pink salmon were enumerated by the sonar counters. The migration reached this point on approximately July 14, midpoint was July 25 and the migration ended on August 20. Between July 21 and August 2, the majority of the pink salmon had passed this station. Fishwheel catches indicated that the migration peak lasted from July 21 to August 6.

- Individuals counted at the Sunshine Station sonar site totaled 72,900. The migration did not reach Sunshine Station until approximately July 23, two weeks later than Susitna Station. The midpoint date for the run was 1 August, with completion on August 20. Seventy-five percent of the migration was counted between July 28 and August 9. Fishwheel catches showed the migration peak to have occurred between July 29 and August 9.

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

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

Population estimates derived from tag and recapture data indicate that approximately 49,500 pink salmon passed Sunshine Station, 2,300 passed Talkeetna Station and 1,000 passed Curry Station in 1981, while 444,000, 73,100 and 59,000 passed the same stations in 1982.

The migrational rates based on plots of sonar and fishwheel catch data indicate that pink salmon took an average of three days to reach Yentna Station from Susitna Station, a distance of approximately 6.2 miles. This represents an average travel speed of approximately 1.9 miles/day. Between Susitna Station and Sunshine Station, the average travel time was 9 days with a travel rate of 6.2 miles/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 indicate that travel time between Sunshine and Talkeetna Station ranged from 2 to 30 days. Pink salmon averaged three days of travel time or 6.2 miles/day between Talkeetna and Curry Stations with a range of travel time between one and thirteen days.

Spawning surveys in the mainstem Susitna River did not reveal any spawning pink salmon. Spawning surveys in sloughs and side channels documented spawning pink salmon 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. 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 August 19 to August 28. The stream survey counts are index counts and do not reflect the total number of spawning fish present in the stream surveyed.

Based on general information from other pink salmon producing areas in Alaska, female pink salmon produce an average of about 2,000 eggs (Bailey 1969). Eggs hatch in midwinter about 3-5 months after they are spawned, but fry remain in the gravel until April or May. Spawning and time of fry emergence are related to temperature regimes of the streams (Bailey 1969). Pink salmon fry are about 1 inch long when they emerge and migrate directly to the sea. Limited information for the Susitna drainage indicates that sac fry of pink salmon appeared on March 23 in Slough 11 and Indian River and yolk sac absorption for pink fry was approximately 50 percent on April 11 (ADF&G 1981d).

(ii) Other Anadromous Species

- Bering Cisco

The Bering cisco is a coregonid that occurs from the Beaufort Sea to Cook Inlet. Although Bering cisco have been collected from upper Cook Inlet and the Knik Arm, the species was not known to inhabit the Susitna River drainage prior to 1980-1981 ADF&G studies. Interior and western Alaskan populations appear to be comprised of both anadromous and freshwater resident forms. Susitna River Bering cisco appear to be anadromous (ADF&G 1981e).

Bering cisco were collected in the lower Susitna River between RM 30.1 to RM 100.8 from August to October 1981. The catch rate gradually increased during this period until it peaked between September 17 and 21; after September 23 catches declined rapidly. Ninety-five percent of the fish collected were captured between RM 70.0 and RM 100.8. The fish were apparently undertaking their spawning migration up the Susitna River from Cook Inlet in August and arrived at Sunshine Station (RM 79) over a five-week period from August 25 to September 30.

Although spawning activity may occur throughout the reach between RM 30 and RM 100, surveys were able to identify only three spawning concentrations at RM 78-79, 76-77.5 and 74.3-74.8. Spawning substrates were composed primarily of 1 to 3 inch gravel. Peak spawning occurred during the second week of October. Susitna River Bering cisco appear to occupy their spawning grounds 15 to 20 days. After spawning, these fish probably rapidly migrate downstream to sea (ADF&G 1981e).

- Eulachon

The eulachon is an anadromous member of the smelt family that 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 close proximity to shore. In the northern portion of its range, eulachon do not spawn until May.

During 1982, the spawning migration appeared to be composed of two segments - an early run that started prior to May 16 and ended around May 31, and a late run that started about June 1 and ended around June 10 (Tables E.3.10 and E.3.11). The migration runs usually take place in larger rivers (such as the Susitna mainstem), but spawning grounds may be located in tributary systems. Eulachon are known to utilize the Susitna River system at least as far upstream as RM 48 (Trent 1982).

(iii) Resident Species

- Dolly Varden Char

Dolly Varden char are an important sport fish and are distributed throughout Alaska where the species occupy aquatic habitats ranging from coastal streams to lakes and streams located far inland. Dolly Varden occur in Alaska in both anadromous and freshwater resident forms. However, indications are that in the Susitna drainage, Dolly Varden are not anadromous. Dolly Varden reach sexual maturity at age 4 to age 7 and normally spawn in clear water streams during the fall.

Only two Dolly Varden were taken in the Cook Inlet to Devil Canyon reaches from November through May 1981. From June through September 1981, the occurrence of Dolly Varden increased Catches of Dolly Varden peaked in June and late September; largest catches per unit effort were recorded at the mouths of tributary streams. Higher catches during late June and July coincided with peak migration periods of pink, chum and sockeye salmon; higher catches during September can be attributed to Dolly Varden moving into their spawning areas within clear water tributaries and the beginning of out- migration into their wintering habitat. Sexually mature fish were found in September and October and Dolly Varden displaying spawning behavior were observed on October 2 in Upper Indian River (ADF&G 1981e).

- <u>Rainbow Trout</u>

Rainbow trout are one of the most valued sport fishes in North America. Susitna River sport harvest and effort levels have steadily increased over the past five years. The general life history is discussed by Morrow (1980) and Scott and Crossman (1975).

Low numbers of rainbow trout were collected throughout winter months (November-May 1981) from RM 10 to RM 133 at seven tributary and four mainstem locations. During summer (June-September 1981), rainbow trout were captured from RM 10 to RM 148 near Portage Creek but not in the impoundment reach. Portage Creek represents one of the northernmost boundaries of the native range for rainbow trout in North America. The most consistent catches were associated with tributary mouths and sloughs between Talkeetna and Devil Canyon. Age groups 2, 4, and 5 made up a majority of the fish collected (ADF&G 1981e).

Catches peaked in late June between Talkeetna and Devil Canyon and again during the first two weeks of September throughout the drainage. The June peak was probably due to the presence and movements of spawning fish, while the high in September probably reflected movement downstream into winter habitat (ADF&G 1981e).

- <u>Arctic Grayling</u>

The Arctic grayling is also one of the most important sport fishes of Alaska and Northern Canada and contributes substantially to the sport fishery of the Susitna River and its tributaries. Grayling are generally residents of clear, cold streams and lakes (Scott and Crossman 1973).

Silt-laden glacial systems, such as the Susitna River, are believed to support relatively few grayling; however, such systems man provide essential migratory channels and overwintering habitat (ADF&G 1981e). The Arctic grayling is characterized by Reed (1964) as a migratory species. During spring breakup, from April to June, adults migrate from ice-covered lakes and large rivers into clear, gravel-bottomed tributaries to spawn (Morrow 1980). In Alaska, Arctic grayling reach sexual maturity at age 2 to 7 years and are capable of spawning several times during their lifetime. After spawning, the adults move from the spawning areas to spend the rest of the summer feeding on aquatic and terrestrial insects taken from the aquatic drift (Vascotto 1970). A downstream migration back to overwintering areas in large rivers and deep lakes occurs in late August to mid-September (Pearse 1974).

During 1980-81 ADF&G studies, grayling were captured between Alexander Creek (RM 10.1) and the upper reaches of the impoundment area. Catches were low throughout winter months, but increased sharply in May, both below and above the impoundment area. Below the impoundment area, catches increased during the period May 1-15 and then declined at all habitat locations throughout the summer until catches again increase at tributary mouths in September. Within the impoundment area, catches were highest in June and July in upper stream reaches and declined towards the end of summer and early fall (Table E.3.12).

Changes in distribution and catch of grayling appeared to be associated with migrational movements to spawning grounds and overwintering areas that may have been initiated in response to surface water temperature (ADF&G 1981e). Below the impoundment area, high catches in May could be associated with migration from the mainstem Susitna into nonglacial tributary spawning grounds. High catches in September are probably associated with migrational movements back to overwintering areas in the mainstem Susitna.

Within the impoundment area in May and June, grayling appeared to move upstream into pool-type habitat in tributaries where they had spawned. The movement may be associated with increasing water temperatures (ADF&G 1982a). As surface water temperatures began to decrease in late summer and early fall, lower numbers of fish were observed in these upper stream reaches and tagged fish were observed migrating downstream. Small-scale distribution patterns and abundance within upper stream reaches appeared to be determined primarily by streamflow and channel morphology. Preferred grayling habitat appeared to be characterized by high pool/riffle ratios, large deep pools and moderate velocities (ADF&G 1982a).

Additional distribution patterns in the impoundment reach were documented by tagging and releasing 2,511 grayling during 1981 (ADF&G 1981f). Many tributary fish appeared to move into the Susitna mainstem for overwintering. Analysis indicates that there is a wide range of intertributary migration as well as movement within individual tributaries. There were also indications that:

- The proposed impoundment area is occupied by grayling that make use of other tributaries in regions that will not be inundated; and

- Overwintering areas are available outside the proposed impoundment zone.

Grayling population estimates were made only for the impoundment reach. The estimate was 10,300 grayling over 6 inches long (95 percent confidence level) with a range of 9,200 to 11,700. This estimate would indicate an average of approximately 500 adult graying per clear water tributary mile or 120 per river mile including the mainstem Susitna in the area to be inundated, assuming an even distribution. Population estimates for individual tributaries are given in Table E.3.13.

There was no evidence of spawning at any sampling locations between Cook Inlet and Devil Canyon or in the impoundment reach during 1981. However, it is speculated that adult grayling from the mainstem Susitna below Devil Canyon migrate into nonglacial tributaries to spawn some time in late April or May. In the impoundment reach, it is thought that spawning occurs from late April through early May under ice or during mid-May spring floods in the lower reaches of all eight tributary samples. Suitable spawning habitat, i.e., proper spawning gravel in pool regions, was observed in each stream (ADF&G 1982a). Assuming other conditions for spawning are favorable, it is not considered likely that spawning habitat is a limiting factor for grayling.

\- Lake Trout

Lake trout were collected only in Sally Lake and Deadman Lake located upstream from Devil Canyon. Both lakes support a limited sport fishery. Of the two lakes, only Sally Lake will be inundated by the proposed Watana impoundment. All lake trout were captured within 128 ft of the shoreline in less than 5.9 ft of water. A total of 35 lake trout were captured, 32 in Sally Lake and 3 in Deadman Lake. All Deadman Lake fish were captured by hook and line, while gill nets produced the greatest results in Sally Lake. Age group 5 dominated the collections. During mid-August, both pre- and post-spawning lake trout were captured in Sally Lake.

- Burbot

In Alaska, burbot are distributed in the Susitna and Copper rivers, Bristol Bay drainages, throughout the interior and in the arctic (McLean and Delaney 1978). Burbot mature between age 3 and 6 in Alaska and may live a total of 15-20 years. Spawning generally occurs between mid-December and April in shallow water over a substrate of sand or gravel. Movements and migration of burbot are not well documented. Burbot support a limited sport fishery in the Susitna.

During winter (November, 1980 through May, 1981) burbot were captured throughout the reach between Cook Inlet to Devil Canyon. The highest catch rates were recorded downstream of Talkeetna particularly at the mouth of the Kroto Creek and Alexander Creek as well as four mainstem sites upstream of Talkeetna.

During summer, distribution of burbot and catch rates between Cook Inlet and Talkeetna and in the impoundment reach increased as summer progressed with maximum in September. In the Talkeetna to Devil Canyon reach, distribution declined from early June until mid-July, then increased along with catch rates thoughout the remainder of summer. In the Talkeetna to Devil Canyon reach, burbot catches during low flows were restricted to the mainstem, deeper sloughs and side channels. During high flows, burbot were captured at a greater number of locations including shallow side channels, sloughs and tributary mouths (ADF&G 1981e).

Age groups 4, 5 and 6 made up the majority of burbot caught in the impoundment zone and age groups 4, 5 and 8 made up the majority of burbot caught between Cook Inlet and Devil Canyon. Population estimates were not made in any of the reaches (ADF&G 1981e, 1981f).

Although no observations of spawning burbot were made during the 1980-81 season, collection of female burbot in early September with well developed eggs and collection of spent burbot from November to May suggested that lower Susitna River burbot may spawn between December and January. Both sexually ripe and unripe mature burbot observed from June through September indicate that nonconsecutive spawning occurs for Susitna River burbot. Location of spawning and rearing areas in the Susitna were not documented, although juvenile burbot were captured at the Alexander and Kroto creeks (ADF&G 1981e).

- Round Whitefish

Round whitefish are distributed across all of arctic and interior Alaska. They are normally abundant in clear water streams with gravel-cobble substrate but can be found in large glacial rivers and lakes. Whitefish mature at age 4-7 and spawning occurs in late September through October over gravel substrate in the shallows of rivers and inshore areas of lakes (Morrow 1980). Upstream migrations are often associated with spawning.

Round whitefish were captured at only four locations (all below Talkeetna) during 1980-1981 winter studies. The fish were all captured as they moved upstream during March and May. The presence of whitefish near the mouths of tributary streams in March and May after none had been caught in the same locations between November-February, indicates a general pattern of movement into the various tributaries in the spring (ADF&G 1981e).

During summer, the incidence of fish in catches between Cook Inlet to Devil Canyon was higher and peaked in June and September. The most productive sites were Anderson Creek, Slough 10 and 11 and Portage Creek mouth. Most prevalent age groups were age 3, 4, and 5 (ADF&G 1981e). During summer, round whitefish were also captured in the impoundment reach with the percentage of incidence dropped July to September. Jay and Kosina Creeks were the most productive areas for round whitefish in the impoundment reach. Age group 7 was encountered most frequently (ADF&G 1981f).

- Humpback Whitefish

In Alaska, there are three closely related species of whitefish in the genus *Coregonus*: the humpback whitefish, Alaska whitefish and the lake whitefish. Because of similar appearance and overlapping distributions, the data collected on the three species has been reported under the general heading of humpback whitefish.

Alaska whitefish are largely stream inhabitants and undertake lengthy up- and downstream migrations to and from spawning grounds. Spawning occurs in September-October. Lake whitefish occur primarily in lakes but spawn only in rivers or creeks. Spawning occurs between October and December. Humpback whitefish is apparently the only species of whitefish that can be considered anadromous although migration habits vary widely in different systems. Spawning migrations generally begin in June with spawning in October-November (Morrow 1980).

During winter, a single humpback whitefish was captured below the mouth of Montana Creek. During summer, peak catches were made in early June and late September (ADF&G 1981e). Largest catches per unit effort were recorded at the mouth of Anderson Creek, the mouth of Portage Creek, and a slough at RM 23.8. Generally humpback whitefish were most abundant in the Cook Inlet to Talkeetna reach. Fish collected ranged from ages 2 to 7; age 4 was the predominant age group (ADF&G 1982e).

No evidence of humpback whitefish spawning was collected at any sampling location betweek Cook Inlet and Devil Canyon in 1981. Inspections of dissected fish caught from mid-September to early October showed well developed gonads but fish were not ready to spawn. Because no whitefish were caught or observed after 7 October, it was speculated that spawning must occur sometime after this date (ADF&G 1981e).

- Longnose Sucker

The longnose sucker, the only representative of the sucker family found in Alaska, is ubiquitous and occurs in most of the mainland drainages. Spawning usually occurs in spring after ice out. Spawning runs (i.e., movement from lakes into inlet streams or from deep pools into shallower gravel-bottomed stream areas) are initiated when water temperatures exceed 5°C. The longnose sucker feeds almost exclusively on benthic invertebrates but will occasionally ingest live or dead fish eggs (Scott and Crossman 1973).

Longnose suckers were collected throughout the study area from Cook Inlet to the upper reaches of the proposed impoundment area. No specimens were collected during winter sampling. During summer, adult suckers were captured in the impoundment zone from May-September, generally near the confluence of the tributary streams (ADF&G 1981f). During the same period, the percentage of habitat locations where fish were collected was relatively high in June from Cook Inlet to Devil Canyon with lower catches recorded during July and August. The percentage increased again during September from Cook Inlet to Talkeetna but not between Talkeetna and Devil Canyon. Anderson Creek, Kroto Creek, Sunshine Creek and mainstem Susitna River (RM 40.6) were the most productive locations. The most prevalent ages were 4, 5 and 6. Juveniles were consistently captured below Curry Station. Their distribution shifted downstream as the season progressed (ADF&G 1981e).

- Threespine Stickleback

Threespine stickleback generally inhabit shallow areas in bays, estuaries and in rivers not more than a hundred miles upstream from the coast. Wintering areas tend to be in deeper waters. Stickleback feed mainly on small crustaceans and insects.

Threespine stickleback were collected in the Cook Inlet to Devil Canyon reach of the Susitna River from Alexander Creek to the mainstem Susitna Island site. Catches per unit effort 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 and declined steadily to September. The higher percentage in early summer indicated that fish had been involved in spring spawning movement. This activity was not observed in September (ADF&G 1982a).

- Cottids

All sculpin species captured in the Susitna River have been grouped under the general heading of cottids. The slimy sculpin is the most common cottid found in the Susitna, although there is a possibility that three other species may be present below the impoundment area.

Between November 1980 and October 1981, cottids were captured throughout the Cook Inlet to Devil Canyon reach of the Susitna River (ADF&G 1981e). The catch rate in the impoundment area from May to September was 0.11/trap day (ADF&G 1981f). The percentage of sampling locations producing catches in the Cook Inlet to Talkeetna portion of the reach, reached a high in late August and a low in late July. For the Talkeetna to Devil Canyon reach, there was a high in early July and a low in late September. Habitats associated with clear water tributaries consistently produced the highest catches throughout the study area from Cook Inlet to above the proposed impoundment zone (ADF&G 1981e, 1981f).

- Lamprey

The Arctic lamprey, one of four lamprey species that occurs in Alaska, was observed in the Susitna River during 1981 (ADF&G 1981e). The Pacific lamprey, an anadromous species that has been reported to range into the Lower Susitna River (Morrow 1980) was not observed during 1981 investigations.

Some populations of Arctic lamprey are composed of both anadromous and freshwater forms. It was speculated that a portion (30 percent) of the Susitna population is anadromous based on analysis of length frequencies (ADF&G 1981e). The anadromous form is parasitic; hosts include adult salmon, trout, whitefish, ciscoes, suckers, burbot and threespine stickleback (Heard 1966). The freshwater forms have been reported to be both parasitic and non-parasitic.

Arctic lamprey spawn during the spring in streams of low to moderate flow. Eggs develop into a larval stage, which spend one to four years burrowed into soft substance. After an indefinite period, adults migrate upstream to spawn.

Arctic lamprey were captured at 14 sampling sites between RM 10 and RM 101 that were surveyed from November 1980 through September 1981. During the winter surveys, the only habitat site to produce Arctic lamprey was Rustic Wilderness, where one lamprey was captured. All other lamprey were collected during the summer months. Lamprey were not collected in the impoundment area (ADF&G 1981e).

The highest catch frequency was recorded during the September 1 to 15 sampling period. All lamprey taken were collected at tributary sites downstream of RM 50.5. The lowest incidence of capture for this species during the summer was observed in the July 16-31 sampling period (ADF&G 1981e).

(b) Habitat Utilization

The physical conditions associated with the free-flowing characteristics of the Susitna River provide essential aquatic habitat for fishery resources. Alteration of this physical environment would ultimately affect associated fish populations. The complexity of the aquatic habitat and physical interactions that exist is compounded by the effects of seasonal and yearly fluctuations in physical habitat components.

Most of the baseline description for Susitna River aquatic habitat presented below is based on reports of habitat evaluation studies conducted by ADF&G during the 1980-81 winter and 1981 summer field seasons (ADF&G 1981c, 1982a) and by results of continuing studies in the 1981-82 season. These studies have attempted to identify seasonal habitat characteristics of selected anadromous and resident species within the study area.

Species occurrence, relative abundance, and the significance of aquatic habitat to species and important life history stages is discussed below for each of the three defined study reaches.

The gradation of habitat types available in the Susitna River were grouped into four classes: mainstem, side channel, slough and tributary mouth. Each of these habitat types encompass a range of physical attributes rather than a set of fixed characteristics.

- Mainstem habitat consists of that portion of the Susitna River that conveys streamflow at all times. Both single and multiple channel reaches are included in this category. The physical characteristics of mainstem habitat in the Susitna River reflect the integration of the streamflow, sediment, and thermal regimes of the upstream basin with the topography and geology of a particular river segment. Groundwater and tributary inflow are generally inconsequential contributors to streamflow within a river segment. Total sediment load and suspended sediment concentrations are primarily dependent upon glacial melt. Stream temperature responds primarily to metrological conditions and directly influence intergravel water temperatures (Trihey 1982).

- Side-channel habitat consists of those portions of the Susitna River that normally convey streamflow during the open-water season but which become appreciably dewatered during periods of low flow. In general, shallower depths, lower velocities and smaller streambed materials occur in side-channels than occur in the mainstem. However, the streamflow, sediment and thermal regimes of side-channel habitats respond directly to mainstem conditions. Tributary and groundwater inflow may prevent side-channel habitats from becoming completely dewatered as mainstem flows receed; however, the presence of these inflows is not considered a necessary component in order for side-channel habitat to exist (Trihey 1982).

- Sloughs are spring-fed perched overflow channels which convey glacial meltwater from the mainstem during moderate and high flow periods. At intermediate and low flow periods, the sloughs convey clear water from local runoff, tributary inflow and groundwater. Sloughs are generally found on the downsream side of old, well-vegetated point bars. The streambed elevation in a slough is notably higher at the upstream entrance than at the mouth, sloughs function like small stream systems. Several hundred feet of channel exist in each slough which convey water without the influence of the mainstem backwater (Trihey 1982).

  The physical characteristics of the slough habitat appears to depend upon the interaction of four principal factors: the discharge of the mainstem Susitna River, surface runoff patterns from the adjacent catchment area, local groundwater flow contributions, and ice processes within the river system. These four principle factors interact to varying degrees during different portions of the year to provide a unique habitat type along the margins of the Susitna River (Trihey 1982).

The amount of streamflow in the mainstem of the Susitna River influences habitat conditions in the sloughs in two ways: 1) causes a backwater effect at the mouth of the slough which facilitates access into the slough and 2) flushes debris and fine sediments from the slough. Local surface runoff contributes a greater portion of the clear water flow to the slough than the groundwater upwelling during the ice-free period of the year. During winter months, groundwater provides nearly all of the flow which exists in the sloughs. Even flow that enters the slough from a tributary originated in the tributary as groundwater. The groundwater upwelling in the sloughs, maintains an open-water conditions (Trihey 1982).

Ice processes in the mainstem river are also very important in maintaining the character of the slough habitat. Besides flushing debris and beaver dams from the sloughs which could be potential barriers to upstream migrants during periods of low flow, mainstem river ice processes are also considered important for maintaining groundwater upwelling in the sloughs (Trihey 1982).

- Tributary habitat consists of the full complement of habitats which occur in the smaller tributary streams of the Susitna River. The streamflow, sediment, and thermal regimes reflect the integration of the hydrology, geology and climatology of the tributary drainage. Therefore, physical characteristics of tributary habitat are not dependent on mainstem conditions which exist at the tributary mouth. The stage of the mainstem river causes a backwater effect which extends into the tributary and the tributary flow creates a clear water plume in the mainstem. This interaction provides another type of habitat (tributary mouth) which is considered a subset of tributary habitat (Trihey 1982).

(i) Impoundment Zone

The impoundment reach of the Susitna River from Devil Canyon to the Oshetna River flows through a steeply cut, degrading channel. From the Devil Canyon damsite upstream to Fog Creek, the river forms one channel, which lies in a deep valley with an average gradient of 20 ft/mile. From Fog Creek to the Oshetna River, the river is wider and often splits into two or more channels with an average gradient of approximately 12 ft/mile. Substrates throughout the impoundment reach and mouths of tributaries generally consist of rubble, cobble and boulders, often embedded in sand; gravels are present in some locations (ADF&G 1981c).

Because of the inaccessibility of the Devil Canyon area and the apparent lack of suitable fisheries habitat, the study area was limited to that section of the Susitna River from Fog Creek to the Oshetna River (ADF&G 1981c). Based upon a preliminary reconnaissance of the upper Susitna River basis (ADF&G 1977), eight major tributaries were selected for fisheries studies: Fog and Tsusena creeks in the vicinity of the proposed Devil Canyon impoundment; and Deadman, Watana, Kosina, Jay and Goose Creeks and Oshetna River in the proposed Watana impoundment. For the purpose of this study, the first 1.0 mile of these streams from their confluence with the Susitna River were sampled. To assess mainstem utilization, sampling was conducted in an area 300 ft up and downstream of a tributaries confluence with the Susitna.

Overall trends for physiochemical parameters measured in this mainstem reach during May to September (ADF&G 1982a) included:

- Well-oxygenated water (9.0-14.1 mg/l);
- pH values near seven or slightly higher (6.8-7.9);
- Moderate conductivity values (44-248 umhos/cm);
- Water surface temperatures in the range of 1.5-12.6°C; and
- Low turbidity levels in the tributaries (0.3 to 19 NTU) compared to the mainstem (10 to 175 NTU).

- Mainstem Habitat Near the Confluence of Major Tributaries

  - Species Occurrence and Relative Abundance

    Although adult chinook salmon were documented to RM 158.2 in 1982, no other anadromous species were reported in the mainstem Susitna in the impoundment reach (Trent 1982). This supports the current opinion (ADF&G 1982a) that hydraulic characteristics of the Susitna River at Devil Canyon may act as a barrier to upstream salmon movement.

    Occurrence of resident species in the mainstem is limited to six species: Artic grayling, longnose sucker, humpback whitefish, round whitefish, Dolly Varden and burbot. The longnose sucker, round whitefish and burbot were almost exclusively captured in the mainstem near the mouths of the tributaries. Based on tagging studies, the Arctic grayling occupied mainstem locations primarily during winter.

  - Significance of Habitat

    The mainstem Susitna River in the impoundment reach appears to provide primary overwintering habitat and essential migration routes between tributaries for Arctic grayling (ADF&G 1981f).

Burbot appear to use the mainstem immediately up or downsteam of tributaries as year-round habitat. All burbot catches in the impoundment area were made in the mainstem between May and September (ADF&G 1981f). It is unlikely that tributaries would be utilized during winter months because of ice conditions.

Round whitefish and longnose suckers also appeared to use the mainstem near tributary confluences as year-round habitat. No spawning or rearing areas were identified (ADF&G 1981f).

- Tributaries

  - Species Occurrence and Relative Abundance

    At least two resident species, Arctic grayling and cottids, occur in tributaries. Other species captured near the mouths of tributaries are discussed above under Section (i). These species are expected to occur in tributaries.

    Relative abundance estimates for grayling indicate that approximately 500 grayling greater than 6 inches per clear water tributary mile are present with a population estimate of 9,200 to 11,700 total for the impoundment zone. Total catch of cottids was 38 in 352 trap days.

  - Significance of Habitat

    Tributaries are primarily utilized by grayling as spawning and rearing habitat (ADF&G 1982a). Although spawning has not been observed in the impoundment zone, suitable spawning habitat (sandy gravel) has been observed in all of the tributaries sampled, and it is likely that spawning occurs in the lower reaches of these tributaries (Morrow 1980). Grayling that have completed spawning move upstream into areas that have pool type habitats where they remain throughout the summer. Large, deep streams with a high pool/riffle ratio and moderate streamflow velocity (below 2.0 ft/sec), such as the Oshetna River and Kosina Creek, appear to provide optimal habitat (ADF&G 1982a). Clear water tributaries produced the highest catch rates for cottids.

(ii) Talkeetna to Devil Canyon

In the reach of the Susitna River from Talkeetna to Devil Canyon the river channel is relatively stable, straight to meandering with minimal braiding, and is restricted by surrounding hills. Numerous islands, gravel bars and sloughs are present. Flow alternates between a single channel and split channels throughout the reach. Between Talkeetna and Curry (RM 120.7) the approximate gradient is 11.2 ft/mile. Typical substrate between Talkeetna and Curry is gravel, rubble and cobble with small amounts of sand and silt. Above Curry the substrate varies from silt to bedrock. The majority of mainstem shoreline substrate is rubble and cobble whereas silt is the most common substrate in slough mouths slow water areas. Below Curry, streambank vegetation is dense spruce/hardwood forest. Tributaries to the Susitna River in the Talkeetna to Devil Canyon reach include Whiskers Creek, Lane Creek, Fourth of July Creek, Gold Creek, Indian River and Portage Creek, in addition to numerous smaller streams draining the surrounding hillsides.

A breakdown of the habitat study sites in the Talkeetna to Devil Canyon reach includes 11 slough sites, 8 mainstem or side channel sites and 5 tributary sites. Range for physiochemical parameters measured in this reach from May to September, 1981 are shown in ADF&G (1982a). Ranges given for tributary sites included all of the sampling sites from that particular tributary. Overall trends for physiochemical parameters measured in this reach included:

- High dissolved oxygen (8.8-12.8 mg/l);

- Moderate conductivity readings, (15-222 umhos/cm);

- pH valves in the range of 5.1-7.8, slightly lower than the impoundment reach or downstream. Tirbutaries, such as Whiskers Creek and Indian River, had slightly lower pH values than mainstem or slough sites;

- Turbidity levels were generally lowest at upstream tributary sites (0.4-148 NTU). Levels were also generally lower in downstream tributary sites and sloughs when the influence of the mainstem Susitna was negligible. Levels were highest in the mainstem (23-230 NTU); and

- Mainstem and Side Channels

The Susitna River from Talkeetna to Devil Canyon has a typical split channel configuration. A split channel river is characterized by numerous stable islands that divide the flow into two channels. The banks of the channels are typically vegetated and stable, and the floodplain is narrow relative to the channel width. There are usually no more than two channels in a given reach and other reaches are single channel. Bed load is deposited at low flow to form gravel bars along the sides or in the middle of the channels. These bars are typically more erodible than the banks. The bars, rather than the banks, are eroded during floods, resulting in a laterally stable channel.

Side channels in a split river configuration may be perched and carry no water during periods of low flow. Maximum flow depths and velocities are typically less than in the active channel, resulting in smaller substrate materials. Because the mainstem provides the primary side-channel inflow, side-channel and mainstem water qualities are similar.

- Species Occurrence and Relative Abundance

  - Salmon

    Five species of Pacific salmon were observed in the mainstem or side channels of the Susitna above Talkeetna. Studies indicate that adult salmon utilize the mainstem above Talkeetna from late spring into the fall during migration and spawning periods (ADF&G 1981b). Approximate use periods for each species are:

    Chinook-mid-June through July;
    Sockey-July 23 through mid-August;
    Coho-July 30 through September;
    Chum-July 28 through September; and
    Pink-July 27 through August.

    Relative abundance estimates based on 1981 escapement data and population estimates are given in Table 3.4 for each for the salmon species that utilize this reach of the Susitna mainstem.

    Juvenile salmon are also present in the mainstem at various times of the year. Approximate periods of use and relative abundance are outlined below.

    Chinook - During winter, juveniles were most abundant in the mainstem. Prior to June 1 through the end of July, age 1+ juveniles were abundant as they were observed moving downstream in the mainstem.

    Sockeye - 1981 studies did not document the presence or abundance of sockeye juveniles in the mainstem.

    Coho - During winter, coho are most abundant in the mainstem. During summer they are slightly less abundant in the mainstem than at the tributary mouths.

    Chum - 1981 studies did not document the presence or abundance of chum juveniles in the mainstem.

    Pink - 1981 studies did not document the presence or abundance of pink juveniles in the mainstem.

    The analysis of the 1982 smolt trapping program will provide an increased understanding of juvenile sockeye, chum, and pink salmon life history in this reach.

.. Resident Species

Resident species reported in this reach included all of the resident fish reported in the Susitna River drainage (Table E3.2) except for the Arctic lamprey and lake trout. Resident fish observed throughout the year in the mainstem include burbot and longnose sucker. Other resident species were most abundant in the mainstem primarily during winter, early spring and late fall.

. Significance of Habitat

Based on existing data it appears as through the mainstem Susitna River between Talkeetna and Devil Canyon is primarily used by anadromous and resident species as a migrational corridor and overwintering area. The significance of mainstem aquatic habitat is discussed below for various species of commercial and recreational importance.

.. Salmon

The mainstem reach from Talkeetna to Devil Canyon serves as a migration corridor for a relatively small percentage of the total Susitna River salmon escapement (Table E3.4). During migration periods, various behavioral and distribution patterns appear to be associated with certain characteristics of mainstem habitat. Water depth, velocity, channel configuration and location or absence of obstructions are variables that influence migration paths within the mainstem (ADF&G 1981c).

Generally, passage of adult salmon during migration corresponded with periods of high seasonal flow, according to preliminary data gathered by ADF&G (1982a). However, passage of adult salmon on a daily basis (measured by sonar), indicated that salmon movements decreased during periods of highest flows (40,000 cfs) and increased as flows subsided following major flow events.

It was hypothesized that increased water velocities associated with peak flows discouraged passage and encouraged milling (ADF&G 1982a). Preliminary radiotelemetry investigation and gillnetting indicated that the confluence of the Talkeetna, Chulitna and Susitna rivers is a probable chum, coho and chinook milling area and that sockeye, chum, coho and chinook mill in the mainstem one mile below Devil Canyon.

Little mainstem spawning was observed. Chum were observed spawning at four sites and coho at two of the six spawning sites identified in the Talkeetna to Devil Canyon reach. Mainstem spawning appeared to be restricted by lack of suitable spawning substrate and upwelling (ADF&G 1982a, 1981c).

Juvenile chinook and coho salmon appear to use the mainstem for overwintering. Salmon juveniles use the mainstem for outmigration.

.. Resident Species

Resident species other than burbot and longnose sucker primarily use this area of mainstem as a migration channel to spawning, rearing, and summer feeding areas in tributaries. No mainstem spawning or rearing areas have been located. Rainbow trout and grayling overwinter in mainstem habitats.

Burbot and longnose sucker use the mainstem as year-round habitat. Burbot catches during low flows were restricted to the mainstem and deep side channels. During high flows, burbot were captured at a greater number of locations including shallow side channels.

- Slough Habitat

The clear water originates from local surface runoff and ground water interception. Water upwells in the slough channel throughout the year keeping these areas ice free in the winter. Preliminary observations indicate the Susitna River is the primary source of the upwelling water in many of the sloughs. Many have tributary inflow. Local runoff is the primary water source in slough habitats in the summer.

The stage in the mainstem controls the water surface elevation of the lower portion of the sloughs by forming a backwater that can extend some distance upstream into the slough. This backwater is divided into two parts--clear water and turbid water. The mainstem water creates a turbid plug at the mouth of the slough, which backs up the clear water in the slough. As the stage in the mainstem drops, the size and character of the backwater changes. At lower summer flows, approximately 8,000 to 10,000 cfs at Gold Creek, the backwater recedes. This reduces the depth of water at the entrance to the sloughs. In some cases the slough mouth and the mainstem become separated by a gravel bar.

At high flows (20,000 to 24,000 cfs at Gold Creek) the Susitna River overtops the head end of the sloughs substantially increasing the flow through the sloughs. These high flows flush the fine sediments that accumulate in the lower portion of the sloughs. As peak flows subside and the stage in the mainstem drops below the head end of the slough discharge drops and the water in the slough begins to clear.

In the summer when mainstem temperatures are ranging from 8° to 12°C, intergravel temperatures in the slough range from 4° to 6°C. Thus, it appears that a significant amount of heat exchange occurs in the gravels. Some winter temperatures measured in the sloughs and the mainstem indicate that when mainstem temperatures range from 0.5° to 0.1°C, intergravel temperatures ranged from 2° to 4°C Atkinson 1982).

. Species Occurrence and Relative Abundance

.. Salmon

Adults and/or juveniles of five salmon species have been observed in slough habitat between Talkeetna and Devil Canyon. Results of escapement and spawning surveys indicated that adult sockeye and chum salmon were the most numerous salmon in these sloughs during peak spawning periods (ADF&G 1981b). Pink salmon were somewhat less abundant. The abundance of coho and chinook was also low. Spawning counts for individual sloughs are reported in ADF&G (1981b).

Studies of species occurrence and relative abundance of juvenile salmon in slough habitat during 1981 indicate the following information.

Compared to other habitats in this reach, juvenile chinook salmon are abundant in all sloughs during winter and relatively abundant in selected clear water sloughs during summer.

Juvenile coho salmon are abundant at slough sites during winter and less abundant but still present at slough sites during summer.

Abundance estimates for other juvenile salmon are limited. Preliminary data indicate that chum, pink and sockeye fry were present in slough habitat during part of the summer. A limited number of sockey fry were also observed in slough habitat during winter.

.. Resident Species

All resident species reported in the Susitna drainage have been observed in slough habitat between Talkeetna and Devil Canyon except for Arctic lamprey and lake trout.

Available data indicate that most species are present in slough habitats as well as the mainstem throughout winter. During summer most adult residents are not abundant in slough habitat. Those that were relatively abundant in slough habitat during summer included burbot, longnose sucker and rainbow trout. Previous studies indicated that juvenile whitefish, grayling and rainbow trout were abundant in slough habitat during late summer (Friese 1975).

. Significance of Habitat

Slough habitat between Talkeetna and Devil Canyon is used by various anadromous species primarily for spawning and also for rearing and overwintering of juveniles. Slough habitat is also important year-round, overwintering and rearing habitat for various resident species. The significance of slough habitat is discussed below for species of commercial and recreational importance.

.. Salmon

Slough habitat in this reach serves as spawning habitat for sockeye and chum salmon and less important spawning habitat for pink salmon. Factors contributing to the relatively high numbers of salmon that spawn in the majority of the sloughs in this reach are outlined below:

Clear water base flows originating from sources such as upwelling, groundwater, or interstitial inflow, insure maintenance flows.

The presence of upwelling clear water in the sloughs oxygenates spawning substrate, keeps silt from compacting the spawning gravels, and provides a stable temperature regime that maintains incubating embyos through the winter.

The mouths of sloughs act as holding areas in proximity to slough spawning habitat.

Sloughs also serve as important rearing and overwintering habitat for juvenile chinook and coho salmon. During summer, tributary sites appear to be more important chinook rearing habitat, although clear water sloughs also supply rearing habitat. Coho juveniles appear to use sloughs and tributary mouth sites for summer rearing. The importance of sloughs as juvenile overwintering and summer rearing habitat may be related to:

Ice-free clear water conditions during winter compared to lowered flow and icing in coho and chinook salmon natal tribuatries; and

During high summer mainstem flows the high stage of the mainstem acts as a hydraulic control at the slough outlet and the backwater increases in the lower end of the slough. These clear water areas promote benthic production, which improves the quality of the rearing habitat for juvenile salmon.

.. Resident Species

Slough habitat between Talkeetna and Devil Canyon is significant as overwintering habitat for adult rainbow trout, grayling and whitefish, as year-round habitat for adult burbot and longnose sucker and as rearing habitat during late summer months for juvenile whitefish, grayling and rainbow trout. The importance of sloughs as overwintering habitat is related to the same factors as discussed above for juvenile salmon.

No resident spawning sites were located in the sloughs of this reach, however spawning surveys for resident fish were limited (ADF&G 1981b).

- Tributary Habitat

The mouths of tributaries between Talkeetna and Devil Canyon are sensitive to changes in mainstem flow. At high flows, the mainstem creates a backwater at tributary mouths, thus increasing the water depth at the mouth. The lineal extent of the backwater in the tributary depends on the stage in the mainstem and the gradient of the tributary. At low stages, the backwater is elminated, resulting in shallower water and increased flow velocities at the mouth.

Small deltas are formed at the mouths of the tributaries. As the tributary enters the mainstem river the change in gradient and subsequent change in flow velocity causes the tributary to drop transported materials. As the stage in the mainstem river drops the tributaries become perched above the river, i.e., flow across steep deltas. Were they to remain under low mainstem flow conditions, upstream passage of adult salmon and resident fish would be inhibited or eliminated. However, tributary flows are sifficient to cut through deltas to establish a channel at a new gradient (R&M 1982f). Tributaries were observed to cut through their deltas during the low flows of August 1982 when the stage in the mainstem altered the gradient of the delta. Even during low flows, most of the tributaries had sufficient energy to move the delta material (R&M 1982f). Under regulated mainstem flow conditions, the unregulated tributaries would continue to experience peak high flows that would contain sufficient energy for sediment movement.

- Species Occurrence and Relative Abundance

  - Salmon

    Except for sockeye salmon, the salmon species present in the Susitna drainage were observed in tributaries within the Talkeetna to Devil Canyon reach. Spawning counts for individual tributaries are given in studies by ADF&G (1981b).

    Species occurrence and relative abundance of juvenile salmon in tributaries or at tributary mouths varied by season and by species. Results of studies to date are outlined below:

      Juvenile chinook salmon are most abundant at tributary mouths during summer. Redistribution of juveniles from areas of emergence in tributaries to more favorable rearing habitat at the mouths of tributaries occurs throughout the summer as fish become more mobile.

      Juvenile coho were slightly more abundant at tributary mouth sites than mainstem sites during summer.

  - Resident Species

    All resident species except for burbot, longnose sucker and lake trout were most abundant in clear water tributaries and at the mouths of clear water tributaries during summer month. Limited information on winter distribution and abundance indicates that few resident fish overwinter in tributary habitat.

- Significance of Habitat

  - Salmon

    Tributary habitat in this reach serves as primary spawning habitat for chinook, coho, and pink salmon. Chum salmon also spawn in tributaries but appear to utilize slough spawning habitat more than tributary habitat (ADF&G 1981b). Important spawning tributaries include Indian River (chinook and coho), Portage Creek (chinook), Gash Creek (coho) and Lane Creek (pink salmon).

Tributaries in this reach also serve as rearing and summer feeding habitat for chinook and coho. Sites associated with tributary mouths also appear to provide important milling and rearing areas for juvenile chinook and coho salmon. Occurrence of age 0+ coho was particularly high at tributary mouth sites (ADF&G 1982a).

.. Resident Species

Between Talkeetna and Devil Canyon, tributaries provide spawning habitat, juvenile rearing areas, and summer feeding habitat for several resident species including rainbow trout, Arctic grayling, round whitefish and Dolly Varden (ADF&G 1981e, 1982d). In general, these fish migrate from mainstem or slough habitat to clear water tributaries to spawn in spring (or early fall for Dolly Varden). Once spawning migration is completed, fish move into favorable tributary habitat for rearing and summer feeding. As freeze-up begins, fish migrate from tributaries to the mainstem or deeper pools near the mouths of tributaries.

(iii) Cook Inlet to Talkeetna

The Susitna River from Cook Inlet to Talkeetna is moderately to extensively braided along most of the reach. From the inlet to Bell Island, the river is separated into two braided channels; from Bell Island to the Yentna River a single meandering channel is formed. From the Yentna River to Sheep Creek, the river is moderately to extensively braided, with forested islands and nonforested bars between the channels of the river. The river is reduced to a single channel near the Parks Highway Bridge and braiding becomes moderate from this point to Talkeetna. Gradients vary considerably in this reach. From Cook Inlet to RM 50, gradient is 1 ft/mile; from RM 50 to 83, it is 5.9 ft/mile and from RM 83 to Talkeetna, the gradient is 6.9 ft/mile. Typical substrate in the reach is silt and sand with some gravel and rubble. Major tributaries include: Alexander Creek, Yentna River, Kroto Creek (Deshka River), Chulitna River, and the Talkeetna River. Flows in these tributaries are considerable. As a result, only about 40 percent of the total flow at Sunshine Station originates in the Susitna River and tributaries above the confluence of the Chulitna River (see Chapter 2).

Study sites located in this reach included 11 tributary mouth sites, 5 tributary sites, 8 slough sites, and 5 mainstem and sidechannel sites.

The ranges for physiochemical parameters in this reach are given in ADF&G (1982a). Trends apparent in this data include the following:

- Tributaries, sloughs, and the mainstem all exhibited high dissolved oxygen readings (7.6-12.9 mg/l).

- Conductivity was generally low in the tributaries (19-46 umhos/cm) and moderately high in mainstem and slough sites (29-216 umhos/cm).

- pH values were in the 6.1-8.0 range, with tributaries having the lowest pH values.

- Turbidity was lowest in tributaries, particularly Caswell and Montana creeks (0.3-1.9 NTU), and highest at mainstem and slough sites (2.2-255 NTU).

\- <u>Mainstem and Side Channels</u>

Braided river reaches such as the lower Susitna are characterized by two or more interconnecting channels separated by unvegetated or sparsely vegetated gravel bars. The active floodplain is wide and sparsely vegetated, and contains numerous high water channels and occasional vegetated islands. Active channels are typically wide and shallow and carry large quantities of sediment at high flows. Bars separating the channels are usually low, gravel surfaced, and easily erodible. The lateral stability of the channels is quite low; channels shift by bank erosion and/or by channel diversion into what was previously a high water channel. The lateral activity of channels within the active floodplain of a braided river that carries large quantities of bed load is expected to be high. Gravel deposits may partially or fully block channels, thereby forcing flow out of the channel to develop a new channel.

Because braided river channels are wide and shallow, they are more sensitive to flow reductions than the deeper channels of a split channel system, i.e., a drop in stage could result in a substantial reduction in the width of the river and loss of large areas of flow along the margins of the channel.

Side channels are typically at higher elevations than mainstem channels and so are more sensitive to fluctuating river stages. They may be completely dewatered at low flows. Side channels are not subject to as high flow velocities as main channels and so the substrate is not scoured from these channels as easily. Water quality in side channels is similar to that found in the mainstem.

. Species Occurrence and Relative Abundance

.. Salmon

Adult salmon are reported in this reach of the mainstem during spawning migration. Generally, the migration period extends from late May into September (specific dates are reported in Section 2.2). The relative abundance of adult salmon in this reach is high because the entire Susitna salmon run must pass the lower sections in order to arrive at spawning grounds. Population estimates for the number of salmon that migrate to various escapement monitoring stations are given in Table E3.4.

With the exception of sockeye salmon, the majority of Upper Cook Inlet salmon is thought to originate in the Susitna drainage and therefore must migrate through portions of the reach of mainstem between Cook Inlet and Talkeetna.

Juvenile chinook salmon are relatively abundant in this reach of the mainstem during winter months. Juvenile coho are less abundant and more often associated with tributary mouth sites. Relative abundance of sockeye, chum, and pink juveniles was not assessed ADF&G 1981d).

.. Other Anadromous and Resident Species

Other anadromous species reported in this reach include Bering cisco and eulachon. Bering cisco are abundant in the mainstem from August to October (ADF&G 1982a). Eulachon are reported from Cook Inlet to RM 48 (Trent 1982).

All resident species reported for the Susitna drainage except for lake trout were reported in this reach or the mainstem. Species reported in this reach but not other reaches of the Susitna include Bering cisco, eulachon and lamprey (ADF&G 1981e).

. Significance of Habitat

.. Salmon

Part of this reach of mainstem habitat serves as a migration corridor for the entire Susitna River salmon run. Adult salmon movement during migration periods appears to show some relationship to discharge (ADF&G 1982a).

Salmon spawning habitat in the mainstem or side channels of the reach appears to be limited and is comparable to the spawning habitat discussed for the Talkeetna to Devil Canyon reach. Of the six mainstem or side channel spawning sites identified, chum salmon occupied six and coho salmon occupied one (ADF&G 1981a). No mainstem or side channel spawning was observed for chinook, or sockeye salmon. Mainstem and side channel spawning habitat is probably restricted because of lack of suitable spawning substrate and upwelling, which contributes to spawning substrate suitability.

Mainstem habitat also provides important overwintering for chinook and coho salmon juveniles, limited summer rearing habitat and a migrating channel for smolt out-migration.

.. Other Anadromous and Resident Species

The mainstem from Cook Inlet to Talkeetna serves as primary overwintering habitat and as an important migration channel. Bering cisco and eulachon are anadromous species that use the mainstem as a migratory channel from Cook Inlet. Arctic grayling, rainbow trout, Dolly Varden, and round whitefish are resident fish that use the mainstem as a migratory channel to tributary spawning habitat and as overwintering habitat. The movement from tributaries to the mainstem for overwintering has been inferred from capture data gathered during the fall and spring near tributary mouths.

Mainstem habitat in this reach provides possible spawning habitat for at least three species: Bering cisco, eulachon and burbot. Although spawning activity by Bering cisco may occur throughout the reach between RM 30-100, three spawning concentrations were identified (see Section 2.2(b)). Spawning substrates were composed primarily of 1 to 3 inch gravel.

Burbot and longnose suckers are present in the mainstem throughout the year and utilize the mainstem for overwintering, spawning, and juvenile rearing. Habitat utilization within the mainstem is probably similar to that discussed above for the reach of mainstem between Talkeetna to Devil Canyon.

- Slough Habitat

In general, the sloughs below Talkeetna appear to be less dependent on the mainstem Susitna than the sloughs located above Talkeetna and Devil Canyon. During periods of low flow, the sloughs are primarily fed by tributaries and ground water upwelling and carry clear water. At high flows, the sloughs are essentially overflow channels for the mainstem and the water in the sloughs becomes quite turbid as it assumes characteristics of mainstem water. Slough water clears as the mainstem stage drops and turbid water no longer enters at the head. Higher velocities associated with higher flows act to flush fine sediments from the slough. Backwaters are created at slough mouths when the river stage is high, but disappear at lower flows.

Because they are somewhat independent of mainstem flow, the sloughs in this reach may not be affected as severely by changes in the magnitude and timing of flow as those above Talkeetna.

. Species Occurrence and Relative Abundance

.. Salmon

Chum, sockeye and pink salmon adults were observed in slough habitat (ADF&G 1981b). No estimates of relative abundance were made for salmon that use slough habitat in this reach.

Juvenile salmon occurrence and relative abundance in slough habitat is expected to be similar to that reported for the Talkeetna to Devil Canyon reach. Chinook juveniles are relatively abundant in slough habitat during winter and less abundant during summer. Juvenile coho are less abundant in slough habitat than in tributaries throughout the year (ADF&G 1981d).

.. Resident Fish

Occurrence and relative abundance of adult resident species in this reach of slough habitat is similar to that discussed for the Talkeetna to Devil Canyon reach. The majority of resident species are present and relative abundance is highest beginning in late summer and continuing throughout winter. Adult residents that are most abundant in slough habitat during summer include burbot, longnose sucker and rainbow trout (ADF&G 1981e).

Previous studies indicated that juvenile whitefish, grayling and rainbow trout were abundant in slough habitat during late summer (Friese 1975).

. Significance of Habitat

.. Salmon

Based on spawning surveys upstream from Talkeetna, slough habitat in this reach probably serves as spawning habitat for chum/sockeye and pink salmon. Factors that may contribute to the suitability of sloughs as spawning habitat are discussed for the Talkeetna to Devil Canyon reach.

Slough habitat may also serve as important rearing and overwintering habitat for juvenile chinook and coho salmon. The importance of sloughs as juvenile overwintering and rearing habitat may be related to factors discussed above for the Talkeetna to Devil Canyon reach.

.. Resident Species

The significance of slough habitat is similar to that discussed for the reach between Talkeetna to Devil Canyon. Slough habitat in this reach is utilized as overwintering habitat for adult rainbow trout, grayling and whitefish; year-round habitat for adult burbot and longnose sucker; and as rearing habitat during late summer for juvenile whitefish, grayling and rainbow trout. The importance of sloughs as overwintering habitat is related to the same factors as discussed above for juvenile salmon species in the Talkeetna to Devil Canyon reach. No spawning sites were reported in the sloughs of this reach (ADF&G 1981e).

- Tributary Habitat

. Species Occurrence and Relative Abundance

.. Salmon

All of the salmon species present in the Susitna drainage were observed in tributaries within this reach. Results of previous studies by ADF&G (1980a and 1980b) and 1981 surveys in tributaries upstream from Talkeetna indicate that the relative abundance of spawning for all salmon species in this reach occurs in tributaries.

Species occurrence and relative abundance of juvenile salmon in tributaries or at tributary mouths varies by season and by species. Results of studies to date indicate:

Juvenile chinook salmon are most abundant at tributary mouth sites during summer; tributary sites accounted for 95 percent of all juveniles captured in this reach. During winter, juvenile chinook were less abundant and were captured near tributary mouths.

Juvenile coho were relatively abundant at tributary mouth sites during both summer and winter.

.. Resident Species

All resident species except for burbot, longnose sucker, and lake trout were most abundant in clear water tributaries and at mouths of clear water tributaries during summer. Information of winter distribution and abundance indicates that few resident fish overwinter in tributary habitat.

. Significance of Habitat

.. Salmon

Tributary habitat serves as primary spawning habitat for all salmon species occurring in this reach.

Based on escapement counts and population estimates at monitoring stations along the mainstem, tributaries in this reach provide the majority of spawning habitat for chinook, coho, and pink salmon in the Susitna drainage.

Other Susitna River investigations have revealed that all adult salmon mill to some degree in the mainstem and that it is not uncommon to find adult salmon in the mainstem well upstream of their spawning destination (ADF&G 1974 and ADF&G 1975).

Tributary habitat in this reach also supports rearing and summer feeding habitat for juvenile chinook and coho salmon. Sites associated with tributary mouths appear to provide particularly important rearing areas for juvenile chinook and coho salmon. Occurrence of age 0+ coho was particularly high at tributary mouth sites during summer. In addition, tributary mouth sites in these reaches appeared to provide overwintering habitat for juvenile coho salmon.

.. Other Anadromous and Resident Species

Tributary habitat in this reach, similar to the Talkeetna to Devil Canyon reach, apparently provides spawning habitat, juvenile rearing areas, and summer feeding habitat for rainbow trout, Arctic grayling, round whitefish and Dolly Varden (ADF&G 1981e). In general, these fish migrate during spring (early fall for Dolly Varden) from the mainstem or slough habitat to clear water tributaries to spawn. Once spawning is completed, fish move into favorable tributary habitat for rearing and summer feeding. As freeze-up begins, fish migrate from tributaries to the mainstem or deeper pools near the mouths of tributaries. Habitat characteristics that influence grayling distribution and abundance within tributary habitat are discussed above for the impoundment reach in Section 2.3(a).

(c) Streams of Access Road Corridor

(i) Stream Crossings

The access road to the Watana and Devil Canyon damsites will depart from the Denali Highway and proceed south to Watana. From there, the road will traverse the north side of the Susitna River to the Devil Canyon dam site. A railroad spur from Gold Creek will connect to Devil Canyon. The access road corridor contains at least 37 streams and rivers in both the Nenana and Susitna River drainages.

From the Denali Highway to Watana, the road will cross Lily Creek, Seattle Creek and Brushkana Creeks, as well as numerous unnamed streams. These streams are tributaries of the Nenana River, which supports populations of grayling, northern pike, whitefish, burbot, and slimy sculpin in this reach. Tributary streams are assumed to contain at least grayling and sculpin.

The upper reaches of Deadman Creek will also be crossed by the Watana access road. This creek is a tributary of the Susitna River and is considered important grayling habitat.

Between the Watana and Devil Canyon dam sites, the access road will cross Tsusena and Devil Creeks. The streams contain grayling and may contain cottids, whitefish, longnose suckers and Dolly Varden.

The road will cross the Susitna River approximately 2 miles below the Devil Canyon dam site. Salmon and probably grayling, whitefish, cottids and longnose suckers occur in the vicinity of the crossing. The habitat in this reach of the Susitna is considered less productive than in reaches further downstream.

The railroad between Devil Canyon and Gold Creek will cross Jack Long Creek and Gold Creek. Jack Long Creek contains pink, coho, chinook, and chum salmon. Gold Creek has been documented to contain chinook salmon (ADF&G 1982c). Three unnamed tributaries of the Susitna River will also be crossed. These most likely do not contain fish due to their step gradients, but they are considered important sources of clear water to sloughs 19 and 20, which are salmon spawning areas.

(ii) Streams Adjacent to Road Corridors

In addition to crossing streams, the access road will parallel some streams, particularly Deadman and Jack Long creeks. The fisheries resources of both are described in Section 2.4(a) above. Devil Creek also will be paralleled by the access road for some distance.

(d) Streams of the Transmission Corridor

Transmission lines will be built from Watana and Devil Canyon to Gold Creek and from there to Anchorage and Fairbanks. From Watana to Gold Creek, the transmission line route is primarily south of the Susitna River.

Resources of this segment are described in Commonwealth et al (1982). At least 27 major salmon streams including Willow Creek, Kashwitna River, Talkeetna River, Chulitna River and Indian River will be crossed by the intertie and, presumably, by the additional lines to be built in conjunction with the Susitna hydroelectric project. Many of the streams are likely to contain grayling, rainbow trout, Dolly Varden and cottids in addition to salmon.

South of Willow, the transmission line will be routed between the Susitna River and the Parks Highway for much of its length. It will cross Fish Creek and the Little Susitna River as well as many unnamed streams. The Little Susitna is a productive fish stream and contains coho, pink, chinook, chum and sockeye salmon, as well as rainbow trout, Dolly Varden and grayling. Fish Creek is known to support chinook, sockeye and coho salmon and possibly rainbow trout. The unnamed tributaries to the Susitna River most likely provide salmon spawning habitat.

The transmission line crosses the Knik Arm and proceeds east and south to the University power substation. Knik Arm serves as a migration corridor for five species of Pacific salmon as well as other anadromous species such as eulachon and lamprey. The transmission line will skirt Otter Lake, which is stocked with rainbow trout, and will cross Fossil and Ship Creeks. Fossil Creek is not considered a fish stream. Ship Creek supports populations of pink, chum, coho, sockeye, and chinook salmon as well as Dolly Varden and rainbow trout, but due to the heavy development along its reaches, it is not considered prime fish habitat.

North of Healy, the transmisson line will cross at least 50 creeks and rivers including the Nenana and Tanana Rivers. These are two of Alaska's major rivers and provide habitat for salmon, grayling, whitefish, suckers, burbot, cottids, northern pike and inconnu.

Panguingue Creek has been documented to contain coho salmon, Dolly Varden and grayling (Tarbox et al. 1978a, 1978b). The streams in the Little Goldstream vicinity are not considered to be important fisheries habitat due to their step gradients. While many of the streams go dry in the summer, some do support grayling populations near their mouths. Little is known about the other streams that will be crossed in this segment.

2.3 - Anticipated Impacts To Aquatic Habitat

Construction and operation of the proposed Susitna Hydroelectric Project would result in both beneficial and detrimental effects on the aquatic habitat and associated fishery resources in the Susitna Basin. Many of the potential adverse effects can be avoided or minimized through design and/or operation of the project, as will be described in Section 2.4. This section examines the potential effects of the project as proposed in Exhibit A and addresses the impacts likely to be sustained as a result of project construction, reservoir filling, and operation of Watana and Devil Canyon dams. Since the project is a staged development, impacts to the aquatic habitat are presented by project stage, phase and river segment. The discussions focus on important anadromous and resident species, with lesser attention being given to other fishery resources.

In this section the term "impact" refers to an effect on fish or utilization of aquatic habitats resulting from project-induced changes in the physical characteristics of the environment. Impacts refer to effects that are both positive and negative. The project may alter physical characteristics of the aquatic environment that do not effect fishery resources, but these changes are not considered to be impacts.

The description of anticipated impacts presented below is a generic statement addressing the types of impacts that have occurred in similar projects or are likely to occur under the various developmental stages of this project. It is based on available baseline information on the biology of the Susitna River fishery resources, predicted changes in physical characteristics, and effects of habitat alterations from similar activities in other basins as found in the literature. The discussion represents the collective understanding of the physical processes, habitat relationships and likely response of fishery resources. Many of the statements are speculative in nature and as yet are unsupported by specific project reports. Data collection and analysis programs currently planned or in progress will provide the basis for a quantitative impact analysis and mitigation plan.

The majority of the anticipated impacts resulting from the project are associated with construction and operation of Watana Dam. Impacts of a lesser magnitude would likely be sustained as a result of the addition of the Devil Canyon Dam. Watana stage of the project would be constructed first and would alter the character of the aquatic environment downstream of RM 238, the upper most extent of the reservoir. The magnitude of change in aquatic habitats below the damsites decreases as the distance from the damsites increases. Alteration of the character of existing aquatic environment would be most notable within the impoundment and the 50 mile reach between the damsites and Talkeetna. Lesser changes are anticipated in the 100 mile reach from Talkeetna to Cook Inlet. Impact issues are generally same in different reaches.

Secondary impacts to aquatic habitat are anticipated to arise during dam construction. Most of these potential impacts can be avoided through careful design and siting and by employing good construction practices.

(a) Anticipated Impacts to Aquatic Habitat Associated with Watana Dam

(i) Construction of Watana Dam and Related Facilities

The analyzed construction effects are those that could potentially result in changes to the fishery resource. These fall into three major areas of construction related activity.

- Effects of permanent or temporary alterations to water bodies (i.e., dewatering, alteration of flow regime, or alteration of channels);

- Changes in water quality associated with the above (such as spills and effluent discharges; and

- Direct effects of the construction activities (i.e., blasting, use of chemicals, noise, etc.).

Table E.3.14 summarizes a number of the individual construction activities that reasonably could be expected to occur during the construction period. Each is classified under one of the above three categories with the potential direct effects that activity may have on the waterbody.

- Watana Dam

The construction of the proposed Watana Dam consists of those activities occurring from initial site preparation to filling the reservoir. The proposed dam will consist of a fill structure constructed at RM 184 of the Susitna River. The fill will be approximately 0.75 miles wide, 0.75 long and 88.5 ft high. Over 63 million cubic yards of material will be used to construct the dam.

Prior to construction of the main fill structure, access will be provided and site clearing activities begun. During this period housing, administrative and transportation facilities will be required in the site area. Heavy equipment will be brought to the site and construction material will be stockpiled in the immediate site area. In addition, instream construction of two cofferdams will be completed. The two cofferdams will surround the area of the main dam construction. One dam will be built upstream from the dam site and the other downstream (refer to Figure Exhibit F). The upstream dam will be approximately 800 ft long and 450 ft wide, the downstream dam will be 400 ft long by 200 ft wide. Water blocked by the upstream cofferdam will be diverted into two 38-ft diameter, concrete tunnels about 4100 ft long. These will be constructed during a two-year period (1985-1987) and will remain in place until the reservoir filling phase begins.

The construction of the proposed dam will have a number of effects on the river and its biota. Some effects will be the direct result of construction activities, other effects will result from alteration of the river environment during construction. Some effects will be temporary, only occurring during certain periods of construction activity and others will be of longer duration.

. <u>Alteration of Water Bodies</u>

The greatest alteration of aquatic habitat during construction of Watana Dam will occur at the dam site and in the Tsusena Creek material site. Other material sites will be located in the impoundment zone at the construction site. At the construction site, the Susitna River is approximately 300 to 400 feet wide in a confined valley. The river bottom is sand, gravel and boulders; no tributaries enter the Susitna at this point. The first major phase of water body alteration is the installation of two cofferdams. The area will be permanently dewatered. Burbot, sculpins, and longnosed sucker may occupy the dam site during the open water season. Grayling may overwinter here (ADF&G 1981f). These fish would be displaced to adjacent habitats by construction activity.

The movement of fill materials and the actual process of construction of the fill dam are potential contributions to turbidity and siltation. During transport of 63 million cubic yards of fill material used in constructing the dam, a small percentage may be released to the mainstem Susitna River. Since even a small percentage of the 63 million cubic yards represents a large amount of material, there is a potential for turbidity and siltation impacts from that source. In addition, there is a potential for silts to erode from fill stockpiles and from the dam fill itself. The release of these materials can potentially alter the nearby aquatic habitats during dam construction and may result in fish avoidance of the area. These is also a potential for the release of suspended silts downstream of the dam site through the diversion tunnels leading downstream.

The construction of the dam and the presence of the two cofferdams surrounding the dam site requires the construction of two diversion tunnels to divert water past the construction area. Construction of the two tunnels will require extensive excavation and production of concrete. These excavation impacts have been addressed above and concrete production impacts will be discussed below.

Construction and operation of the diversion tunnels may lead to the entrainment of fish into the tunnels and transport below the dam site. Water velocities within the tunnel will serve as a barrier to fish passage upstream. In addition, if river transport mechanisms move rocks and other materials into the tunnels, or if the tunnels are not smooth, fish may be damaged or abraided while moving downstream through the tunnels. Experiments with fish transport indicate that fish are adversely affected when exposed to velocities in excess of 9.0 ft/sec (Taff et al. 1975).

Tunnel velocities are expected to exceed 18 fps during much of the summer. Since few fish are expected to occupy this area in the summer, little impact is expected. During the winter, the gate will be partially closed to create a head pond approximately 50 ft deep. Entrance velocities of the tunnel are expected to be in excess of 20 fps. The creation of the head pond in conjunction with velocities of this magnitude are expected to adversely affect overwintering resident populations. Grayling and other residents move into mainstem habitat to overwinter and physical conditions within the head pond will provide substantial overwintering habitat. Entrance velocities of 20 fps would entrain fish into the tunnel resulting in fish mortality.

Tunnel operation may cause scouring due to high velocity discharges at the downstream end of the tunnels. This could result in removal of smaller gravels, sands and silts from the immediate area of the tunnel discharge. The velocities will also tend to deter fish from entering the area immediately downstream of the tunnel (Bates and VanDer Walker 1965, Stone and Webster 1976).

- <u>Changes in Water Quality</u>

There are a variety of water quality impacts that could potentially occur during construction of Watana Dam. These generally involve the discharge of run-off and effluents. Peters (1978) notes that under present environmental legislation and by use of current engineering practices, most impacts due to such discharges can be mitigated, if not eliminated altogether. Mitigative treatment techniques will reduce the potential for impacts from these sources.

Mud-laden waters from collected run-off and from excavation of facilities, such as the two tunnels, could represent a considerable source of silt and turbidity to the river. Holding ponds will be used for sedimentation of suspended silts prior to discharge to reduce potential impacts.

The primary change in water quality that may occur from Watana Dam construction is increased turbidity. This would be produced by the increased erosion resulting from dam construction activities. Increases in turbidity would vary with the type and duration of construction activity and may be a severe local condition, but would not be expected to produce a wide-spread detrimental effect upon aquatic habitat in the Susitna system. Temperature, dissolved oxygen, nitrogen concentration and other water chemistry parameters are not expected to be affected, although minute increases in trace metals could occur due to leaching from exposed soil.

Increased turbidity can reduce visibility and decrease the ability of sight-feeding fish to obtain food (Hynes 1966 and Pentlow 1944). This represents a potential decrease in feeding habitat. Many salmonids will avoid spawning in turbid waters. Many fish will avoid turbidity and turbid areas. Turbidity originating from these sources is often temporary, and associated only with actual clearing activities and rainfall events.

Siltation (sedimentation) is also associated with these activities. There is a considerable amount of literature dealing with these effects (Burns 1970; Shaw and Maya 1943; Wandard Stanford 1979) particularly the effect on spawning and incubation. A general conclusion reached by a review of the literature (Dehoney and Mancini 1982) is that siltation and turbidity impacts have their greatest adverse impacts on the immobile eggs and relatively immobile larval fish. In general, siltation can cause significant losses of incubating eggs and fry in redds in the areas affected, particularly by interferring with oxygen exchange in the redds. Areas of upwelling flow would tend to be impacted to a lesser extent that others. Only resident fish are found in this reach potentially affected. These could potentially include Dolly Varden, Arctic grayling, round whitefish, and similar species. Release of suspended materials can also affect other water quality parameters including dissolved oxygen, BOD, trace metals, pH, and other water quality parameters (Pierce et al. 1970).

The production of concrete for tunnel lining, facility construction and grouting can result in the production of concrete batching waste to be discharged. Peters (1978) points out that the discharge of this waste, if untreated, could lead to detrimental effects on the fish populations and habitat. A particular problem with this waste is the need to adjust its pH (10+) prior to discharge.

Spills are generally short duration events, but which may have severe impact depending upon the substance spilled. Any substance used around the site or waste produced on-site could potentially be spilled into a waterbody. It is likely, however, that substances used in large quantities and over greater areas, including fuels and lubricating oils, would be more likely to be involved in spills. Diesel oil will be used in large quantities and will need to be stored in large quantities on-site. New and used lubricating oils will also be commonly used. There is a great deal of literature (USEPA 1976; AFS 1979) describing deleterious effects caused by oils and waste oils. Aromatic compounds in oils are particularly toxic. Trace metals in waste oil may require the handling of waste oil as a hazardous waste under 40 CFR 261-265). If more than 10,000 gallons are stored on site an SPCC plan would be required under the Clean Water Act and provisions for spill control would be required on site. Solvents, while probably present in much smaller quantities than petroleum products, are usually considerably more toxic to aquatic life. Other chemicals of concern could include antifreeze, hydraulic oil, grease and paints among others.

In general, spills will be most serious if they occur in areas of high biological activity and are not dissipated quickly, or if a large area of the waterbody is affected.

The number of factors that will affect the severity of spill impact on fish are:

- The substance spilled;
- The quantity spilled;
- The biota present;
- The life stages present;

- The season;
- Mitigation and clean-up; and
- Frequency of spills in that area.

As in the case of siltation and turbidity, the less motile life stages are most likely to be impacted, juveniles and adult fish can usually leave an affected area. Due to increased fish motility and ability to clean-up spills in winter, spills have the potential for greater impacts in winter.

It should be noted that the use of good engineering practices, and a thorough SPCC plan can greatly reduce or avoid the potential for such impacts.

- Direct Construction Activities

Floodplain gravel mining has the potential to adversely affect aquatic habitats. The alluvial fans at the mouths of Tsusena Creek and Cheechako Creek and the mainstem Susitna River are the only proposed floodplain material sites. These sites will be operated in accordance with guidelines set forth in Joyce, Rundquist and Moulton (1980). Tsusena Creek will be rehabilitated according to the same set of guidelines, but the Cheechako Creek and Susitna River sites will not because they will be inundated by the reservoir. Anticipated impacts from gravel removal operations include increased turbidity due to erosion and minor instream activities, introduction of small amounts of hydrocarbons from equipment and the possibility of accidental spills. These impacts are expected to be temporary and not expected to last beyond site operation. A long-term impact to aquatic habitat is expected at the mouth of Tsusena Creek. The volume of material to be removed will result in a large pit that will become filled with water. This pit will result in increased lentic habitat in exchange for lost riparian and upland habitat.

Direct construction activities include activities that can be expected to occur throughout the construction of the dam. These activities, for the most part, will not necessarily be confined to limited areas.

During construction, some of the first activities to take place will include the clearing of areas, construction of access roads, stockpiling of construction materials and fuel, movement of heavy equipment,and construction of support facilities. The construction of support facilities and access roads are discussed below. The activities that will take place, both for support facility construction and other construction will include cutting and clearing in areas adjacent to and near the stream banks.

Removal of cover vegetation will potentially cause a number of effects. One effect of the removal of cover is to increase the potential for greater run-off, erosion, increased turbidity and increased dissolved solids (Likens et al. 1970, Boreman et al. 1970 and Pierce et al. 1970). These effects are well documented for many types of construction. The extent of potential impacts is directly related to the use of mitigative practices to control erosion and run-off induced sedimentation and turibidity. This is discussed under mitigation in Section 2.4. Without the use of proper mitigative practices, erosion and run-off could greatly increase turbidity in affected areas and result in sedimentation both locally and in areas downstream.

Removal of bank cover will also tend to affect temperature by exposing bank areas to direct sunlight. In addition, the removal of bank cover may also increase the exposure of fish to terrestrial predators, and/or lead to a decrease in their populations (Joyce, Rundquist and Moulton 1980a).

The operation of heavy machinery in streams will be reduced through the use of arched culverts to provide passage across streams, however, some instream use of heavy machinery is inevitable. The primary effect of heavy machinery will be increased siltation and turbidity. The extent of potential impacts due to siltation and turbidity will be dependent upon the extent of machinery operation and the substrate of the streams affected (Burns 1970). Smaller substrates tend to be most affected (Burns 1970); however, effects are also dependent upon stream flows in the local area. If velocities are sufficiently high, deposition of suspended silts stirred up by the machinery will not occur locally and the effects could be minor (Shaw and Maga 1943). Since velocities can be expected to vary seasonally, the potential for impacts can be expected to vary seasonally as well. Impacts due to machinery induced siltation and turbidity will tend to be of a more temporary nature than that described for cleaning of banks. Potential spills of fuel or other hydrocarbons are discussed under Water Quality above.

Current construction plans do not require any in-stream blasting. Blasting is planned for areas 500-600 ft from streams as a means of reducing the impacts normally associated with blasting near streams (Joyce, Rundquist and Moulton 1980a). A review of the effects of blasting on aquatic life (Joyce, Rundquist and Moulton 1980b, Appendix G) indicates that effects from such blasting would probably not be lethal (at least with charges of less than 200 kg of TNT). Blasting effects include increased turbidity and siltation due to loosened soils and dust (see effects described above). The extent of such effects would be dependent upon local conditions and extent of blasting.

The transmitted shock waves from the blasting, while probably not lethal, will disturb the fish and at least temporarily displace them from areas near blasting activity. This type of behavior is well documented for a variety of noise sources (VanDerWalker 1967, Latvaitis et al. 1977 and USEPA 1976).

Some excavation is expected to be associated with the construction of Watana Dam and facilities. Excavation may be specifically expected in conjunction with cofferdam installation, installation of the diversion tunnels and installation of culverts. The effects of excavation are essentially similar to those of instream operation of heavy machinery, but with greater release of sediments and turbidity in the stream. Excavation effects will probably involve a greater degree of impact to local habitats than previously discussed. Some excavated areas will be permanently lost as fish habitat due to replacement of the habitat. Other areas will be temporarily altered as discussed above.

Overall, all impacts causing changes in habitat due to siltation and turibidity will be of a temporary nature. The duration of the change will be dependent upon the amount of material released, local flow conditions and the time of year (flow regime) it occurs. For major releases of material it may require the passage of an entire water-year for conditions to be restored (Dehoney and Mancini 1982).

As part of the construction activities, water will be diverted from the streams in the construction area to be used for dust control, drinking water, fire-fighting water, sanitary water, concrete batching, and wet processing of gravel among other uses. The diversions will probably be accomplished by pumping from local stream segments and intakes will be designed to avoid fish impingment and entrainment.

- <u>Watana Camps, Village and Airstrips</u>

  - <u>Construction and Operation of Camps, Village and Airstrips</u>

During peak construction activity for Watana Dam, facilities to house between 4000 to 4800 people are anticipated (see Exhibit A, Section 1.13). The facilities will be located in close proximity to the construction site. The construction camp will be located near Deadman Creek about two miles from the dam and the construction/permanent village will be within a mile of the dam site. Each development will occupy approximately 170 acres. The permanent townsite will encompass a small (approximate 25 acre) lake. The water source for both camp and village will be Tsusena Creek. Sewage will be treated and the effluent discharged into Deadman Creek. Utilidors will connect the village and camp to the water and sewage treatment facilities.

.. <u>Alteration of Water Bodies</u>

Alteration of water bodies from the construction of camps and related facilities will be confined to the immediate area of the development. Few adverse impacts are anticipated. Gravel or other material required for facilities construction will be mined from upland sites that will be operated and rehabilitated to minimize erosion. Project facilities will be located 500 ft from water bodies to minimize the potential of increased sediment input to waterbodies.

Water will be withdrawn from Tsusena Creek near RM 6 for domestic use in the camp and permanent village. An estimated 1.5 cfs will be required to meet peak demands in both the construction camp and permanent village. This represents less than one percent reduction in flow during the open-water season and little impact is expected to result from decreases of this magnitude. An 8 percent reduction is expected during the winter period. Since few fish are expected to overwinter in Tsusena Creek, this is not expected to adversely affect fish populations.

The village is proposed to be built around a lake. Erosion from the site could enter this water body during construction . No fish are believed to live in this lake. The impacts resulting from construction of camps and related facilities are anticipated to be confined to the immediate area of development.

.. <u>Water Quality Changes</u>

Due to the presence of a large construction force in the area, sanitary waste will be treated and discharged. The extent of treatment of sanitary waste, its volume, and the point of discharge will control the extent of potential impact (see Chapter 2 for discussion of treatment techniques). Wastewater effluents can affect BOD and therefore dissolved oxygen, pH, nutrients, trace metals, and buffering of the receiving water. This can affect the water quality of the fish habitat (USEPA 1976; AFS 1979; Hynes 1966).

No disruption of fish populations are expected during camp and village construction,because there are no fish habitats in the vicinity of these activities.

Storm drainage, oily water run-off and fuel spills are expected to occur at both the camp and the village, but it is not likely that oily and silty water will reach Tsusena and Deadman creeks because the developments are nearly one half mile from the creeks. The small lake within the town limits will be more susceptible to intrusions of oily water, storm drainage and fuel spills.

.. Indirect Construction Activities

Operation of the camps will result in increased access to an area that has previously experienced little fishing pressure. The areas potentially affected would be those stretches of Deadman and Tsusena Creeks and the Susitna River that are easily accessible by foot from the camps and the dam site. Studies on these streams have indicated a relatively high percentage of "older" age group graylings (up to 9 years) (ADF&Gf). Sport fishing may remove larger, older fish, resulting in a change in the age distribution of the population.

(ii) Filling Watana Reservoir

Filling of Watana Reservoir will impact aquatic habitats both up and downstream of the dam. The 9.5 million acre foot reservoir is expected to take approximately three spring runoff periods to fill. The length of time required to fill Watana Reservoir depends on the amount of runoff that occurs during the filling perod. If low-flow years occur, filling will be extended for an additional spring runoff period. Table E.3.17 presents the flows expected during reservoir filling at Gold Creek Station under median flows. Expected flows at Gold Creek exceed the flow regime proposed during reservoir filling in all but the second year of filling where the required flows are provided. Impacts to downstream fisheries are summarized in Table E3.16a.

During filling, downstream releases will be made through one of the diversion tunnels. This will be a low level outlet with limited capability to control downstream water temperatures.

- Watana Reservoir Inundation

  Filling Watana Reservoir will inundate 59 sq mi. This area contains 54 miles of Susitna River mainstem habitat and 28 miles of tributary habitats that would be converted from lotic to lentic systems with accompanying changes in hydraulic characteristics, substrate, turbidity, temperature and nutrient levels. These changes may result in a shift in species composition in the area.

  Preliminary population estimates indicate that the impoundment area support at least 10,000 Arctic grayling greater than 6 inches (ADF&G 1981f). In addition to grayling, the impoundment area has populations of burbot, longnose sucker, whitefish, and Dolly Varden (ADF&G 1981f).

  Reservoir filling will begin in May with the spring runoff flows. Table E.3.15 presents water surface elevation of the reservoir and rates of filling for Watana Reservoir. The greatest changes in water surface elevation and the most significant impacts will occur during the first year. During May of the first year, the water surface elevation of the reservoir will rise an average of 5 ft per day reaching a depth of approximately 165 ft by the end of the month (an elevation of 1625 ft). Increases in water surface elevation of 3 ft and 4 ft per day are predicted in June and July, respectively. At the end of the first year, the reservoir will encompass an area of approximately 13,000 acres. It is expected to have a surface elevation of 1875 ft and depths of 425 ft.

  - Mainstem Habitats

    Impoundment of the Susitna River by Watana Dam would alter the physical characteristics of mainstem habitats and consequently affect the associated fishery resources. Burbot, longnose sucker and whitefish generally occupy mainstem habitats year-round. Arctic grayling use mainstem habitats for overwintering (ADF&G 1981f). Mainstem habitats would be eliminated in the impoundment and replaced by a reservoir environment. The physical characteristics expected to occur in the reservoir are presented in Chapter 2.

During the open-water season, mainstem habitats are utilized by burbot. Longnose sucker and whitefish generally occupy mainstem habitats only in the vicinity of tributary mouths (ADF&G 1981f). Since these fish are generally associated with habitats similar to those that may be present in the reservoir, conditions within the reservoir during filling are not expected to adversely affect these species. Burbot, longnose sucker, and whitefish are found in glacial lake environments in southcentral and southwestern Alaska (Bechtel Civil and Minerals, Inc. 1981; Russell 1980). These species are expected to utilize reservoir habitats year-round.

Whitefish and burbot spawning areas may be located in mainstem habitats near tributary mouths. These areas would be inundated during the first year of filling, probably eliminating their habitat value. Since the habitat in the vicinity of tributary mouths would be changing rapidly, it is unlikely that stable spawning areas (similar to those presently existing) would develop during reservoir filling. The loss of spawning habitat is expected to adversely affect burbot and whitefish production in the proposed impoundment. However, since the water surface elevation in the reservoir remains constant during spawning and incubation periods for both burbot and whitefish, any spawning that does take place would probably not be adversely affected during reservoir filling.

The reservoir is expected to increase the amount of overwintering habitat available in this reach. Water depth, water quality, and food availability may be critical factors associated with overwintering habitat (Bustard and Narver 1975; Tripp and McCart 1974; Tack 1980). The reservoir is expected to provide adequate depth and water quality conditions for overwintering fish. At the end of the first year of filling, water depths would exceed 400 ft. Turbidity levels of the impoundment are expected to be suitable for fish although slightly higher than existing winter turbidity levels in the mainstem Susitna River. Particles less than 5 microns in diameter are expected to remain in suspension (Chapter 2). Fish in the project area may overwinter in lakes where available, or in mainstem habitats. Other studies report fish move to lake habitats with suspended glacial flour for the reservoir for overwintering (Russel 1976 de Brugan and McCart 1974). The reservoir will have a surface area of approximately 59 square miles, which greatly increases the amount of habitat having suitable conditions for overwintering fish. The increase in overwintering habitat may have a beneficial impact on fishery resources of the upper Susitna basin.

Winter reservoir water temperatures may increase the quality of overwintering habitat in the upper Susitna Basin. Reservoir temperatures in the top 100 ft are expected to be in the range of 1 to 2°C (Chapter 2). Winter water temperatures in mainstem habitats in the proposed impoundment area are near 0°C. These warmer water temperatures may benefit fish. During the winter of 1981-1982, fish appeared to seek out water with warmer temperatures in the lower Susitna River. Other investigators have reported fish occupying warmer water areas in the winter (Umeda et al. 1981).

Aquatic studies in progress will provide further information to characterize and quantify the effects of a reduction in spawning habitat and an increase in overwintering habitat.

Longnose sucker and grayling generally spawn in tributary habitats during late spring (Morrow 1980). The reservoir is expected to be filling rapidly at this time of year, perhaps 5 ft per day. Spawning areas in tributary habitats may be inundated before embryo development is complete.

- Tributary Habitats

Filling Watana Reservoir will inundate portions of six tributaries (Table E.3.16) including Deadman, Watana, Kosina, Jay and Goose Creeks and the Oshetna River. All of these tributaries support grayling populations. Grayling that depend on habitats inundated by the reservoir would probably be lost. Portions of these tributaries that would be inundated provide spawning and summer feeding areas for grayling.

The initiation of reservoir filling in May 1992 coincides with grayling spawning activities. In the project area Arctic grayling spawn in the clear water tributaries during spring break-up and the embryos take approximately 11 to 21 days to develop (Morrow 1980). Most of the spawning activity appears to take place in the lower portion of the tributaries. Spawning areas in the six creeks will be inundated in May and June of the first year of filling. The water surface elevation is forecast to increase at a rate of 5 ft per day during the spawning period with increases of 3 ft per day during the latter part of the incubation period.

Eggs deposited in inundated areas are expected to be adversely effected. Inundation of grayling spawning areas would be expected to result in sediment deposition over the embryos. During the grayling spawning period, streams generally carry increased sediment loads from high flows and breakup. The sediments carried by the stream will be deposited at the confluence with the reservoir. Thus embryos on the stream bottom would likely be covered with sediment and suffocate.

Longnosed sucker may spawn in tributary mouths during the spring (ADF&G 1981f). They are expected to experience the same effects as grayling.

Arctic grayling depend on tributary habitats for summer rearing areas. Grayling are not expected to occupy reservoir habitats during the summer as they are not found in lake habitats with turbidity levels similar to those projected to occur in the reservoir (Russell 1980). Grayling densities in tributaries appear to be high averaging 500 fish per mile, indicating that available summer habitats are occupied (ADF&G 1981f). Grayling occupying tributary habitats inundated by the reservoir will likely be lost.

Approximately 2.3 miles of Deadman Creek would be inundated by the reservoir at full pool. Presently a waterfall located about 1 mile upstream from the mouth prevents upstream fish migration. The reservoir would eliminate this barrier and allow fish passage to the upper Deadman Creek and Deadman Lake.

Dolly Varden are expected to be slightly affected by the inundation. In the project area, Dolly Varden are residents occupying tributary habitats during the open-water season. Dolly Varden occupy a wide range of habitat types in southcentral Alaska including glacial lakes with a wide range of water quality (Russell 1980). It is anticipated that Dolly Varden will occupy reservoir habitat year-round.

Dolly Varden spawn in the fall, the embryos incubate through the winter and the alevins emerge in the late spring. Since the reservoir is not filling during the spawning and incubation period, any spawning areas available in the fall would probably not be inundated before emergence.

- <u>Lake Habitats</u>

Sally Lake and several other small lakes would be inundated by the reservoir. Sally Lake has populations of lake trout and grayling that appear to be stunted (ADF&G 1981f). Since grayling populations are not usually associated with glacial lakes or turbid water, the grayling population would likely be lost. Lake trout may be able to survive in the reservoir if an adequate food base exists. Lake trout are found in glacial lakes including Chakachamna and Kontrashibuna Lakes (Bechtel Civil and Minerals, Inc. 1981, and Russell 1980).

- Talkeetna to Watana Dam

Table E.3.17 presents a comparison of average monthly pre-project flows and projected monthly flows at Gold Creek during initial reservoir filling. The greatest change to the system will occur during the open-water season. Filling phase of the Watana development will alter streamflows, water quality and water temperatures downstream from Watana Dam to Talkeetna (Chapter 2).

. Mainstem Habitats

Mainstem habitats in this reach can be divided into two segments: from Watana Dam to RM 156.8 in Devil Canyon and from RM 156.8 to Talkeetna (RM 99). High velocities associated with natural flows through Devil canyon appear to prohibit upstream passage of fish beyond RM 156.8. Thus, anadromous fish are prevented from using habitats upstream of the canyon. During the open-water season (June through October) mainstem habitats below Devil Canyon are generally used as a migratory corridor by adult and juvenile fish as they move to and from spawning and rearing areas that are located in other habitat types associated with the river. Only a few isolated salmon spawning areas have been identified in the mainstem (ADF&G 1981b). Few juvenile salmon are suspected to rear in this habitat type during most of the open-water season. Juvenile salmon and resident fish move into mainstem habitats for overwintering as the river clears in late fall (ADF&G 1981d and 1981e). Several resident fish including burbot, whitefish and longnose sucker may occupy mainstem habitats year-round (ADF&G 1981e). Upstream of Devil Canyon, mainstem habitats are used by burbot, sculpin, longnose sucker and whitefish year-round and by Arctic grayling for overwintering habitat (ADF&G 1981f).

A variety of changes may occur in mainstem habitats as a result of the proposed reservoir filling schedule. Flows will be substantially reduced during the spring period. With the exception of the first year, average monthly flows in May and June will be reduced to 6000 cfs from pre-project flows of 13,200 to 27,800 cfs, respectively (Table E.3.17). Decreases of this magnitude will likely affect the physical processes in this reach, which may in turn affect fish associated with this habitat type.

Filling flows during May and June may affect the mechanical process and ice removal in this reach. Presently, the natural flows increase during May, causing a mechanical breakup of the ice cover, and rapidly transport large chunks of ice and sediment downstream. This force results from the rising stream flows from snowmelt and is common to many Alaskan rivers. Under the filling schedule, mechanical break-up may be restricted in mainstem habitats and unlikely to occur in side-channel or slough habitats. Thus ice scouring and bank gouging would be reduced. Ice jams and resultant overflows would be diminished (Chapter 2).

Outmigration of salmon fry and smolts generally occurs in June, apparently on the receding limb of the spring high flows. Flows of 6000 cfs would probably not affect downstream migrations in mainstem habitats as sufficient depth and velocities would exist to transport fry or smolts. Depths and velocities predicted by the water surface profile model at several transects selected for navigation studies indicate that at 6000 cfs, depths would be approximately 2 ft. Access to mainstem channels from slough and side-channel habitats may be adversely affected. This will be addressed in those sections.

Flows of 6000 cfs would persist until the last week of July. Chinook salmon are passing through the system during this time to spawning habitats in tributary streams. These fish hold in mainstem areas to mature before moving into the tributaries (ADF&G 1981b). A cursory examination of the river indicates that many of the holding areas available at flows of 20,000 cfs would probably not be available at 6000 cfs. Other suitable holding areas are expected to exist under the low-flow conditions resulting from the reservoir filling. If adult fish prematurely move into the tributaries due to lack of mainstem holding areas, they may be subjected to increased predation and angling pressure.

Under the proposed filling schedule, Devil Canyon may not block all upstream fish passage. Chinook salmon would likely be able to pass through the canyon and utilize spawning habitat available in tributaries upstream of Devil Canyon and below Watana Dam. In 1982, chinook salmon spawned in the mainstem at the mouth of Cheechako Creek (RM 152.5) and in an unnamed Creek (Chinook Creek RM 156.8), both above the Devil Canyon dam site. High velocities blocked migrations past RM 156.8 (Trent 1982). According to 1982 USGS provisional streamflow data, flow levels dropped to 17,000 cfs at Gold Creek in early July, then rose to 25,000 for the remainder of the month. Since the telemetry studies placed chinook salmon in Devil Canyon in late June, the salmon probably passed through the canyon in early July. High flows in 1981 prevented them from migrating past RM 151.7 (ADF&G 1981b). Under the proposed filling schedule, a flow of 6000 cfs would be present in the canyon through late July. The entire canyon is expected to be passable by chinook salmon, allowing them to enter Tsusena and Fog Creeks (RM 178.9 and 173.9).

Pink, chum and coho salmon spawning areas in the mainstem may be adversely affected by the filling schedule. These spawning areas are generally small, isolated areas on the river margins or behind velocity barriers. Lateral areas are more susceptible to changes in flow. The quality of these habitats may be degraded through reduced depth and velocity, some areas may be completely dewatered.

Fall flows drop rapidly under the filling schedule (Figure E.2.19). Spawning areas of fall spawning fish, such as Bering cisco, and other whitefish, could be adversely affected by receding flows. In addition, salmon spawning areas may be dewatered. Generally, the lateral areas are somewhat buffered. The river develops an ice cover and increases in stage before the flow drops to its lowest level. Under the filling flows, the river would reach 2000 cfs in October, whereas flows of 2000 cfs do not normally occur until November. Thus, the stage during filling in October would be reduced, decreasing the wetted perimeter.

Since the diversion tunnels will function as a single, low-level outlet for downstream releases, the thermal regime of the Susitna River from Talkeetna to Watana Dam will be altered (Chapter 2). Water temperatures during the first open-water period of reservoir filling (May through October) will be similar to pre-project temperatures as the inflow has water temperatures of 9 to 4 degrees Celcius. Thus, the entire reservoir will be near 9° to 10°C (Chapter 2). Since the reservoir acts as a heat sink, winter temperatures above Devil Canyon may range from 2 to 4°C. When the water reaches RM 160, water temperatures are expected to near 0°C (pre-project levels). Temperatures during the second open-water season may be substantially reduced. Water released at Watana Dam is expected to be 4°C. Due to the large volume (12,000 cfs) and the high water velocities (3-4 fps), water temperatures are expected to be in the range of 5° to 6°C at Talkeetna. During

During the third year of filling, reservoir water surface elevations are expected to be high enough to utilize the multiple level outlet structure. This should provide sufficient control to release water near 10°C during July, August, and early September.

Lower water temperatures during the second open-water season may adversely affect fish populations in the reach from Talkeetna to Watana Dam. Projected water temperatures of 5° - 6°C are well below normal water tempertures of 10° to 12°C in August. Low water temperatures may deter adult salmon from entering the reach above Talkeetna. Pink and Coho salmon may be especially sensitive to low water temperatures as these species are usually found in warmer areas. Chum salmon may tolerate lower water temperatures as they reportedly spawn in water temperatures near 6°C (AEIDC unpublished data 1980, ADF&G unpublished water temperature data 1982), however, low water temperatures in mainstem holding areas may delay spawning. Temperatures in the range of 4° to 6°C retained seasonal maturity of gonads and delay spawning activity in salmon (Reingold 1968).

Lower water temperatures during the open-water season are expected to adversely affect resident and juvenile anadromous fish that utilize mainstem and side-channel habitat. Water temperature is closely correlated with feeding activity and growth (Clarke, Shelbourn, and Brett, 1982). Colder water temperatures may reduce growth during the open-water season. Fish may avoid mainstem and side-channel habitats and move to warmer water in turbidity and slough habitat. Juvenile salmon were found to avoid cooler water when possible (Bustard and Narver 1975).

- <u>Side-Channel Habitats</u>

Many of the physical changes identified for mainstem habitats would also occur in side-channel habitats. Since the side channels are generally characterized by higher streambed elevations, the forecasted changes in streamflow may cause greater effects in side-channel habitats. During the open-water season, side-channel habitats are used for passage by salmon and rainbow trout, for spawning by pink, chum and coho salmon and for summer feeding areas by longnose sucker, burbot and whitefish (ADF&G 1981b, 1981d and 1981e). Little juvenile salmon rearing has been reported in side-channel habitats during the open-water season (ADF&G 1981e).

As in mainstem habitats, the greatest changes would probably occur in the spring (Table E.3.17). Many side channels that normally convey water in May, June and the first three weeks of July, would likely be dewatered under filling flows, which represent a decrease in average monthly flows of approximately 70 and 40 percent, respectively for June and July.

In other side-channels, flow may be reduced to an extent that the outmigration of salmon fry would be delayed. Higher spawning flows may allow fish to spawn in areas that are essentially cut off from the mainstem river. Thus, fry may be delayed until higher flows are released in late July. Few side-channels that are wetted at 12,000 cfs are expected to be cut off at 6,000 cfs.

Filling flows would alter the hydraulic conditions of the side channels as lower discharges would decrease velocities and depths. This may improve the quality of these areas as rearing habitat for some resident and juvenile anadromous fish. Juvenile fish are generally found in association with low velocities (ADF&G 1982, Wilson et al. 1981 and Environaid 1982). Burbot, longnose sucker and whitefish are also found in waters with a low velocity but require greater depth.

Use of these areas by juvenile salmon may be presently limited by lack of a food source. Under filling flows suspended sediment would be decreased allowing greater light penetration; the scouring effect of the suspended solids presently carried by the river would also be reduced (Chapter 2).

Some side channels above Talkeetna would be completely dewatered under the proposed filling flows thus eliminating any rearing or feeding habitat normally supported by pre-project flow levels. Benthic production from these areas would also be lost.

Reduced flows in the spring may inhibit emergence and outmigration in some side-channel spawning areas. At times, spawning areas can be substantially dewatered but the embryos can be maintained by intergravel flow that allows development to proceed. Normally, increased spring streamflow in these areas provides water for emergence and outmigration. Filling flows may not be sufficient to provide streamflow in some of these areas.

Forecasted August and September flows under the filling schedule may adversely affect spawning habitat in side-channels. Reductions in average monthy streamflows of 46 and 30 percent respectively may dewater some spawning areas currently used by salmon (Table E.3.17). Decreased mainstem flows would likely result in decreased depths and velocities in side-channel habitats which may alter the availability of spawning habitat.

It is unlikely that new spawning areas would become available under the filling flows. Side-channel habitats with a stream bed elevation low enough to convey water under the forecasted flows would probably not have substrate of a suitable size for spawning. Under natural conditions these side channels are subject to peak flows that have removed most of the gravel substrates, leaving the stream bed armoured with large cobbles and boulders (R & M Consultants 1982c). It is unlikely that the substrate in these areas would change as a result of the project (Chapter 2). Thus, the use of these areas by spawning fish would continue to be limited by substrate. The lateral areas where suitable substrates may exist would likely be dewatered.

Stream temperatures during filling in side-channel habitats will be similar to mainstem habitats (see previous section).

- Slough Habitats

Slough habitats in the Talkeetna to Watana Dam reach have been identified as the most important spawning areas directly influenced by the Susitna River. Sockeye, chum, pink and coho salmon have spawned in 16 of the 33 sloughs found above the confluence with the Chulitna River. Juvenile coho, chinook, sockeye and chum salmon have been found utilizing these areas for rearing habitat and overwintering sites (ADF&G 1981d). Rainbow trout, burbot, longnose sucker and whitefish have been found in these habitats at various times of the year (ADF&G 1981e).

Sloughs in this reach of the river resemble perched side-channels. In general, they function as overflow channels at high flows and convey turbid water from the mainstem. During low flow, clear water originates from surface runoff and groundwater upwelling and flows through the slough channel into the mainstem river. (Refer to Section 2.2 (b) (iii)).

The proposed reductions in mainstem flow during reservoir filling would likely affect slough habitats. Ground water upwelling in the sloughs is probably driven by the stage of the mainstem Susitna River. A reduction in mainstem flow may result in decreased flow in the sloughs (Chapter 2). This could affect the quality and quantity of both spawning and rearing habitat presently available in the system.

Filling flows may cause passage problems for adult salmon moving from mainstem and side-channel habitats into slough habitats. With mainstem flows above 14,000 cfs, a backwater forms at the mouth of the slough. This increases water depths at, and upstream of, the slough mouth. Based on field observations during the low flows of August 1982, streamflows in the range of 12,000 to 14,000 cfs, combined with low surface run off, appeared to hamper or restrict the passage of adult salmon into several sloughs. The stage of the mainstem at flows of approximately 12,000 cfs did not create backwater effects at the mouths of some sloughs great enough to allow free passage by adult salmon. Reduced surface water inflow restricted adult passage to spawning areas that were used in 1981. Under post-project conditions, only the backwater areas would be affected. Surface runoff, which is controlled by rainfall and snow melt, will contribute to flow in the sloughs and control the physical characteristics of the habitat upstream of the backwater during the open-water season.

Preliminary estimates indicate that flows of 16,000 to 18,000 cfs at Gold Creek may be required to insure easy passage of adults into slough habitats. Fish moved rapidly into sloughs during late August 1982 when the surface water runoff increased slough flows and mainstem flows rose from 12,000 to 18,000 cfs (Trihey 1982c).

A reduction in mainstem stage may degrade or eliminate some spawning habitat in the sloughs. Adult sockeye and chum appear to seek out areas with upwelling groundwater to spawn. If a reduction in mainstem discharge reduces the amount of upwelling or the area influenced by upwelling, spawning habitat may be reduced or eliminated. Often, the backwater at the mouth of the slough increases water depth in the lower portion of the spawning area. A decrease in stage may prevent the use of these areas. Reduced water depth could also increase the effectiveness of fish predators.

Since juvenile fish occupy habitats with a relatively wide range of depth, decreases in the depth of sloughs may have little effect on the utility of rearing habitat. The greatest impact to juvenile habitat would occur if the reduction in depth also eliminates or reduces the utility of cover objects associated with slough habitats. In addition to object cover, young chinook have been observed occupying the interface between the turbid and clear water portions of the backwater at the mouth of the slough. Under the proposed flow regime during reservoir filling the amount of this particular habitat would be reduced by decreased backwater effects and lower turbidities. Additional rearing habitat may become available in mainstem and side-channel habitats. (These habitats are discussed in their respective sections.)

The reduction of mainstem flows during the spring and the altered breakup process may affect outmigration from slough habitats. There is some speculation that changes in water levels and temperatures may trigger outmigration in young salmon. Fish were observed to outmigrate on the receding edge of the high flows in spring 1982. Under the filling schedule, the high flows during the spring would be eliminated. Flow from local runoff would be unaffected. This flow and rising water temperatures may stimulate fry to out-migrate (Thomas 1975).

Under filling flows and increased beaver activity may have an adverse affect on slough habitats. The elimination of spring break-up flows will allow beaver to become established in most sloughs. During the low flows of August 1982, beaver dams located in slough 8A, 9B, and 19 have inhibited use of upstream habitats by adult salmon.

- Tributary Habitats

Compared with other habitat types in the reach from Talkeetna to Watana Dam, tributary habitats receive the largest salmon escapement (ADF&G 1981b). They also provide important spawning habitat for grayling and rainbow trout and rearing habitat for chinook and coho salmon juveniles (ADF&G 1981d and 1981e).

With the exception of tributary mouths, tributary habitats below the impoundment will not be affected by the proposed project. Seasonal alterations of the mainstem discharge may alter the hydraulic conditions associated with the tributary mouths. During the open-water season, the present stage in the mainstem river causes a backwater to form at the tributary confluences. The backwater area provides rearing habitat for resident species and juvenile salmon (ADF&G 1981d and 1981e) and facilitates passage of upstream migrants.

Lower mainstem flows during filling will reduce the backwater effects and decrease water depths at tributary mouths. Rearing fish are not expected to be impacted as similar backwater areas will probably form in mainstem habitats just downstream from tributary mouths. Rearing habitat presently located in tributary mouths will shift slightly downstream in location.

A reduction in the stage of the mainstem river could potentially affect passage of adult fish if the tributaries become perched. As the tributary enters the mainstem river, the change in gradient causes the tributary water to drop transported materials. These gravels and sand form small deltas at the mouths of tributaries (Figure E.2.79). As the stage in the mainstem recedes, the tributaries become perched above the river. However, since the flow in the tributary is not regulated, the tributary would continue to experience peak high flows, which may be sufficient to down cut through the delta material to establish a channel at a new gradient. Most tributaries that support fish will not become perched but will cut a new channel through their deltas (R&M 1982f). Some creeks may become perched under the proposed filling schedule, which might impede migration by adult salmon and residents to upstream spawning areas. Of the streams that may become perched under the proposed filling flow, Jack Long (RM 144.8), Sherman (RM 130.9) and Deadhorse (121.0) creeks are the only streams used by adult salmon.

The reduced flows through Devil Canyon may allow chinook salmon access to tributaries upstream from the rapids that have historically blocked salmon migrations (see mainstem section). Under a filling regime of 6,000 cfs in June and 12,000 cfs in late July, chinook salmon would likely have access to Cheechako Creek (RM 152.5) and the unnamed tributary (Chinook Creek) at RM 156.8 on an annual basis. In addition they may have access to Tsusena and Fog Creeks at RM 178.9 and 173.9 respectively. There appears to be adequate habitat in these creeks to allow for salmon production. Thus, the Watana Development may increase the amount of spawning habitat available in tributary habitats in this reach. Future development of the Devil Canyon Dam would, however, eliminate access to these tributaries.

- Cook Inlet to Talkeetna Reach

Project effects below Talkeetna are expected to be considerably reduced in magnitude from those presented for the Talkeetna to Watana Dam reach. Just upstream of Talkeetna, the Chulitna and Talkeetna rivers join the Susitna River. These rivers contribute 40 and 20 percent, respectively, of the stream flow in this reach (R&M Consultants 1981c). Many other major tributaries enter the Susitna in this reach (Chapter 2). In order to apportion the streamflows two streamflow stations were established in this reach; Sunshine and Susitna stations. Tables E.3.18 and E.3.19. present a comparison of pre-project and proposed filling flow regimes for these stations.

Since the project would have no effect on the tributary basins, project-related physical changes in the Susitna River below Talkeetna will be of less magnitude than physical changes above Talkeetna. Impacts to fish habitats below Talkeetna are expected to be limited since only minor changes will occur in physical characteristics of mainstem habitats. Physical characteristics of sidechannels are generally more susceptible to changes in mainstem discharge and the proposed filling flows may affect side-channel habitats. Slough habitats below Talkeetna appear to be less influenced by mainstem streamflows than those above Talkeetna.

. Mainstem Habitats

During the open-water season mainstem habitats in this reach of the Susitna River are used primarily for passage and spawning. A limited number of spawning areas for chum salmon, Bering cisco and eulachon have been located (Trent 1982; ADF&G 1982b). Few rearing fish have been found in this reach, but only limited investigations have been conducted in its lower portion (ADF&G 1981d). Resident fish including burbot, whitefish, and longnose sucker may occupy mainstem habitats during the open-water season (ADF&G 1981e).

Little change is expected in water temperature or turbidity in this reach. The Chulitna River carries a much heavier sediment load and has approximately the same discharge as the pre-project Susitna River at their confluence (R&M Consultants 1981d). Under the proposed filling schedule, the water from the Susitna River would comprise approximately 14 percent of the streamflow below the confluence of the Chulitna and Talkeetna rivers in July and 25 percent in August. The inffluence of the Chulitna and Talkeetna rivers would probably dominate the thermal, water chemistry, and suspended sediment characteristics of the Susitna River below their confluence (Chapter 2).

Only a small reduction in the number and magnitude of peak flows in the Cook Inlet to Talkeetna reach is anticipated. Since the project controls such a small portion of the runoff in this reach, a 1 in 2 year flow event at Susitna Station would become a 1 in 5 or 1 in 10 year event (R&M Consultants 1982). Thus, high flows may still inhibit fish passage at times as well as limit benthic production.

Under the proposed filling schedule, average monthly streamflow in July and August would be reduced by 27 and 17 percent at Sunshine Station (Table E.3.18). Due to the channel geometry of the mainstem, flow reductions of this magnitude would probably not change the utilization of mainstem habitats with regard to salmon passage and resident fish summering activities. The reductions in depth resulting from this decrease in streamflow would probably not create passage problems. Nor is it likely that summer feeding areas would be eliminated. Flow reductions may have a more significant effect on spawning habitat since this habitat tends to be located on the lateral margins of the mainstem.

Most salmon spawning areas in the mainstem are located in broad or braided segments that are more sensitive to changes in flow. Small changes in stage near the threshold value necessary to open the upper end of the braided channel can potentially result in large changes in the availability of spawning areas within the braid.

Salmon and Bering cisco spawning habitats may be subject to greater changes since they occur primarily in the upper portion of this segment from RM 75 to 79 (ADF&G 1982). Eulachon spawning areas would be subject to the least amount of change since they occur in the lower part of the reach, RM 4.5 to 48 (Trent 1982). Project effects here are further muted by tributary inflow from Kroto Creek, Yentna River and several large tributaries.

Bering cisco spawned in mainstem habitats from RM 75 to RM 79 during October 1981 (ADF&G 1982a). During filling, October flows would be reduced by 9 percent the 2nd year and by 27 percent the third year at Sunshine Station, (Table E.e.18). Reductions less than 10 percent are not expected to impact fish as changes in depth and velocity are small. Reduction of 27 percent may affect Bering cisco spawning habitat presently.

In the Susitna River, eulachon mainly spawn below the Yentna River in mainstem habitats (Trent 1982). Eulachon spawning areas were tentatively identified by ADF&G during spawning surveys in May 1982 in relatively shallow water along the margins of the river, along islands and in backwaters at the mouths of side channels. Because of the channel geometry in broad braided floodplain of this reach, similar habitats would probably exist in this portion of the river under the proposed filling schedule. This river segment is buffered by inflow from several major tributaries. Reductions in long term average montly streamflows of 12 percent (from 60,500 to 53,100 cfs) are predicted at Susitna station during May (Table E.3.19). Even if some of the habitat presently utilized is dewatered, habitat that would be available along the margins under the filling flows may provide replacement habitat.

Winter streamflow reductions are not expected to affect habitat utilization in the mainstem below Talkeetna. Low winter flows can stress overwintering fish and embryos and are often a limiting factor for fish populations in Alaska. The most critical time for fish occurs when flows are lowest. In the Susitna River flow generally reaches its lowest level in March. Reductions of 4 and 2 percent are projected at Sunshine and Susitna stations, respectively. Changes in flow of this magnitude would not change water depth under ice or wetted permeter (Chapter 2). Therefore, overwintering success of fish or developing embryos in mainstem habitats are not expected to differ from existing conditions.

Spring break-up flows would be decreased during filling. Average monthly flows in May and June would be reduced by 26 percent at Sunshine Station and by 12 percent at Susitna Station. This reduction is not anticipated to adversely affect the passage of out-migrating salmon smolts in mainstem habitats; neither is it expected to affect the spawning migration of rainbow trout or grayling as they move to the tributaries.

- <u>Side-Channel Habitats</u>

Many of the effects identified for the mainstem under the proposed filling schedule would also probably pertain to side-channel habitats. Mainstem flow generally controls the characteristics of side-channel habitats. However, changes in stream discharge can result in greater effects on side-channel habitats than on mainstem habitats. As in mainstem areas, water temperature and turbidity are expected to be similar to existing conditions below Talkeetna.

During the open-water season side-channel habitats are used for passage by adult and juvenile salmon and resident fish; for spawning by chum salmon; and for summer feeding areas by longnose sucker, burbot and whitefish. Only limited rearing of juvenile salmon has been reported in this habitat type during the open-water season.

Reductions in streamflow during August may dewater some salmon spawning habitat in side channels. Salmon spawning activity in this habitat type is generally located in side channels with relatively high streambed elevations. These areas are protected from the high scouring flows and are able to retain substrates suitably sized for spawning. The high streambed elevation also makes them susceptible to dewatering under reduced mainstem discharge. The lower streamflows proposed during August may reduce the availability of spawning habitat in these areas.

It is unlikely that lower flows during reservoir filling will create new spawning areas in side channels that do not presently support spawning activity. Even though suitable hydraulic conditions will occur, the presence of large substrate particles would probably limit their utility to fish. Side channels with suitable hydraulic conditions under the proposed filling flows will also have fairly low streambed elevations. Because of the low streambed elevations, they will still be subject to high scouring flows and will be armoured with large cobbles.

Studies are planned to investigate the relative incubation success in side-channel habitats and to quantify the changes in the availability of side-channel habitat to determine the effect on salmon production.

The proposed filling flow regime may affect rearing habitat in side channels below Talkeetna. Side channels have a gradation of streambed elevations from high overflow channels to deep channels. The effect of reduced streamflows on rearing habitat will depend on the streambed elevation of the side channel. Some rearing habitat for juvenile anadromous and resident fish may be lost if side channels dewater or water depths become too shallow. Generally, reduced flows increase the available rearing area as young fish prefer low velocities (ADF&G 1982a, Wilson et al. 1980, and Environaid 1982). New rearing areas may become available in other side channels where the flow reductions decrease velocities but maintain sufficient depth. Thus, the potential exists for the location of the rearing habitat to change, but the availability of rearing habitat to be similar to pre-project levels.

Rearing habitat and summer feeding areas may be limited by the availability of food in side-channel habitats. Suspended sediment load and peak flows may cause low benthic production in the Susitna River. Since little change is expected in these parameters below Talkeetna (R&M Consultants 1981, 1982c), the change in hydraulic characteristics may not be sufficient to increase utilization of these habitats by anadromous juvenile and resident fish.

- Slough Habitats

Few sloughs below the confluence of the Chulitna River have been extensively sampled. Slough habitats in this reach have been identified as spawning and rearing areas (ADF&G 1981b, 1981d, 1981c). Many of these areas are influenced by tributary streams and, to a lesser degree, by the mainstem system. Chum, pink and sockeye salmon spawn in slough habitats below the Chulitna confluence. Juvenile coho and chinook salmon have been found using these areas for rearing and overwintering; (ADF&G 1981d). Rainbow trout, burbot, longnose sucker, and whitefish use these habitats seasonally (ADF&G 1981e).

Sloughs in the Cook Inlet to Talkeetna Reach may be affected in generally the same way as sloughs above Talkeetna. The magnitude of predicted change in mainstem flow is less in this reach, therefore the magnitude of changes to slough habitats and the resultant impacts to fishery resources is expected to be smaller.

- Tributary Habitats

For the most part, tributary habitats in the Cook Inlet to Talkeetna reach of the Susitna River are not expected to be affected by the project. The project would not alter any of the existing physical processes in the tributaries with the exception of the area near tributary mouths. The mainstem creates a backwater at the mouths of the tributaries which provides habitat for rearing juveniles and resident fish (ADF&G 1981d, e).

The stage in the mainstem controls the extent of these backwater areas. Flow reductions under the proposed filling schedule may alter the physical characteristics of the tributary mouths in the upper portion of this reach. During the open-water season, mainstem discharge would be reduced by 12 to 34 percent at Sunshine Station (Table E.e.18). Reductions in flow in June (34 percent) and July (28 percent) may reduce the areal extent of these backwaters. Depth would decrease and velocity would increase as the stage of the mainstem drops.

Tributaries that enter the mainstem Susitna River in the lower portion of this reach would probably be minimally affected since the percent change in dischare would be relatively small. Flow reductions ranging from 13 to 8 percent are anticipated in June through August at Susitna Station (Table E.3.19). Tributaries are not expected to become perched because of these reductions in mainstem discharge.

During the winter, tributary mouths provide important overwintering habitat and may provide spawning habitat for burbot. Because of the small reduction in mainstem discharge, winter conditions are expected to remain similar to pre-project conditions.

- Estuary

Since only minor increases in salinity are anticipated during reservoir filling, impacts to fishery resources are not expected.

(iii) Operation of Watana Dam

- Reservoir Habitats

Watana Reservoir will have an area of approximately 59 sq. mi. with depths up to 735 ft. The reservoir will experience an annual drawdown of 105 ft (Maximum drawdown is 120 ft). The reservoir will reach its lowest level in mid May (2080 ft) and full pool by early September.

Water quality conditions expected in the reservoir are discussed in Chapter 2 and are not expected to preclude seasonal fish utilization of the reservoir.

Habitat potential of the reservoir is considered to be limited due to low productivity. The reservoir will be oligotrophic due to summer turbidity levels of 30-50 NTU and the 105 ft drawdown will inhibit development of a litteral zone. Thus, food availability may limit fish populations in the reservoir.

As discussed under reservoir filling (Section 2.3 (a) (ii)), limited populations of burbot, lake trout, and whitefish may utilize the reservoir year-round. Reproduction of reservoir fish is expected to be limited due to the drop in water surface elevation during reservoir operation in winter. In Alaska and British Columbia, lake trout spawn in depths from 3 ft to 110 ft (Morrow 1980). Drawdown during the probable incubation period for lake trout is 70 ft. Burbot probably spawn in December and may take 60 days to hatch (Morrow 1980). Drawdown during December and January is expected to be 40 ft.

Grayling and longnose sucker are expected to use the reservoir for overwintering (as discussed in Section 2.3 (a) (ii), Filling Watana Reservoir). Water level fluctuations in the reservoir are expected to adversely affect the spawning activities of these species. Both grayling and longnose sucker spawn in tributary habitats during late spring (Morrow 1980). The reservoir will be rapidly filling at that time of the year (1 ft per day). Even though these fish have a relatively short incubation period (2 to 3 weeks), spawning areas will be inundated before the eggs hatch. Table E.3.20 shows the length of tributaries inundated during late May and June. Rising water levels will cause sediment deposition in spawning areas resulting in mortalities to developing embryos. (This is discussed in Section 2.3 (a), (ii), Filling Watana Reservoir). The incubation success of fish spawning in tributary habitats above 2135 ft in elevation would not be effected.

As presented in Section 2.3 (a) (ii), reservoir habitats are expected to provide overwintering habitat for grayling, lake trout, burbot, whitefish, longnose sucker and Dolly Varden.

- Talkeetna to Watana Dam

  . Mainstem Habitats

Mainstem habitats in this reach can be divided into two segments: those above Devil Canyon and those below Devil Canyon. Water velocity in Devil Canyon presently prohibits the upstream passage of fish, thus, anadromous fish and rainbow trout are prevented from utilizing habitats upstream of the canyon.

Post-project streamflows in the mainstem during the open-water season would be substantially reduced from pre-project conditions. Table E.3.24 presents a comparison of pre- and post-project stream flows for Gold Creek station. Reductions in average monthly flows from 40 to 62 percent are predicted in June through August (Chapter 2). Because of the rectangular channel configuration of existing mainstem areas, reductions of this magnitude would probably not adversely affect their utilization. In fact, decreased stream flows may slightly improve the utility of mainstem habitats for both anadromous and resident fish. Use of these areas may presently be limited in part by high velocities.

Streamflows during project operation are not expected to adversely affect the upstream passage of migrating fish in the mainstem. Average monthly flows in July are projected to be 9,200 cfs, a decrease of 62 percent from pre-project conditions. Although water depths would be decreased in many mainstem habitats, sufficient depth would still be available for fish passage. Operating flows are higher than filling flows from May through July and are expected to provide greater depths than filling flows.

As in filling flow conditions, velocities in Devil Canyon may not block all upstream fish passage during project operation. Chinook salmon would likely be able to pass through the canyon and utilize spawning habitat available in tributaries upstream from Devil Canyon and below Watana Dam (Section 2.3 (a) (ii)).

A significant reduction in the number and magnitude of flood events in this reach of the Susitna River would likely result from project operation (Chapter 2). This could have several beneficial effects on mainstem habitats. Presently, the Susitna River at Gold Creek carries peak flows of 75,000 to 80,000 cfs (10 yr frequency). These floods transport large amounts of sediment, scour the river bed and remove most of the suitable spawning gravels. Reduction of these peak flows would reduce the habitat disruptions associated with high flows.

There is some indication that high flows may, at times, limit fish passage. High stream flows that occurred in August 1981 appeared to inhibit upstream migration of adult salmon (ADF&G 1981b and 1982a). Migration resumed when flows receded. Operation of the project would decrease the magnitude of high flows and associated velocities thus reducing disruptions in migrations.

Small isolated spawning areas are presently available in the mainstem. Some of these areas, generally located on the river margins behind a velocity barrier, may be degraded or dewatered. The creation of new spawning habitat appears unlikely. Although adequate depth and velocities are likely to exist, the lack of suitable substrate would likely limit spawning in this type of habitat. The streambed of most mainstem channels is composed of large cobbles and boulders (R&M Consultants 1981c). Even though flood flows would probably no longer flush gravels from this reach, the recruitment of gravel to the river may be limited. Small, isolated deposits of gravel may occur downstream from tributary mouths and may provide some suitable spawning habitat.

Sediment transport under post-project conditions would be markedly different from present conditions. The reservoir is expected to act as a settling basin, removing much of the suspended sediment load presently transported by the river. Nearly all sediments less than 5 microns in size would be trapped by the reservoir. A large portion (20 to 25 percent) of the sediments carried by the river is glacial flour in the 2 micron diameter range (R&M Consultants 1982c). These would pass through the dam and be transported downstream to Cook Inlet.

The sediment load of the outflow water would be reduced by 75 to 80 percent from that of pre-project conditions (Chapter 2). The relatively clear water may pick up silts and sand downstream of the dam and transport them down river. Over time, this would result in the removal of fine sediments from the streambed. However, much of the riverbed above Talkeetna is presently armoured with large gravels and cobbles. Silts may be removed only from the surface of the streambed (Chapter 2).

Reduction in the number of high flows should also reduce the frequency of streambed scour in mainstem habitats. At present, high flows may be limiting benthic production in the mainstem as frequent bed movement may preclude the development of a stable environment. Decreased sediment load would also be expected to improve benthic production as siltation of interstitial spaces would be reduced.

Rearing habitat in the mainstem may be slightly increased under post-project conditions. Reduced velocities and turbidity would probably benefit young fish and resident adults. Areas providing suitable habitat would likely still be limited to river margins or other low-velocity areas created by obstructions in the channel. Increased benthic production would also enhance rearing habitats by providing increased availability of prey items. Some fish presently use the turbidity as cover. Increased clarity may result in greater predation on small fish. Resident fish would probably also be more susceptible to sport fishing.

During the winter (November through April), mainstem habitats are used by rearing salmon and resident fish including rainbow trout, burbot whitefish and longnose sucker. Fish move out of the tributaries to mainstem habitats where most overwintering occurs (ADF&G 1981d, 1981e). Average monthly stream flows for the Susitna during this period would increase as a result of dam operations, i.e., from 1800 cfs to 10,700 cfs at Gold Creek in December, (Table E.3.20). Increases of this magnitude would likely alter the character of winter habitats.

Winter thermal characteristics of the reservoir determine the outflow temperatures and directly influence downstream water temperatures. Increases have been postulated that would likely raise mainstem water temperatures above Devil Canyon from near 0 to 2-4°C. Stream temperatures such as these would preclude development of an ice cover in much of this reach eliminating the associated staging and backwater effects.

Under post-project winter conditions the river in this reach may have higher velocities, less depth and less wetted perimeter than under pre-project conditions with an ice cover.

Warmer water temperatures may benefit overwintering fish by reducing mortalities associated with freezing. Stream temperature and discharge should remain fairly stable, preventing fish from becoming trapped in unfavorable areas that freeze solid. During the winter of 1981-1982 winter fish distribution appeared to coincide with warmer water temperatures. Bustard and Narver (1975) reported that juvenile coho move to warmer water for overwintering when warmer water is available.

Suspended sediments are projected to increase slightly over present winter conditions. Particles greater than 5 microns would remain in suspension in the reservoir, increasing downstream turbidity levels (Chapter 2). This slight increase in turbidity is not expected to adversely affect fish populations using mainstem habitats. Fish apparently successfully overwinter in habitats with similar levels of turbidity in the Kenai River, Alaska (Burger et al. 1982).

In the portion of the river below Devil Canyon, increased winter flows would probably cause significant changes in winter habitat characteristics. Water temperature is expected to sufficiently decrease to form an ice cover by RM 14, assuming outflow temperatures of 1 to 2°C. Under outflow temperatures of 4°C an ice cover would form by RM 130 (Chapter 2). Downstream of this, winter water temperatures are expected to differ little from pre-project conditions.

The effects of increased winter flows on backwater and staging processes expected to occur under post-project flows may impacts on fish habitat. Wetted perimeter of the river and depth are expected to greatly increase in many mainstem habitats because of increased discharge. High velocities in several steep gradient sections may prevent the formation of an ice cover in these areas. This may cause the formation of frazil ice, which would likely augment backwater effects already increased in magnitude from increased flows. Thus, the stage of the river may be raised more than that expected from the incremental increase in flow. If the stage of the river is raised sufficiently, mainstem water may flood side channels and sloughs.

Increase winter flows are not expected to adversely affect overwintering habitat in mainstem habitats. Greater water depth and increased wetted perimeter is expected to provide more living space for juvenile anadromous and resident fish.

Increased winter temperatures and altered ice processes may affect fishery resources associated with mainstream habitats in the winter period. If the increased surface water temperatures cause an increase in intergravel water temperatures, then incubating embryos will be affected. Incubation rates of fish embryos and benthic invertebrates are closely tied to water temperatures. An increase in intergravel water temperatures would likely accelerate development and may result in early emergence. Early emergence has been related to decreased survival rates in both benthic invertebrates and Pacific salmon (Bailey, Pella, and Taylor 1974). Pink salmon would be especially vulnerable to mortality related to early emergence as they tend to select areas directly influenced by surface water and tend to outmigrate shortly after emergence. Young fish may begin to outmigrate before downstream conditions are suitable. Temperatures below the confluence of the Chulitna River are likely to be near 0°C. Outmigrants encountering these temperatures may experience thermal shock, which has been linked to increased mortality (Brett and Alderdice 1958, Brett 1952).

Chum salmon would be less susceptible to changes in surface water temperatures as the adults tend to select areas influenced by upwelling groundwater, which is buffered from changes in mainstem surface water. In addition, salmon may rear for approximately a month before moving downstream. Early emergence may have little affect on coho salmon as they remain in freshwater habitats for two years and have been found to seek out warmer areas in the spring.

U.S. Fish and Wildlife Service is conducting an incubation study to determine the effects of different water temperatures on embryo development rates for Susitna River chum salmon.

No adverse impacts to water quality parameters are anticipated under post-project conditions. Gas supersaturation in outflow waters has caused significant fish mortalities from gas bubble disease (Nebeker, Stevens, and Baker 1979; Stevens, Nebeker and Baker 1980). Water passing over a high spillway into a deep plunge pool dissolves air causing supersaturation. The degree to which this occurs depends on the depth of the plunge pool, height of the spillway and amount of water being spilled. Supersaturated water is unstable and over time will return to normal levels if exposed to the ambient air pressure. However, travel time downstream during high flow periods can be fairly short, causing supersaturation to extend considerable distances downstream. The spillway design includes the installation of cone valves, which help prevent gas supersaturation from occurring for all floods with a return period of less than once in 50 years (Chapter 2).

- Side-Channel Habitats

Many of the project-induced physical changes identified for mainstem habitats would also occur in side-channel habitats. Reductions from pre-project streamflow during the open-water season may dewater some spawning habitat presently used by salmon. However, spawning habitat under operational flows may be greater than that under filling flows.

The lower post-project flows during the spawning season may tend to concentrate spawners in areas that are less likely to dewater under higher winter flows. Side channels with lower streambed elevations are presently subject to high scouring flows and many do not have substrates suitable for spawning. Most are armored with large cobbles and boulders that are underlain with large gravels embedded in silt and sand.

Operational flow may result in additional rearing areas becoming available in side-channel habitats during the open-water season. Lower discharges generally result in decreased velocities and depths. This would likely improve the quality of these areas as rearing habitat for some resident and juvenile anadromous fish.

Post-project water temperatures in the side-channel areas would be similar to mainstem water temperatures since mainstem water would be the controlling factor. However, temperatures of water in lateral margins of the side channels may be slightly warmer than mainstem water due to shallower depths and slower velocities. The projected decrease in turbidity may result in more solar radiation being absorbed by the water. Increased water temperatures may enhance the quality of rearing habitat in side channels (Abbed 1980; Clarke, Shelbourn and Brett 1981).

Major impacts downstream of Watana dam expected to result from project operations, are summarized in Figure E.3.20a.

A decrease in turbidity would also likely have a beneficial effect on food production in side-channel habitats. More energy would be available for primary production thus increasing the food base for other trophic levels. The lower sediment load may also remove many of the silts and sands presently occupying the interstitial spaces of the substrate. This may provide more habitat for benthic invertebrates.

During the late fall and winter period mainstem discharges would be increased approximately 250 to 650 percent (Table E.3.24). The magnitude of the increase in flow expected to occur in side channel habitats is dependent on the stage in the mainstem and the streambed elevation of the side channels. Wetted perimeter, depth and velocities may increase in these habitats during the winter months. The seasonal variation in flow pattern would be substantially reduced under the post-project flow regime. Presently, the stage in the side channel drops in the fall as mainstem flows decrease. As the river forms an ice cover, the stage in the side channel increases because of the backwater effects caused by ice formation. Under post-project conditions, the flow would not drop significantly below 8,000 cfs in the fall/winter period. Thus, some side channels would be less susceptible to dewatering and freezing under higher post-project winter flows than at present.

Incubation success in side-channel areas may be improved under post-project conditions as the eggs would not be as likely to dewater. Increased flows may also provide greater intergravel flow, which would benefit incubating embryos and alevins. Post-project flows would also improve the quality of overwintering habitat for juvenile anadromous and resident fish in side channel habitats. Greater water depths would provide more living space and would be less likely to freeze solid during the winter.

. Slough Habitats

During the open-water season, impacts to slough habitats above Talkeetna under operation of Watana Dam are not expected to differ from those resulting from filling Watana Reservoir. Streamflows during late fall and winter will be increased, providing a higher stage in the mainstem. The increased stage may increase the rate and areal extent of groundwater upwelling in the sloughs. Incubation success of salmon embryos may be improved.

Post-project winter conditions may affect incubation and overwintering in the sloughs. The increased flows in conjunction with increased water temperatures would change the ice processes in this reach of river. Presently, as the mainstem forms an ice cover, the stage increases due to the backwater effects. Thus at winter discharges of approximately 1500 cfs, the stage in the river and the wetter perimeter resembles that of a discharge of approximately 23,000 cfs. Under postproject conditions the river may not form an ice cover above RM 130. Thus, the stage in the river and the wetted perimeter of sloughs and side channels would probably be decreased relative to pre-project conditions during the winter months. If the decrease in wetted perimeter and water depth results in dewatering or increased depth of freeze, eggs incubating in the gravels could be adversely affected. Overwintering areas could also be adversely affected by the same physical processes which may cause increased mortalities for juvenile anadromous and resident fish.

In sloughs near the edge and downstream of the ice cover, surface water temperatures could be affected. If the post-project mainstem flow enters the head ends of the sloughs, the addition of mainstem water would reduce the surface water temperatures of the sloughs and increase the formation of ice. In some cases considerable glaciation could occur and the value of these areas for overwintering may be reduced.

The ice could also remain and reduce surface water temperatures in the sloughs well into the spring. Since the mechanical break-up likely would not occur, these ice formations in the sloughs would have to melt out rather than being carried out by high flows. Ice may be present in the sloughs until late June. The presence of ice would reduce the surface water temperatures and may alter the quality of these areas as early nursery areas for emerging fry.

. Tributary Habitats

Tributary habitats in the Talkeetna to Watana Dam reach would likely be affected simlarly under both filling and operation during much of the open-water season.

Augmented winter flows may increase the amount of overwintering habitat associated with tributary mouths. A higher discharge in the mainstem may increase the water depth and extent of backwaters at the tributary mouths. Studies indicate that tributary mouths may be important overwintering habitat (ADF&G 1981d, 1981e).

- Cook Inlet to Talkeetna Reach

Project effects in this reach of river are expected to be considerably reduced in magnitude from those presented for the Talkeetna to Watana Dam reach because of the influence of the Chulitna and Talkeetna Rivers. Many of the changes identified under the filling schedule (Section 2.3 (a) (ii)) for the open-water season would persist under operation flows. Winter flows would be increased.

. Mainstem Habitats

During the open-water season, mainstem habitats will be similarly affected under filling of Watana Reservoir and operation of Watana Dam. Operational flows are slightly greater in the spring and fall (Tables E.3.25 and E.3.26).

Bering cisco spawned in mainstem habitats during October 1981. Since little change in average monthly streamflow or in stream temperature is anticipated for October, these fish would probably not be adversely affected by the project.

In the Susitna River, eulachon spawn mainly below the Yentna River in mainstem habitats. Eulachon spawning areas tentatively identified during spawning surveys in May 1982 were located in relatively shallow water along the margins of the river, along islands and in backwaters at the mouths of side channels (Trent 1982). These habitats would probably exist in this portion of the river under post-project conditions. This segment would be subjected to the least amount of change since it is buffered by inflow from all major tributaries. Reduction in average monthly streamflow of 5 percent (from 60,500 to 57,600 cfs) are predicted at Susitna Station during the month of May (Table E.3.26).

During the winter increases in discharge from 2600-5000 cfs to 9,500-13,000 cfs are predicted at Sunshine Station (Table E.3.25). Water temperatures are not expected to differ from pre-project conditions. Increases in discharge may result in a slight increase in wetted perimeter.

The availability of overwintering habitat may increase due to increased water depth and wetter perimeter. Since the flow would remain fairly constant, increased survival may result from reduction of mortality associated with freezing.

Increased winter flows may also increase the survival of salmon embryos. Spawning areas presently dewatered or frozen during low winter flows that occur under pre-project conditons may be improved. The increase in depth and wetted perimeter under post-project flows may prevent dessication or freezing of embryos and alevins in these areas.

- Side-Channel Habitats

As discussed under the reservoir filling flow regime, reductions in stream flow during the open-water season may dewater or degrade some spawning habitat presently used by salmon, as well as affect rearing and summer feeding habitat for residents and anadromous juveniles.

During the winter period streamflows in side-channel habitats would be increased. The increase in wetted perimeter resulting from greater winter discharge has not been quantified, but the seasonal variation in flow through the side channels would be decreased under the post-project flow regime. Presently, the stage in the side channel drops in the fall as mainstem flows decrease. As the river forms an ice cover, the stage in the side channel increases from the backwater effects caused by ice formation in both the mainstem and side channels, which raises the stage in the side channel. Post-project increases in winter discharge will result in increased wetted perimeter.

Increased winter discharge may have a beneficial effect on overwintering fish and incubating embryos. Increased discharge may result in increased depths in side-channel areas. This would provide more living space and perhaps prevent freezeing in these areas. Increased depths may prevent side-channel habitats from being dewatered thus protecting embryos from dessication and freezing. Increased surface flow may also result in increased intergravel flow, which would also benefit embryo development and overwintering juveniles.

- Slough Habitats

  Increases in winter streamflows may have a beneficial effect on slough habitats. The augmented discharge may increase the areal extent of the backwater at the slough mouth creating greater water depth within the slough. The upstream extent of the backwater effect would depend on the gradient of the slough. Increased water depth may prevent a portion of the slough from freezing and increase the availability of overwintering habitat.

- Tributary Habitats

  Tributary mouths are expected to be affected similarly under both filling and operation of Watana Dam during the open water season. During the winter, tributary mouths provide important overwintering habitat. The effects of higher discharge in the mainstem may increase the areal extent of the backwaters, and increase the amount of overwintering habitat associated with tributary mouths.

- Estuary Habitats

  Since only minor changes in salinity are predicted under project operation (Chapter 2), no impacts to fish resources in estuary are anticipated.

(b) Anticipated Impacts to Aquatic Habitat Associated with Devil Canyon

Impacts sustained by aquatic habitats as a result of construction and operation of Devil Canyon Dam will be similar to those occurring under construction and operation of Watana Dam. This section addresses additional impacts and increased magnitude of impacts to aquatic habitats attributable to the development of Devil Canyon Dam assuming Watana Dam is in place.

(i) Construction of Devil Canyon Dam and Related Facilities

- Devil Canyon Dam

  Devil Canyon Dam will be located at RM 152 of the Susitna River approximately 32 miles downstream from the Watana Dam site. A concrete arch dam will be built at the downstream end of Devil Canyon and a fill saddle dam will be connected to the south end of the arch dam. The reservoir behind Devil Canyon will be about 26 miles long and not more than one half mile wide.

The concrete dam and foundation will be approximately 650 feet high and will have a span of 1200 feet at the dam crest. An estimated 2.7 million cubic yards of aggregate will be needed to construct the concrete arch dam. The saddle dam will be approximately 900 feet across and 275 feet high and will require about 1.2 million cubic yards of material.

As with Watana, Devil Canyon Dam will have a powerhouse, inlet, outlet and emergency spillway. A 39-foot diameter tailrace tunnel will direct turbine discharge approximately 1.5 miles downstream of the arch dam.

During construction of the dam, the river will be blocked above and below the site by cofferdams. The flow will be diverted into a 30-foot diameter tunnel 1490 feet long and discharged back into the river. The up- and downstream cofferdams will be about 400 feet long and 200 to 400 feet wide.

The adverse impacts upon aquatic habitat at the Devil Canyon Dam site are expected to be similar to, but less than, those at the Watana site.

At the Devil Canyon Dam site, the Susitna River is confined to a canyon about 600 feet deep and 200 to 400 feet wide. The river bottom is primarily composed of cobbles, boulders, and blocks of rock; the water is extremely turbulent. It is surmised that few fish live in the area of the dam site (ADF&G 1981e). Chinook salmon migrated upstream of Devil Canyon Dam site in 1982 and are expected to pass through the Canyon during the operation of Watana Dam.

- <u>Alternation of Waterbodies</u>

  Impacts from Devil Canyon Dam construction will be primarily restricted to the vicinity of the dam site. A 1000 foot section of the Susitna River between the cofferdams will be dewatered for several years during construction. Although that stretch of river may be inhabited by sculpins and possibly other resident species, it is not expected that dewatering will have more than a minor impact upon availability of suitable habitat. The dam foundation will cover about 90 feet of river bottom. This, too, is considered to be a minor impact.

  Construction of the arch dam and the saddle dam will require excavation in the river channel at the damsite. Excavation by blasting or by mechanical means may result in the introduction of materials into the

Susitna River that may be carried downstream. The turbulence of the water at the site would preclude sedimentation in that stretch of river. Adverse impacts from introduction of increased sediment are expected to be minor.

The greatest impacts during construction of the dam are likely to be associated with gravel mining and processing in streams and floodplains. Gravel for filter material and for concrete aggregate will be removed from the Susitna River and from Cheechako Creek alluvial areas upstream from the dam site. The effects of gravel mining on aquatic systems have been discussed under Section 2.3 (a) (i). Since the material removal sites will be inundated, impacts at the sites will be transitory.

- Changes in Water Quality

Potential impacts to water quality would be primarily caused by increased turbidity due to erosion, and through discharge of effluent from the concrete batching process. Turbidity increases in the Susitna River may be negligible. See Section 2.3 (a) (i) for discussion.

- Disturbance of Fish Populations

Instream activities during material extraction near Cheechako Creek could disrupt fish movements, spawning and rearing depending upon location, type and duration of the activities. It is unlikely that the dam site itself is located in a stretch of the Susitna regularly inhabited by fish, therefore it is not expected that the excavation and blasting required at that location would be disruptive to fish populations.

- Devil Canyon Camp and Village

- Construction and Operation of Camp and Village

During construction of Devil Canyon Dam, housing will be needed for 2300 persons (Exhibit A). Both a construction camp and a construction village will be located about a mile to the southwest of the dam site. The camp will include bachelor dormitories, cafeteria, warehouses, offices, hospital, and recreational buildings. The village will contain housing for 170 families and will include a school, stores and a recreation area.

The camp will be approximately one half mile from the village. Both developments will be more than 700 feet above the Susitna River and more than 4000 feet from the edge of the canyon. Water, sewage and solid waste disposal facilities will be shared by both developments. Water will be withdrawn from the Susitna River and effluent from a biological lagoon system discharged into the river below the water intake. The upper reaches of Jack Long Creek border the camp and the village to the south, coming to within 200 feet of the camp. A small unnamed creek drains a series of lakes 3000 feet to the east of the camp and enters the Susitna at about RM 150. The creek is paralleled by the sewage outfall line for about 1000 feet or about 1/5 of its length.

Both the camps and the village are temporary developments. Permanent personnel responsible for operation of Devil Canyon Dam will live at Watana Village.

The unnamed creek and lakes may support grayling. Jack Long Creek contains pink salmon and chinook salmon in its lower reaches, and also may support chum salmon and coho salmon. Portage Creek contains chinook salmon, coho salmon, rainbow trout, round whitefish and humpback whitefish. Chinook salmon, grayling and Dolly Varden are found in the lower reaches of Cheechako Creek. Impacts as a result of camp/village operations are expected to be limited to the area within a few miles of the dam site.

.. <u>Changes in Water Quality</u>

Erosion into the Susitna River from gravel mining in Cheechako Creek is not expected to result in adverse impacts to fish. Because of its proximity to the developments, Jack Long Creek may receive run-off from the camps. Increased sediment levels may adversely affect spawning habitats downstream.

Water for camp use will be removed from the Susitna River and treated effluent and waste water will be returned to the river. It is anticipated that the treated effluent will be diluted 2000:1 by the Susitna and will therefore have no effect upon fish (Chapter 2). Storm drainage and oily water runoff from the construction camp may affect the upper portion of Jack Long Creek. The fuel storage area is located on the south side of the construction camp about 200 feet above Jack Long Creek. It is possible that accidental fuel spills could reach the creek if storage facilities failed. It is not expected that runoff from the solid waste disposal site and the construction village will adversely affect any water bodies since both are more than 1000 feet from Jack Long Creek.

- Direct Construction Activity

  The camp and village at the Devil Canyon site will house 2300 workers for several years. It is expected that, as a result, streams and lakes in the vicinity may be subjected to increased fishing pressure. This area has not been heavily utilized for sport fishing in the past.

  The water bodies most likely to be affected include Cheechako Creek, unnamed creek and lakes, Jack Long Creek, and to a lesser extent, Portage Creek. With the exception of Portage Creek, these water bodies are within a short distance from the camp/village and the dam site. Portage Creek enters the Susitna River from the north about 2.5 miles downstream from the dam location.

(ii) Filling Devil Canyon Reservoir

- Inundation of Upstream Habitats

  Filling Devil Canyon Reservoir would inundate approximately 26 miles of Susitna River mainstem habitat and 11 miles of tributary habitats over a 5 month period. These habitats would be converted from lotic to lentic systems with accompanying changes in hydraulic characteristics, substrate, turbidity, temperature and nutrient levels. These changes may result in a shift in species composition. The area presently supports Arctic grayling, burbot, longnose sucker, whitefish and Dolly Varden (ADF&G 1981f). Impacts to mainstem habitats are expected to be similar to those presented in Section 2.3.3 (b) (ii) for Watana Reservoir. Effects on tributaries are also expected to be similar to those presented for Watana Reservoir. However, most of the tributaries in the Devil Canyon impoundment area are characterized by steep slopes with occasional barriers, such as waterfalls. Cheechako, Devil and Tsusena Creeks, three tributaries entering the Devil Canyon impoundment, all contain waterfalls. These falls would not be inundated by the impoundment and would still function as effective barriers to fish passage. Thus, the increased overwintering habitat provided by the reservoir may not benefit fish populations in the area.

(iii) Operation of Devil Canyon Dam

Post-project streamflows under the operation of Devil Canyon Dam would be similar to those under the operation of Watana Dam alone. Most of the impacts to the aquatic habitat would have occurred under the start-up and operation of Watana Dam.

Few additional impacts are expected to result from operation of Devil Canyon during the open-water season. Changes in streamflow are presented in Tables E.3.27, E.3.28 and E.3.29.

- Reservoir Habitat

Operation of Devil Canyon Reservoir would likely have effects similar to those discussed for Watana Reservoir. Devil Canyon Reservoir is smaller and its water quality and temperature characteristics would be controlled by Watana Reservoir outflow.

Burbot, whitefish, and longnose sucker may be able to utilize reservoir habitats under project operation. Devil Canyon Reservoir would provide overwintering habitat for tributary fish, but this additional habitat may not be utilized. Most of the tributary habitats would be eliminated by the inundation, perhaps reducing the associated grayling population. Fish passage barriers exist on most streams, which would preclude reservoir use by upstream populations.

- Talkeetna to Devil Canyon Dam

. Mainstem Habitats

Flow in approximately 1.5 miles of river between the dam and the powerhouse outlet would be reduced to 500 cfs. This reduction is not expected to adversely affect fish populations in this portion of the river.

As described in Section 2.3(b)(iii), use of mainstem habitats may significantly change during operation of Watana Dam. Below the Devil Canyon Dam tailrace, however, there would likely be little additional changes in mainstem habitat use during the open-water season. Flow reductions in July and August of 9 and 6 percent, respectively, may slightly increase the magnitude of effects identified under operation of Watana Dam.

Under operation of Devil Canyon Dam, winter water temperatures in the Talkeetna to Devil Canyon reach will be altered. Water temperatures may be sufficiently warm to prevent the formation of an ice cover on the mainstem and some side channels upstream of approximately RM 100, thus the staging and backwater affects associated with an ice cover would not occur in this portion of the river. Winter temperatures in this reach under the operation of Watana Dam are expected to range from 0 to 1°C. Outflow temperature from Devil Canyon Dam may be 2 to 4°C, with downstream temperatures ranging from 0 to 2°C. Although this is a slight increase over natural conditions, it will preclude an ice cover on most of the river above Talkeetna. Impact resulting from altered ice conditions are discussed under Operation of Watana Dam.

. <u>Side-Channel Habitats</u>

Side-channel habitats are expected to sustain impacts similar to those predicted for mainstem habitats under operation of Devil Canyon Dam (see previous section).

. <u>Slough Habitats</u>

The changes in streamflow during the open-water season predicted under operation of Devil Canyon are not expected to affect slough habitats. Alteration of the thermal regime during winter will affect a greater number of sloughs than under operation of Watana but effects are expected to be similar to those discussed in Section (iii).

- <u>Cook Inlet to Talkeetna</u>

No additional impacts are expected to occur in this reach as a result of operation of Devil Canyon Dam. The physical changes to habitats downstream of Talkeetna resulting from the operation of Watana Dam would likely remain the same when Devil Canyon Dam commences operation. A comparison of proposed downstream flows for Watana Dam alone and with the addition of Devil Canyon is presented for Sunshine Station in Table E.3.28. Changes in streamflow ranges from a reduction of 7 to an increase of 11 percent. Changes in flow of this magnitude are not expected to result in effects different from those identified under the operation of Watana Dam. The addition of Devil Canyon would probably not result in meaningful changes in water temperatures, water quality or sediment transport in this reach. Thus, the addition of Devil Canyon Dam is not expected to result in adverse effects on fishery resources associated with habitats below Talkeetna.

- Estuary

The operation of Devil Canyon Dam is not expected to impact the estuary. Physical changes occurring under operation of Watana alone would essentially remain the same under the operation of both dams.

(c) Impacts Associated with Access Roads and Auxiliary Roads

(i) Construction

- Construction of Watana Access Road and Auxiliary Roads

The main access to the Watana Damsite will be from the Denali Highway (APA 1982a). The Watana access road will depart the Denali Highway at milepost 20 and will run approximately 40 miles south to the dam and camp sites. The northern portion of the route traverses high, rolling, tundra-covered hills. The road will cross numerous small streams such as Lily Creek, Seattle Creek, and Brushkana Creek. The northern streams, which are part of the Nenana River drainage, contain grayling and probably other resident species. The southern part of the road will cross and parallel Deadman Creek, which also contains grayling and probably other resident species.

The gravel road will have a crown width of approximately 24 feet and will be constructed over a layer of Typar or similar fabric in some areas. The fabric allows roads to be placed in areas of high organic content and reduces the amount of gravel needed. Before road construction is begun, a corridor at least ten feet wide on either side of the road itself will be cleared.

Short access roads will be needed to reach material sites and disposal sites. The locations and alignments of these auxiliary access roads will be determined when material sites and disposal sites are identified during final road design.

Access construction will involve upgrading the Denali Highway from Cantwell to intersection with the Watana access road, a distance of 23 miles. At this point, planned upgrading includes straightening road curves, improving one bridge, and topping the road with more gravel.

Within the project area, the Denali Highway crosses several small drainages, side channels of the Nenana River, Edmonds Creek and Jack River. Jack River contains grayling and the Nenana River in this region supports several species of resident fish.

Any bridge work or straightening associated with road upgrading will have potential impacts similar to those resulting from new construction. Extension of culverts in places where the road is widened could affect fish passage.

. Alteration of Water Bodies

Stream crossings can be a cause of adverse impacts. Bridges and culverts will be used in fish streams on the main access road. These structures need to be properly sized and bedded to ensure fish passage. This subject will be discussed further in Section 2.4. Other causes of adverse impacts due to road construction can result from the following:

.. Clearing

Clearing must take place in areas of dense or tall vegetation before road building can begin. In some upland areas with tundra vegetation, clearing will be minimal. Clearing can cause degradation of habitat when:

1. Cleared areas by streams and lakes are not stabilized and erode into the water body;

2. Cleared material is pushed into water bodies causing blockage of fish movements, deposition of organics on substrates and downstream erosion; and

3. Clearing along streams affects cover, availability of food organisms and temperatures in that stream stretch.

.. In-stream Activity

During road construction, it may be necessary for heavy equipment to enter water bodies. This can alter the substrate and can cause turbidity and sedimentation.

.. Erosion

Erosion can result from in-stream use of heavy equipment, placement of fill with high organic and/or fines content, lack of stabilization or revegetation on fills and cuts and inadequately placed or sized culverts. The increased sedimentation that may result can degrade downstream habitats.

.. Fill Placement

Fills that are placed within floodplains and streams can remove habitat previously used by fish. The severity of the impact depends upon the type and amount of habitat covered.

Roads can block sheet flow to or across wetlands. When a road bisects a wetland within sufficient drainage, one side becomes ponded while the other side dries. The change in water quantity will affect the vegetation and the nature of the wetland. Some wetlands that are contiguous with streams provide rearing habitat for juvenile fish. If the wetlands are dewatered, that habitat can be reduced or lost. Potential alterations of sheet flow are being considered during the detailed road design.

. Changes in Water Quality

As with dam construction, impacts on water quality during road construction will result mainly from erosion and petroleum product spills. Erosion may occur due to excavation for placement of drainage structures in streams, run-off from disposal sites, run-off from unstabilized fills, placement of material within water bodies, and heavy equipment operating within streams. The road will primarily affect small, clear water systems.

Since the systems to be crossed by the road are most likely clear water grayling streams, they would be among the more sensitive habitats to petroleum products. Chronic or large spills into these streams during construction could have severe effects upon the biota, either causing mortalities or causing fish and their food organisms to avoid contaminated areas (Maynard and Weber 1981, Weber et al. 1981). When equipment is operated in streams or refueling of equipment takes place within a floodplain, petroleum products are likely to enter the water.

. Disruptions of Fish Populations

Fish will tend to avoid areas where in-stream work is being conducted, areas contaminated by petroleum products or, depending on the circumstance, areas experiencing excessive turbidity. Barriers to fish movements and migrations are created when streams are diverted, flumed, or blocked during installation of drainage structures. Fish can also be prevented from moving upstream if the drainage structure is incorrectly installed. Pumping water from streams can adversely affect local populations by entraining juvenile fish.

During road construction, the area between the Denali Highway and the Watana dam site will be occupied by hundreds of workers. Although this area has been recreationally utilized in past years, it has not experienced such a large influx of people. Unless controlled, this influx can increase fishing pressure on the streams and lakes in the area.

- Construction of Devil Canyon Access Road and Auxiliary Roads

Access to the Devil Canyon damsite will either be by road north of the Susitna River from Watana or by rail from Gold Creek south of the Susitna. The road will depart from the Watana road north of the Watana townsite and will parallel Tsusena Creek for approximately 1.5 miles. The route then roughly follows the 2900 foot contour west to Devil Creek. The road turns south along Devil Creek for about 2 miles and proceeds southwesterly to intersect the Susitna River at approximately RM 150, where the road crosses the Susitna and parallels an unnamed creek for a short distance, ending at the construction camp/village site.

For most of the Devil Canyon access road traverses high tundra. Dense shrub vegetation and trees are not encountered until the road nears the Susitna River crossing downstream of Devil Canyon. The road crosses numerous small streams between Tsusena and Devil Creeks. Tsusena Creek contains grayling and possibly cottids and whitefish. Devil Creek may support populations of grayling, suckers, cottids and whitefish. Between Devil Creek and the Susitna River, there appear to be few areas that host fish.

The railroad access will leave the existing railroad at Gold Creek and proceed north to the construction camp site. It will remain on the south side of the Susitna River. The railroad will cross Gold Creek, which is known to contain chinook salmon (ADF&G 1982a) and will cross at least three tributaries that enter the Susitna River near Slough 19. These tributaries most likely do not contain fish, but are probably an important source of clear water for the slough, which is a spawning area for salmon. The railroad will then parallel Jack Long Creek for approximately 3 miles. Jack Long Creek has been documented to contain pink, coho, chinook, and chum salmon. It is assumed that the road between Watana and Devil Canyon will be constructed in the same manner as the segment from the Denali Highway (see Section 3.3 (a) (i)).

. Alterations of Waterbodies

Impacts to aquatic habitat will result from stream crossings and other instream activities.

Considerable floodplain and side channel habitat in Devil Creek, Tsusena Creek, and Jack Long Creek could be affected by road and railroad alignment. Encroachments on streams often reduce sheet flow and flow from springs to the river and cut off side channels and wetland areas. These encroachments often require construction of river training structures to protect road integrity. These structures can further alter the river system, often causing degradation of aquatic habitat. Stream crossings and drainage structures have been discussed. The problems that may occur on the Denali Highway to Watana segment are also applicable to the Devil Canyon access.
Construction of a railroad between Devil Canyon and Gold Creek would present similar problems as road construction: aquatic habitat will be affected by gravel mining, fills, clearing and stream crossings. However, in wetland areas, there is the option of building on trestles rather than fill. This would be less disruptive to natural water movement within the wetland.

. Changes in Water Quality

It is expected that water quality will be affected by turbidity and petroleum product spills as has been discussed for Watana access.

. Disruptions of Fish Populations

Fish populations in areas affected by the Devil Canyon road, auxiliary roads or the railroad will experience disruptions similar to those previously described for Watana access.

(ii) Operation and Maintenance of Roads

- Operation of Watana Access Road and Auxiliary Roads

Impacts due to the operation of the road system will likely result from road traffic and maintenance activities.

. Alteration of Waterbodies

Alteration of waterbodies during road operation will occur as a result of continued maintenance activities. Maintenance involves road grading and replacement of material. Improper maintenance techniques can result in gravel being pushed off the roadway into streams and wetlands and in increased erosion. Road maintenance would have a greater impact on the smaller streams, such as Deadman Creek, than on the Susitna River.

This section considers only the road section from the Denali Highway to Watana Dam, therefore, impacts resulting from road construction will be confined to systems along this road alignment.

- Changes in Water Quality

During road operations, changes in water quality can occur as a result of fuel spills, and erosion from poorly stabilized roadways. Fuel spills would have the most potential impact.

The Watana access road will cross numerous streams, many of which contain fish. In areas where the road crosses or encroaches on a water body, an accident involving large vehicles, including those carrying petroleum products, could occur. The impacts associated with spills will depend upon the season, the type of substance spilled, the size of the system, and the species present.

Erosion from unstable road cuts could be locally chronic, however, these activities are not expected to cause major impacts.

- Disturbance to Fish Populations

Fish have been shown to avoid areas contaminated with petroleum products (Maynard & Weber 1981, Weber et al. 1981) and areas of excessive sedimentation or turbidity. Chronic seepage of oil into streams or lakes could render some areas unusable.

Fish impasses due to either physical or velocity barriers have been discussed under Section 3.3(c)(i).

Possibly the greatest source of adverse impacts upon fish populations is the increased accessibility of fish streams and lakes to fishermen. This will be a greater impact than that resulting from operation of the camps because the network of access roads and auxiliary roads will increase access to lakes and streams.

As stated in Section 2.3(c) (i), the Watana access road will cross Brushkana, Lily, Seattle, and Deadman Creeks as well as other small unnamed streams. These creeks are clear water streams and are usually inhabited by grayling. Deadman Creek, in particular, is known for its large and abundant population of grayling. The reaches above the falls and below Deadman Lake are considered prime grayling habitat. By subjecting this stream to increased fishing pressure many of the larger, older fish may be removed from the population thus causing a decrease in productivity. A similar impact may occur to other grayling streams in the area.

- Operation of Devil Canyon Access Road Auxiliary Roads, and Railroad

Aquatic habitat and fish populations will be influenced by the operation of roads and railroads through activities such as road traffic and maintenance.

. Alteration of Waterbodies

The majority of adverse impacts will have occurred during road construction. Activities such as road grading and replacement of drainage structures will continue to affect stream systems.

. Changes in Water Quality

The impacts described on water quality that may occur during operation of the Watana access road, are also applicable to the Devil Canyon access road and auxiliary roads.

. Disruptions of Fish Populations

Disruptions of fish populations resulting from operation of the Devil Canyon access road, auxiliary roads and railroad most likely will be: avoidance of areas of unacceptable turbidity, sedimentation and contamination; blockages of fish passage and increased accessibility to lakes and streams.

(d) Transmission Lines Impacts

(i) Construction of Transmission Line

- Watana Dam

The transmission line will be built from Watana Dam to Gold Creek on a route that crosses the Susitna River below Watana Dam, runs south of the Susitna to the Devil Canyon construction area, then follows the proposed railroad from Devil Canyon to Gold Creek. At Gold Creek the transmission system will converge with the Anchorage-Fairbanks intertie, which extends from Willow to Healy. The route south of Willow will extend to Point MacKenzie where a submarine cable will cross Knik Arm. The terminus of the southern leg will be the University substation in Anchorage. The northern leg will extend from Healy to Ester near Fairbanks.

A transmission line consists of a series of steel towers that support conductors. In this case, the towers will be x-framed guyed towers that can carry three conductors. From Watana to Gold Creek, there will be two parallel sets of towers. At Gold Creek, two lines will go to Anchorage and two to Fairbanks. This will necessitate construction of one new line parallel to the intertie between Willow and Healy and two new lines north of Healy and south of Willow. With the addition of Devil Canyon Dam, two more lines will be built from Devil Canyon to Gold Creek. This will result in an arrangement of 4 parallel lines of towers in this area.

Throughout the majority of the route, a 400 foot wide right-of-way will be designated. The Devil Canyon - Gold Creek segment will require a 500 foot wide right-of-way. Within the right-of-way, trees and shrubs within 55 feet of the tower centerline will be cleared as well as any other trees or shrubs that may hamper construction or pose a threat to the completed line. Clearing width for a 3-line corridor would be approximately 350 feet (Commonwealth et al. 1982).

The towers within the corridor will be located about 1300 feet apart. The type of foundation used to support the towers will depend upon the substrate. Standard installation involve driving two, 25 foot long steel pilings into the ground to anchor the tower and two 15 foot long cables. For wetlands, the pilings will be 50 feet long and the anchor cables 30 feet long (APA 1982).

- <u>Alteration of Waterbodies</u>

  Adverse impacts of waterbodies will result primarily from clearing stream crossings, and other instream activities associated with installation of the towers and conductors. Permanent roads will not be built and gravel requirements will be minimal. The effects of clearing and heavy equipment traffic have been previously discussed.

  The transmission line can be divided into four segments: central (Watana to Gold Creek), Intertie (Willow to Healy), northern (Healy to Ester), and southern (Willow to Anchorage). In the central section, the line will cross a number of small unnamed tributaries entering the south bank of the Susitna River. The impact of constructing a transmission line through this area will be similar to, but less than, that of the access road (see Section 3.3(c) (i)).

The Anchorage-Fairbanks Intertie is being built as a separate project and will be completed in 1984 (Commonwealth et al. 1982). The Susitna project will add another line of towers within the same right-of-way. The impacts will be similar to those experienced during intertie construction. The Environmental Assessment Report for the intertie (Commonwealth et al. 1982) discusses the expected environmental effects of transmission line construction in this segment. Fish streams that will be crossed include the Nenana River, Talkeetna River, Chunila Creek, Susitna River, and the Kashwitna River.

In the southern segment, the transmission line will begin at the Willow substation approximately one half mile north of Willow Creek. Proceeding south, the line will be routed between the Susitna River and the Nancy Lake area, passing within 0.75 miles of the river. It will cross several Susitna River tributaries including Fish Creek at approximate milepost (AMP) 18, before crossing the Little Susitna at AMP 26. Few streams are crossed between the Little Susitna River and Knik Arm at AMP 44. Knik Arm, which is approximately 2.5 miles wide at that point, is crossed by a submarine cable. The Knik Arm switching station is located between Sixmile Creek and Eagle River. From there the transmission line bypasses Otter Lake, and crosses the Alaska Railroad and Fossil Creek. After crossing the Davis Highway it parallels the Glenn Highway for about 2 miles. Ship Creek is crossed at AMP 75 and traverses the Chugach Foothills before terminating at the University substation near the corner of Tudor and Muldoon Roads.

The northern portion begins at the Healy substation and immediately crosses the Nenana River, proceeding west to Dry Creek at AMP 4.75. The line turns north at this point and roughly parallels the Parks Highway for the majority of its length. The Nenana River is crossed again at AMP 2.75 and AMP 58.75. The line ends at the Ester Substation (AMP 94.25).

During transmission line construction, it will be necessary for heavy equipment such as hydroaxes and drill rigs to cross streams. Several factors will influence the severity of impact on the aquatic habitat.

1. Season in which construction takes place;
2. Size of the system;
3. Type of habitat in the crossing area;
4. Species present;
5. Frequency of crossing;
6. Type of crossing, i.e. temporary bridge, temporary culvert, low water crossing;
7. Stream bank configuration; and
8. Stream bed composition.

It is expected that small, confined systems will be more susceptible to adverse impacts from transmission line construction than will larger streams.

The access points for construction of the transmission line will be decided during the detailed design. The Willow to Healy section will probably use access established during construction of the Intertie. It is likely that access will require crossing streams and wetlands and thus expand the area in which adverse impacts due to transmission line construction may occur.

Details of the installation of the cable under Knik Arm are to be developed during final design. Knik Arm is primarily a migration route for anadromous species that utilize the Knik and Matanuska River drainages. Benthic organisms and other resident species are sparce due to the excessive amount of glacial material on the sea floor. It is unlikely that alteration of this area will have any effect upon resident or anadromous species.

- Changes in Water Quality

It is expected that temporary increases in turbidity and sedimentation will occur in streams subjected to instream activities during construction of the transmission line. Temperatures in stream reaches where vegetation is removed may slightly increase, but this increase is expected to have an insignificant effect upon species in the area. Small, clear water systems will most likely be affected to a greater extent than will large systems. The effects are not expected to be long-term.

In addition, streams that are crossed will be exposed to possible contamination by petroleum products due primarily to vehicle accidents.

- Disturbance of Fish Populations

  Avoidance reactions associated with increased turbidity and petroleum product contamination may occur. Fish will also avoid areas where instream activities occur and, depending upon the timing, migrations may be affected. Clearing may remove overhanging vegetation that provides cover for fish.

  Construction of the line will open areas to increased fishing. During construction, this will most likely be confined to workers. The effects may be greater in the northern segment where access has previously been limited.

(ii) Operation of the Transmission Line

- Watana Dam

  Once the transmission line has been built, there will be very few activities associated with routine maintenance of towers and lines that could adversely affect aquatic habitat.

  - Alteration of Waterbodies

    Some localized habitat disruption could occur when maintenance vehicles need to cross wetlands and streams to repair damaged lines or towers. In most cases, permanent roads are not built in conjunction with transmission lines. Rather, revegetation is allowed to proceed to a certain extent around the towers. The vegetation is usually limited to grasses and shrubs and not large trees so that vehicles are able to follow the cleared area associated with the lines. Streams may need to be forded in order to effect repairs. Depending on the season, crossing location, type and frequency of vehicle traffic, aquatic habitat in the immediate vicinity of the crossing could be affected. In addition, downstream reaches may be affected by increased sedimentation due to erosion.

  - Changes in Water Quality

    Changes in water quality during operation of the transmission lines are likely to result from increased turbidity, instream activities, possible contamination from fuels.

  - Disturbance to Fish Populations

    Instream activities associated with line repair and maintenance could cause disruptions of fish populations in limited areas. The greatest disruption will result from the increased accessibility to some fishing areas from the cleared transmission corridor. Because the vegetation is kept relatively low, hikers and allterrain vehicles can use the corridors as trails. In winter, snowmachines also traverse these cleared areas. This will result in greater numbers of fishermen being able to reach areas that previously experienced little or no fishing pressure. This effect will be more acute in areas where the new transmission route diverges from existing roads and transmission lines, such as south of Willow and north of Healy. The area between Healy and Willow will have been subjected to disturbance and increased pressure during construction of the Anchorage/Fairbanks Intertie. Any increased pressure from the Susitna power system will probably be minor. The presence of an operating cable under Knik Arm should cause no impacts to fish populations.

Notes on irregularities in the following pages:

Pages E-3-116 and E-3-117 contain sections 2.5 and 2.6 (not listed in the table of contents) before section 2.4 starting on p. E-3-120.

Pages E-3-118 and E-3-119 do not exist.

2.5 - Aquatic Studies Program

The aquatic studies program is an integral part of the continuing planning and design for the Susitna Hydroelectric Project. The information presented in this document is primarily based on results of 1981 field studies with some preliminary information from the 1982 study program. Interpretation and analysis of the 1982 data is in progress and supplemental reports containing the results of these analysis will be completed in June 1983. Continuing field data collections have been funded through the 1982-1983 winter season. Modeling efforts have been initiated to incorporate all project data into a quantified impact assessment. Scopes of work for the 1984 field season are being development. As information becomes available from field studies and impact analysis, the conceptual mitigation plan will be refined into a detailed plan specifying number, location, and design of mitigation features.

Additional studies will evolve from the analysis of the previous studies. As a more refined understanding of project impacts and viable mitigation features is acquired, the emphasis of the study program will shift towards providing the design criteria needed to implement the mitigation features. The aquatic studies will produce the information required to prepare mitigation programs for the preconstruction, construction, filling,, and operational phases of the project.

(a) Preconstruction Phase

During the preconstruction phase, the aquatic studies program will:

- Provide supplemental information required for support of the license application;
- Continue to define seasonal habitat relationships;
- Continue quantifying the predicted impacts; and
- Evaluate the proposed mitigating measures.

The need for specific tasks will be translated into field programs.

(b) Construction Phase

During the planning for construction, information will be needed to properly design site facilities and schedule construction activities to avoid impacts to aquatic habitats. Incorporating environmental design criteria into design, siting, and scheduling activities is a major feature of the construction migitation plan. Review of proposed actions and facilities will generate the need for some additional data. These needs will be translated into an orderly field study program. Environmental design criteria will be incorporated during the planning stage in order to avoid or minimize impacts.

(c) Filling and Operation Phases

During filling and operation, monitoring studies will permit refinement of mitigation features to improve performance.

2.6 - Monitoring Studies

As discussed in Section 1.3 and the Susitna Hydroelectric Project Mitigation Policy Report, monitoring studies are recognized as an essential project mitigation feature that provides for a reduction of impacts over time. Monitoring will be conducted during project construction and operation for the following:

- To insure that good construction practices are being employed on the project;

- To evaluate the effectiveness of the operation and maintenance of mitigation features; and

- To recommend changes in construction practices or mitigation features to further avoid, minimize, or reduce impacts.

(a) Construction Monitoring

Construction monitoring will consist of monitoring construction activities to ensure that proper construction practices, as detailed in the project construction practices manual, are being followed and that project facilities are being properly maintained. This monitoring activity will cover all project facilities, including access road construction and maintenance, camp and village construction, material removal, washing operations for dam construction, reservoir clearing, abandonment, and rehabilitation activities.

(b) Operational Monitoring

Operational monitoring will be conducted to evaluate the effectiveness of the project mitigation plan. Mitigation features to be monitored to evaluate if an adequate level of mitigation is being achieved include:

- Sloughs;
- Mainstem and side channel salmon spawning areas;
- The grayling population provided by the stocking program; and
- The fixed-cone valves designed to avoid gas supersaturation.

The monitoring activity will include evaluating the operation and maintenance procedures to ensure that the facilities are operating effectively.

2.4 - Mitigation Issues and Proposed Mitigating Measures

(a) Mitigation of Construction Impacts Upon Fish and Aquatic Habitats

Mitigation of construction impacts is achieved primarily by incorporating environmental criteria into pre-construction planning and design, and to good construction practices. By incorporating environmental criteria into design activities, construction of the Susitna dams and related facilities impacts to aquatic habitats will be avoided or minimized.

The aquatic studies program will make major contributions to pre-construction planning and design. Studies will be used in siting, design, and scheduling of project facilities and activities. For example, the final alignment of the Watana access road will take into consideration the fish streams along its route. The road is sited to avoid encroachment on streams, to minimize, stream and crossings and impacts at required crossings and to minimize cut banks.

Biological information will be incorporated into design criteria and construction practices. A high degree of communication and cooperation will be maintained between environmental staffs and design and construction personnel in order to facilitate integration of biological criteria into designs, specifications, and construction practices.

Scheduling of construction activities is an important aspect of pre-construction planning and is another means of avoiding or minimizing adverse impacts to fish and aquatic habitats. Whenever possible, activities will be scheduled to avoid known sensitive periods.

Continued monitoring of the construction facilities and activities will ensure that impacts to the aquatic environment are avoided or minimized. Monitoring can identify areas that may need rehabilitation or maintenance, and areas where previous mitigation measures have proven inadequate and remedial action must be taken.

Potential impacts are identified in Section 2.3. The following is a discussion of the impact issues and the mitigation measures that will be applied during and after construction. Those issues considered to have the greatest potential for adverse impact to the aquatic environment are discussed first. Avoidance, minimization, rectification and reduction of impacts are discussed.

(i) Stream Crossings and Encroachments

- Impact Issue

Improperly constructed stream crossings can block fish movements and/or increase erosion into the stream. Roads with inadequate drainage can alter run-off patterns to nearby wetlands and streams.

- Mitigation

The objective in constructing stream crossings is to maintain the natural stream configuration (Lauman 1976) and flow so that passage of fish is assured. Maintenance of fish passage is required under AAS 16.840. For the project area, the evaluation species used in developing criteria for stream crossing is Arctic grayling. In constructing a crossing consideration will be given to the following: presence or absence of fish/fish habitat, location of crossing, type of crossing structure, flow regime and method of installation.

. Location of Crossing

Project roads will be aligned and located to minimize the number of stream crossings. When crossings are unavoidable, the crossing will be located to cross the stream at a right angle in a stream stretch that is straight (Lauman 1976), and with narrow stable banks which do not require cutting or excessive stabilization. The crossings will be located so that important habitats, such as spawning beds and overwintering areas, are not disrupted.

. Type of Crossing Structure

Open-bottom arch culverts will be installed wherever possible. Multiplate elliptical and oversized circular culverts can also be used to maintain the natural stream bed (Joyce, Rundquist and Moulton 1980 and Lauman 1976) and will be used when open arch culverts are not feasible. Standard size circular culverts will only be used in intermittent drainages that do not constitute fish habitat.

Culverts will be designed to the Alaska Department of Fish and Game criteria needed to pass grayling at critical times. Culverts will be set to avoid perching and will be armored, when necessary, to minimize erosion at the outlet.

Log stringer and temporary bridges will be used where infrequent, light vehicle traffic is expected. Their use on the Susitna Project will be limited to the transmission line corridor. During winter transmission line construction, snow and ice bridges will be used to cross streams.

. Methods of Installation

When culverts other than open-bottom arches are used, streams will be diverted around the work area until the crossing is completed. On small systems, the stream may be flumed. Diversion or fluming will reduce the amount of sediment transport.

In some areas, roads and transmission lines must parallel a stream or river. The alignment will be away from the floodplain to the greatest extent possible. Where this is not possible, the road will be aligned to preclude channelization of the stream.

The transmission towers will be aligned so structures are out of streams and floodplains to the best extent practical. Instream activities will be confined to installation of drainage structures on access routes. Where practical, construction will be scheduled for winter months when heavy equipment can cross frozen creeks without elaborate constructed crossings.

(ii) Increased Fishing Pressure

- Impact Issue

The sport fishing pressure on the local streams and lake will substantially increase. The access road and portions of the transmission line will allow fishermen to reach areas previously unexploited.

- Mitigation

During the construction phase, access to the streams will be limited by closing roads to unauthorized traffic. The Alaska Board of Fisheries will be provided such information as they require to manage the fisheries. Some streams, such as Deadman Creek, will require modification of current seasons and catch limits if current stocks are to be maintained. These regulations may take the form of reduced seasons or catch limits, imposition of maximum size limits or control of fishing methods. Since public health regulations will not allow sport-caught fish to be stored or prepared at public food service facilities, the project policy will be that all fishing is restricted to catch-and-release.

This doesn't appear to be mitigation to me

(iii) Erosion Control

- Impact Issue

Sustained high levels of sediment in a system can change the species composition of the system (Bell 1973, Alyeska

Pipeline Service Company 1974). Siltation can affect development of fish eggs and benthic food organisms.

- Mitigation

The primary mitigation measures that will be used to minimize construction erosion are: 1) location of facilities away from the clear water fish streams; 2) employ erosion control measures such as run off control, stilling basins and revegetation; 3) schedule erosion-producing activities at biologically non-critical seasons (APSC 1974); 4) minimize the time necessary to complete the activity so that erosion is a short-term, non-reoccurring problem; and 5) maintenance of vegetated buffer zones.

The natural vegetation in an area is a major factor in preventing erosion (APSC 1974). Clearing for roads, transmission lines and other facilities will be confined to the minimum area necessary. For transmission lines, only taller trees and shrubs will be removed; the vegetative mat itself need not be disturbed. Adjacient to streams, especially small systems, clearing will be done by hand. Cleared material will be removed from the floodplain to approved disposal sites, if it is not salvaged or burned on site.

Disposal sites that contain cleared slash and substandard materials (overburden) will be located in upland locations away from waterbodies. Disposal sites will be constructed so that neither run-off during breakup nor rainfall will wash silty material into streams. This may entail run-off control structures, surrounding the disposal site with berms, or channeling run-off through containment ponds.

If run-off is expected to carry silt to nearby waterbodies from a construction site, settling basins will be built. Clarified water will be dicharged into receiving waters at an approved point.

Proper grading, mulching and revegetation of cut and fill areas will be used to avoid chronic erosion.

(iv) Material Removal

- Impact Issue

Removal of floodplain gravel can cause erosion, siltation, increased turbidity, increased glaciation, fish entrapment and alteration of fish habitat.

- Mitigation

Adverse impacts on aquatic habitats will be avoided or minimized by application of guidelines more fully discussed in Joyce, Rundquist and Moulton (1980b), and in Burger and Swenson (1977).

Before floodplain material sites are used, it will first be determined that upland sources are inadequate to supply the needed material. Floodplain sites will be thoroughly explored to verify that they can supply the necessary quantities. Important habitats such as overwintering and spawning areas will be identified and avoided.

Buffers of undisturbed vegetation will be retained between the sites and any active channels. The site will conform to the natural river features, including shaping gravel bars to conform to their original shape and excavating to provide irregular plane (shorelines) and profile (depths). If possible, mining will be scheduled to avoid conflicts with fish migrations, spawning, or other important occurrences. If mining is to occur during the winter, buffer zones and other sensitive areas will be flagged to avoid disturbance. Sites will be located to avoid or minimize instream work. Mining areas that may trap fish will not be created. Material will be stockpiled outside the floodplain to avoid backing flow at higher stages and the possibility of material being eroded into downstream reaches. Overburden will be disposed of in upland sites or returned, contoured and planted.

Material washing operations will recycle water and will not discharge into adjacent streams.

The Tsusena Creek material site will be rehabilitated after mining has ceased. The goal of rehabilitation will be to return the system to productive aquatic habitat. The site will be shaped and contoured to enhance fish habitat (Joyce, Rundquist and Moulton, 1980b), and all man-made items removed from the site. Exposed slopes will be graded and seeded. Clear water in settling ponds will be removed. The drained ponds will be covered with gravel, contoured and seeded to avoid erosion.

Rehabilitated areas will be monitored to ensure that grading, revegetation and other mitigation measures are effective. The Cheechako Creek and Susitna River borrow sites will be inundated and will not require rehabilitation.

(v) Oil and Hazardous Material Spills

- Impact Issue

Oil spills into streams are toxic to fish and their food organisms.

- Mitigation

An oil and hazardous materials transfer, storage and accident response plan will be developed as part of the construction practice manuals required by Alaska Department of Environmental Conservation (DEC).

Equipment refueling or repair will not be allowed in or near floodplains without adequate provisions to prevent the escape of oil. Waste oil will be removed from the site and be disposed of using ADEC/EPA approved procedures. Fuel storage tanks will be located away from waterbodies and within lined, bermed areas capable of containing 110 percent of the tank volume. Fuel tanks will be metered and all outflow of fuel accounted for. All fuel lines will be located in aboveground or ground surface utilidors to facilitate location of ruptured or sheared fuel lines.

Vehicle accidents, although difficult to fully protect against, can be minimized by constructing the roads with properly desilgned curves to accommodate winter driving conditions. The roads will be adequately signed and during the winter, difficult stretches will be regularly cleared and sanded. In summer, dust control will be accomplished with water.

State law requires that all oil spills, no matter how small, be reported to DEC. Personnel will be assigned to monitor storage and transfer of oil and fuel; and to identify and cleanup spilled oil and other hazardous material.

All personnel employed on the project, especially field personnel, will be trained to respond to fuel spills in accordance with the approved oil spill contingency plan. The plan will include a manual and training program describing:

. Actions to take as a first line of defense in the event of a fuel spill.

. Contact persons in the construction organization and in state agencies.

- The locations of sensitive habitats.

- The location of all oil spill control and clean-up equipment, the types of equipment at each location, and appropriate procedures.

- Records to keep during an oil spill and clean-up operation.

Oil spill equipment will be appropriate to the types of spills expected during the project and adequate to handle the largest spill expected. Personnel will be trained in the operation of the equipment and the equipment will be inventoried and tested regularly to make sure it is in proper working order in the event of an emergency (Bohme and Brushett 1979, Lindstedt-Siva 1979).

(vi) Water Removal

- Impact Issue

Fish fry and juveniles can be impinged on intake screens or entrained into hoses and pumps.

- Mitigation

If possible, surface water withdrawal will be from streams or lakes that do not contain fish. If water must be withdrawn from a fish-bearing waterbody, the Alaska Department of Fish and Game intake design criteria will be used for all intakes.

The ADF&G criteria are that: 1) all intakes should be screened; 2) openings in the screen should not exceed 0.04 sq. in.; and 3) water velocity at the screen should not exceed 0.1 fps. No more than 20 percent of the instantaneous flow will be removed at any time.

(vii) Blasting

- Impact Issue

Blasting in or near fish streams can rupture swim bladders and damage incubating embryos.

- Mitigation

The Alaska Department of Fish and Game has standard blasting guidelines that establish the distance from water bodies at which charges can be detonated without harming fish. Blasting will be accomplished using these guidelines.

(viii) Susitna River Diversions

- Impact Issue

Fish passing downstream through the diversion tunnels are expected to be lost because of the high tunnel velocities (over 18 ft/sec during summer flows that exceed 20,000 cfs and 20 ft/sec during winter). During summer, relatively few fish are present in the tunnel entrance vicinity. During winter, resident fish are expected to overwinter in the head pond above the upstream cofferdam.

- Mitigation

The fish lost in the diversion tunnel, primarily in the winter, would have been lost during reservoir filling. Mitigation for these losses is discussed under Mitigation for Inundation Impacts in Section 2.4(b).

(ix) Water Quality Changes

- Impact Issue

Discharge of camp effluents result in increased levels of metals and nutrient loading. Concrete batching plants release high alkoline effluents.

- Mitigation

Effluents will comply with ADEC/USEPA effluent standards.

The concrete batching effluent will be neutralized prior to discharge to avoid impacts related to change in the pH of the receiving water.

(x) Clearing the Impoundment Area

- Statement of Issue

Removing vegetation along streams can lead to accelerated erosion into the streams altered temperature regimes and equipment entering perennial or ephemeral stream ways.

- Mitigation

Clearing will be scheduled as close to reservoir filling as is feasible. Disturbance to the vegetative mat will be avoided. Erosion control methods will be employed wherever needed to minimize unnecessary erosion to streams. To the extent practical, clearing will take place during the winter.

(b) Mitigation of Filling and Operation Impacts

(i) Approach to Mitigation

The objective of the fisheries mitigation, as discussed in Section 1.3, is to mitigate the adverse impacts of the Susitna Project on fish resources using the heirarchical approach to mitigation contained in the Susitna Hydroelectric Project, U.S. Fish and Wildlife and Alaska Department of Fish and Game mitigation policies. The five basic mitigative actions, in order of priority, are:

- Avoiding impacts through design features or scheduling activities to avoid loss of resources.
- Minimizing impacts by carefully scheduling and locating operations, timing and controlling flow releases, and controlling impacts through best management practices.
- Rectifying impacts by repairing disturbed areas to provide optional fish habitat and re-establishing fish in repaired areas.
- Reducing or eliminating impacts over time through monitoring, maintenance and proper training of project personnel.
- Compensating for impacts by conducting habitat construction activities that rehabilitate altered habitat or managing resources on project or nearby public lands to increase habitat values.

Each of the following impact issues is addressed in terms of these five mitigation actions. Figure E.3.30 summarizes mitigation features for major impact issues associated with operation of the project.

(ii) Mitigation of Downstream Impacts Associated with Flow Regime

- Impact Issue

As described in Exhibit A, the proposed project consists of two stages, the first stage (Watana-development) and the second stage (Watana-Devil Canyon development). Each stage requires its own flow release schedule during both filling and operation. The flow release schedule is designed to provide a balance between filling power generation and instream flow requirements. The initial filling of Watana reservoir will take approximately three years using a flow release schedule as shown in Table E.3.17. After filling is complete, Watana Dam power plant will be operated outlined in Table E3.24. Devil Canyon Dam reservoir will be filled in about five months following the Watana filling schedule. The operation of the two dam stage will result in a flow regime in Table 3.27. Flows in these tables are stated for a gage at Gold Creek.

As discussed in Section 2.3, a primary fishery concern is to provide suitable flows between Talkeetna and Devil Canyon that:

. Allow adult salmon access to tributary spawning areas;

. Allow adult salmon access to slough spawning habitat;

. Maintain a suitable water depth on the spawning beds throughout the spawning period;

. Maintain flow through the spawning gravels during the incubation period; and

. Provide a flow-related stimulus to stimulate the out-migration of fry.

Additional fisheries concerns related to instream flow needs of resident and juvenile anadromous fishes include the need to:

. Maintain overwintering and summer feeding habitat; and

. Maintain access to tributary spawning and rearing habitat.

- Measures To Avoid Impacts

Adverse impacts to fishery resources resulting from flow alteration can be avoided or minimized through selection of an appropriate flow regime. While hydroelectric developments with storage facilities alter the natural flow regime in the river, changes in streamflow patterns do not necessarily result in adverse impacts to fish populations. For example, if low flows are limiting fish populations then supplementing low flow may result in enhancement to that population.

It is presently considered that the proposed project flows will impact salmon. The proposed summer flow of 12,000 cfs between July 25 and September 15, may not allow free pasage of adults into some spawning sloughs. In addition, the spawning area within the slough may be reduced because of reduced upwelling. Although the aquatic studies program is continuing to evaluate flow requirements, it is believed that flows needed to avoid any impacts to adult salmon in the July 25 - September 15 period may be the range of 18,000 to 20,000 cfs at Gold Creek.

- Measures To Minimize Impacts

A flow release schedule will be used that minimizes the loss of downstream habitat and maintains normal timing of flow-related biological stimuli. One criterion that influences the establishment of the flow release schedule is the choice of the key fish species and/or life stage to be protected. The evaluation species and life stage for each time unit has been identified. Instream flow requirements are being determined for each species/life stage/time unit combination. A flow regime that is beneficial to one evaluation species/life stage may adversely affect another. A hierarchy of the species/life stages is established and preference is given to the species with the higher priority. The species/life stage hierarchy for this proposed project is based on the evaluation of the species important to the region as commercial, recreational, subsistence, and aesthetic resources and their value to the ecosystem. In the reach between Talkeetna and Devil Canyon, chum salmon were given highest priority followed by sockeye, chimook, coho and pink salmon (Section 2.1(d)).

. Winter Flow Regime (November-April)

The winter flow regime will be reduced during filling flow regimes and sustantially increased during operation of both project stages. Primary species/life stages impacted by the modified winter flows would be (in order of sensitivity): incubating salmon embryos (all species), overwintering salmon juveniles and overwintering resident species (all life stages). Average monthly flows during filling of Watana reservoir from about 90 percent of the pre-project average for March at Gold Creek to 38 percent of the pre-project average in November (Table E.3.17). Since only minor reductions in March, the low-flow month, impacts are expected to be minor.

During operation, the winter releases are substantially increased to provide power during the high demand winter seasons. The increased winter flows are largest during the two dam stages, when increases above the normal average monthly flow ranges from about 269 percent at Gold Creek in November to about 750 percent in February and March (Table E.3.27). The increased flows will increase the available overwintering habitat downstream for salmon juveniles and all life stages of resident species. The slough habitat for the incubating salmon embryos may be enhanced through increased intergravel flow associated with the larger flows, or it may be degraded if the higher flows substantially alter the intergravel temperature regime or ice conditions. These and other potential impacts to slough habitats are the subject of ongoing studies.

. Spring Flow Regime (May-June)

The spring flow regime will be reduced below the pre-project flows for all post-project regimes. Average post-project flows at Gold Creek in May will be 45 percent of pre-project flows during Watana filling, 79 percent of pre-project flows during Watana operation and 66 percent pre-project flows during Watana/Devil Canyon operation.

Average post-project flows in June will be 22 percent of pre-project flows during Watana filling, 41 percent during Watana operation and 46 percent during Watana/Devil Canyon operation.

During project operation, the post-project flows will nearly equal the normal preproject flows for a short time in late April or early May as the post-project flow regime passes from a condition of winter flow augmentation to summer flow reduction. Breakup flood flows are reduced in the regulated flow regimes.

The primary species/life stage that would be impacted during spring flows are salmon fry. It is hypothesized that the spring breakup flows may induce salmon fry, particularly chum and pink salmon, to move out of the sloughs, and other incubation gravels, and begin the process of outmigration. During the 1982 spring flood, considerable mainstem ice jamming was observed, resulting in increased stage in the side channels and sloughs. Fry were observed to vacate the sloughs as the river stage dropped. Operational flows would reduce the magnitude of the spring flows such that sloughs would not be overtopped. If the sloughs are not overtopped, fry may not be exposed to the triggering stimulus needed to initiate outmigration. The effects of spring breakup on fry migration during the 1983 spring breakup period will be evaluated to 1) test the hypothesis that the breakup flood is important to fry outmigration; and 2) identify the magnitude of flow that will provide the proper conditions for fry outmigration. If the 1983 studies indicate that a spring flood is necessary for outmigration, this information will form the basis for modifying the spring release schedule to provide a sufficient stimulus. The effectiveness of these releases will be evaluated during the filling and operational monitoring studies.

. Summer Flow Regime (July - October)

The five species of Pacific salmon enter the spawning areas during the summer high flow periods. Most of the spawning in the Talkeetna to Devil Canyon reach is confined to sloughs and tributaries. Access to the slough spawning areas is apparently provided by a combination of the high summer flows in the Susitna River mainstem and the summer surface inflow to the sloughs. In addition, the useable spawning area in sloughs is at least partly controlled by backwater levels from the mainstem into sloughs. Upwelling groundwater in the sloughs attracts adults, maintains the permeability of spawning gravels and provides a stable winter flow during the embryo incubation period. The primary species/life stage that would be impacted in the summer is adult chum salmon.

The summer flow regime will be lower during filling and operation than the natural regime. This permits for filling the reservoir during the season of high flow and low power demand. The greatest reductions will be during the filling operation, with post-project flows at Gold Creek reduced to 27 percent of pre-project flows in July nad 70 percent in September (Table E.3.17. A smaller change is anticipated during project operation, ranging from a 66 percent reduction in July to a 38 percent increase in October (Tables E.2.24 and E.3.27.

The proposed operational flows from July 25 to September (described in Chapter 2) would provide 12,000 cfs at Gold Creek, and will neither avoid nor minimize impacts to spawning salmon. It is anticipated that adult salmon will experience difficulty in gaining access to the sloughs. The flows are of sufficient magnitude, however, to undertake to rectifying impacts to salmon spawning activity by modifying existing spawning habitat to maintain natural spawning by salmon. Rectifying measures are discussed below.

- Rectification of Impact

. Winter Flows

Since minimal impacts are expected during both filling and operational winter flow, rectifying measures are not needed.

. Spring Flows

If salmon fry require a high breakup flow in order to successfully outmigrate, a properly timed flow of sufficient level will be proivded to minimize impacts. Rectifying measures will not be needed.

. Summer Flows

Impacts to salmon spawning areas cannot be eliminated at the proposed project flows. The method selected for rectification is to physically modify the geometry of the sloughs to restore their suitability as spawning and incubation habitat. Because such slough modifications have not previously been attempted in Alaska, a demonstration project to examine the feasibility of slough modification program is scheduled to be initiated in the summer 1983 field season.

The goals of slough modification area: 1) to maintain or enhance ground water flow; 2) to provide a water depth that will permit access and spawning; and 3) to maintain or enhance permeable spawning gravels. These goals will be met by: 1) selecting a site that can provide sufficient ground water flow to support salmon embryos through the winter, 2) providing upstream control works that will allow control of mainstem flow entering the slough; and 3) constructing downstream control works to allow access by adults and maintain a suitable depth of water over suitable substrate for spawning. Elements of this slough modification program are illustrated in Figure E.3.9.

- Reduction of Impacts Over Time

Post-operational monitoring will be conducted to evaluate the effectiveness of mitigation measures (see Section 2.6). If further impact reduction is required to maintain existing fish populations, additional mitigation measures will be incorporated. Certain target mitigation issues will receive priority in the monitoring program. These include monitoring fry outmigation and the effects of summer project flows on adult salmon movements. The outmigration of salmon fry will be monitored to evaluate if the proper timing of outmigration is achieved. The basis for such an evaluation will be the baseline outmigration studies and within year comparison to adjacent unregulated systems. If there are significant differences in the timing of fry outmigration and these differences are related to flow levels, an adjustment of the spring breakup flow will be made to provide a properly timed outmigration to reduce the impact.

Monitoring will be conducted to evalute if the summer base flow achieved the intended level of mitigation. The monitoring study will include documentation of adult migration rates, access to slough spawning habitats, and embryo survival. If natural production cannot be maintained in the sloughs with the proposed flows, then it will be necessary to alter the flow schedule to achieve the proper flow. If such flows are not feasible, then selected sloughs will be modified to increase their suitability as salmon spawning and incubation habitat. The production of these modified sloughs will be monitored to measure the success of these modifications, including studies of access, available spawning habitat and incubation success. Periodic maintenance of spawning gravels and flow control structure inspection will be required to ensure that the modified sloughs are adequately functioning. The maintenance schedule will be determined based upon the results of the slough modification demonstration project and ongoing monitoring studies.

- <u>Compensation For Impacts</u>

If the flow-related impacts cannot be minimized, rectified or adequately reduced with the implemented mitigation measures, it may be necessary to compensate for the lost fishery resources. Compensation for lost salmon productivity will consist of: 1) channel modifications in side-channel and mainstem areas to increase the suitability of these habitats for spawning and 2) providing spawning channels in areas of groundwater upwelling or in association with clearwater tributaries.

The lack of suitable substrate may limit the availability of spawning habitat under project operation. In areas with suitable hydraulic conditions, the addition of gravels or the cleansing of gravels in areas with suitably sized particles will provide additional habitat required to accommodate adults displaced from other habitats.

Some of the existing side channels have substrates suitably sized for spawning, but the particles are cemented together by glacial silts and sands. The heavy sediment load and peak flows that presently exist in the Susitna River have resulted in a high degree of compaction in the substrate. If the sands and silts cementing the gravels together are removed, these areas may provide suitable spawning habitats. In some of these side-channels it may be sufficient to create a mechanical disturbance that would allow the streamflow to remove the silts and sands. It may be possible to use a bulldozer with a scarifier to rake the streambed and stir up the fine sediments (Trihey 1982b), allowing the fines to be carried away by the streamflow. This excavation would be accomplished during reservoir filling. During filling there will be a reduction of the suspended sediment load and flood peaks (Chapter 2), which will be beneficial in maintaining these areas after cleaning. A higher flow released for one week during the spring would assist in removing the fines from these areas.

In other areas where the above technique would not work, a mobile gravel cleaning machine could be required to remove silts and sands from the substrates. "Gravel Gertie" developed by Washington State University may be suitable for use on slough substrate. The "Gravel Gertie" is a mobile gravel cleaner that uses high velocity water jets to flush and then collect the silts from gravels for disposal (Mih 1980). Silts and sands removed from the gravels could be discharged into the mainstem river or disposed of on land. Habitat improvement activities on side channels would be conducted in a downstream sequence to reduce the chance of sedimentation of fines from upstream sites impacting downstream sites.

Side channels and mainstem sites may have suitable hydraulic conditions for spawning under project operation, but the streambed may not have substrate of appropriate particle size for spawning. The addition of gravels may be requied to create spawning habitat. Under project operation, the peak flow events will be significantly reduced in the reach from Talkeetna to Devil Canyon (Chapter 2). Thus, gravels could be placed in the side channels and mainstem to create stable spawning habitat (Figure 3.10).

Adding appropriately sized gravel to side channels will probably be more effective for pink, chinook and possibly sockeye than for chum. Spawning chum salmon apparently select areas with upwelling ground water. Cleaning and supplementing spawning gravel cannot be implemented until reservoir filling. Material added to the mainstem and many of the side channels prior to the controll of flow would be quickly redistributed during summer floods. A survey of candidate areas is being conducted to identify potential sites.

The size of a spawning bed and amount of spawning gravel needed would be determined by physical conditions at each selected site. A pilot project will be undertaken prior to full scale implementation.

Habitat enhancement as described above would provide a spawning channel similar to that illustrated in Figure E.3.11 which depends on the natural flows at the channel site.

If alternative mitigation schemes prove to be unfeasible, a hatchery could be developed.

(ii) Mitigation of Downstream Impacts Associated With Altered Water Temperature Regime

- Impact Issue

The creation of Watana and Devil Canyon reservoirs would change the downstream temperature regime of the Susitna River. Reservoirs act as heat sinks, generally reducing the annual variability and the rate of change in water temperatures by moderating summer and winter temperatures and introducing a time lag. The magnitude of change in the thermal regime downstream depends on the thermal stratification of the reservoir and the design of the power intake and release structures.

Some seasonal stratification is expected to occur in Watana Reservoir (Figure E2.91). Reservoir thermal modelling indicates that surface water temperatures may reach 10°C by August 1 and that the top 100 ft. of the water column will range between 8-9°C (Chapter 2).

The water temperatures downstream of the dam are set in part by the elevation of the intake structures, which in-turn determine the temperature of the water drawn from the reservoir. Since growth rate in many aquatic organisms is temperature-dependent, changes in the thermal regime can have profound impacts on aquatic communities. Potential adverse effects of higher winter temperatures include acceleration of incubation and early emergence of salmonid embryos and benthic invertebrates. The impact of lower summer temperatures include slower growth of invertebrates, juvenile anadromous and resident fish. The lag effect may cause delayed spring spawning activity. Changes in the thermal character and its effects will decrease downstream as tributaries contribute to the flow and as the temperature regime approaches an equilibrium state. The impacts related to the thermal changes are expected to be confined to the Talkeetna to Devil Canyon Reach.

- Measures to Avoid Impacts

The only mitigative alternative that would completely avoid temperature changes downstream of the project is the No Project alternative. Hydroelectric project involving reservoir storage dams will alter the natural temperature regime.

- Measures to Minimize Impacts

. Water Temperatrues during Filling Watana Reservoir

Summer water temperatures during the second year of filling Watana Reservoir are expected to range from 5 to 6°C in the reach above Talkeetna. The diversion tunnel functions as a low-level release and affords no temperature control. Water will be pulled from depths greater than 425 ft where water temperatures are expected to be near 4°C. The low water temperatures are expected to adversely affect adult salmon, and resident and juvenile fish. Adult salmon may avoid the Susitna River above Talkeetna and juvenile anadromous and resident fish may be displaced to warmer areas or be subjected to reduced growth.

Adverse impacts associated with filling Watana Reservoir could be mitigated by providng a temperature control structure. A low-level portal could be installed in the multiple level outlet structure proposed for project operation. The additional portal would allow withdrawal of warmer water from the upper layer of the reservoir during the second year of filling. With the addition of the fifth portal, summer temperatures under both filling and operation are expected to be near preproject levels (8 to 10°C).

. Water Temperatures During Operation of Watana Reservoir

The impacts associated with alteration of the temperature regime during reservoir operation can be minimized by incorporating multiple level gates in the power intake. Multiple level intakes have been successful in preventing temperature regulation by the selection of discharge water from various depths (Nelson, Horak, and Olson 1978).

The success of a multiple-level intake depends on the thermal structure of the reservoir, the existence of sufficient water at the desired temperature and location within the reservoir and intake ports located at the desired elevations. In the summer months, preproject temperatures range from 8-12°C in the Talkeetna to Devil Canyon reach. Temperatures near this range may exist in the top 100 feet of the reservoir (Chapter 2). If this layer is present, it can be accessed by the multiple-level intake gates, and impacts could be essentially avoided during the summer.

During the winter months, temperatures in the mainstem are near 0°C in the Talkeetna to Devil Canyon reach. Water temperatures near 2°C are likely to occur in Watana Reservoir to a depth of 100 feet. Water temperatures of 2°C released from Watana Dam are expected to cool to near 0°C by RM 148 just below Devil Canyon.

- Measures to Rectify Impacts

The most significant adverse impact associated with the altered thermal regime would be accelerated incubation and early emergence of salmon fry. The major concerns are related to the potential lack of food items in late winter/early spring and the colder temperatures encountered in the lower river and Cook Inlet. The modified sloughs or spawning channels designed to rectify or compensate for lost spawning and incubating habitat will be provided with a rearing pond at their downstream end. These rearing ponds will be used to collect the early emergents and hold them to prevent their downstream migration into colder water. Fry will be maintained in these rearing areas until appropriate conditions, including temperatures, are reached in downstream habitats. Fry emerging from other spawning habitats would not benefit from these facilities.

(iii) Mitigation of Inundation Impacts On Mainstem and Tributary Habitats

- Impact Issue

The Watana Reservoir will inundate those portions of the Susitna River and its tributaries between Elevation 1480 and 2185 feet. This corresponds to a loss of 54 mi of mainstem habitat and approximately 28 mi of tributary habitat. In 1981, the Arctic grayling population in the impoundment area was estimated to be approximately 10,000 grayling greater than 6 inches (ADF&G 1982a). This population uses the clearwater tributaries as spawning and rearing habitat and the tributaries and Susitna River mainstem as overwintering habitat. Continuing studies are being conducted to measure the amount of spawning and rearing habitat that will be inundated and assess potential alternative habitat above the impoundment area that will be made available by raising the water level. Overwintering habitat will increase under the proposed project.

A major project impact will be the loss of grayling spawning habitat in the tributaries. During the spawning period the water level in the impoundment will be at its lowest level, with average annual drawdown at 105 feet. This substrate will subsequently be inundated by the rising reservoir water as the impoundment fills. If the grayling spawn in areas that are inundated prior to the hatching, the embryos will likely be covered with silt and suffocate. The significance of this loss to the post-project grayling population will depend on the proportion of grayling spawning within the portion of the draw-down zone that will be inundated prior to hatching.

- Measures to Avoid Impacts

The only mitigation alternative that will avoid impoundment impacts for the proposed project is the No Project alternative.

- Measures to Minimize Impacts

Mitigation measure that would substantially minimize impoundment impacts would be to substantially lower the surface elevation of the reservoiror to maintain surface level during the incubation period. Neither measure would be feasible.

- Measures to Rectify Impacts

Since the impoundment is essentially a permanent impact, rectification measures are not feasible. Rectifying measures, such as providing replacement grayling spawning habitat within the impoundment are not considered feasible because of the timing and magnitude of the drawdown cycle.

- Reduction of Impacts

Impacts cannot be reduced over time since no effective mitigation measures have been identified.

- Compensation For Impacts

Since effective mitigative measures to avoid, minimize, rectify or reduce impacts to the grayling population in the impoundment area are not available, it will be necessary to compensate for the loss of these grayling. Compensation is proposed to be in the form of hatchery propagation of grayling. These grayling can be planted in certain lakes in the project area that are presently devoid of fish. Lakes will be chosen that contain suitable grayling habitat. The number of grayling to be planted and number of lakes to receive grayling will be determined based on the carrying capacity of the selected lakes. Sufficient grayling will be planted such the number of catchable grayling will be similar to that number lost. If suitable habitat does not exist in the vicinity of the impoundment to support the number of lost grayling, suitable areas outside the project area will be selected for stocking grayling. The lakes to be stocked will be selected in consultation with ADF&G, USFWS, and BLM. Preference will be given to areas near the project area that currently support high levels of harvest pressure.

(iv) Mitigation of Downstream Impacts Associated with Nitrogen Supersaturation

- Impact Issue

Nitrogen supersaturation in outflow waters has caused significant fish mortalities from gas bubble disease. Water passing over a high spillway into a deep plunge pool entrains air. Nitrogen passes into solution at depth and a state of supersturation exists when the water returns to the surface causing supersaturation. The degree to which this occurs depends on the depth of the plunge pool, height of the spillway, amount of water being spilled, and downstream turbulence. Supersaturated water is unstable and over time will return to equilibrium levels if exposed to the air. However, travel time downstream during high flow periods can be fairly short, causing supersaturation to extend considerable distances downstream.

- Measures to Avoid Impacts

Gas supersaturation will be avoided by including fixed-cone valves in the outlet facilities. These valves, in combination with the powerhouse flows, will discharge all flood flows up to the 1 in 50 year flood without causing supersaturation. A prototype test of Howell-Bunger valves showed them to be effective in preventing gas supersaturation (Ecological Analysts Inc. 1982).

- Measures to Minimize Impacts

The likelihood of creating gas supersaturation downstream from the dam can be reduced by minimizing release through reservoir management. Releases occur when the reservoir is full and inflow exceeds outflow. By holding the reservoir below full pool for most of the year flood control capacity would be increased, thus, decreasing the probability of spills. However, the reservoir must reach maximum storage level by September 30 to meet winter power demands. Storms do occur in the Susitna drainage that may require release of water; however, the structures and operation criteria have been designed to minimize releases and spills.

Spillage deflectors have been successful in reducing supersaturation in the Columbia basin (Nelson, Horak and Olson 1976). These deflectors consist of concrete sills placed near the base of the spillway that deflect the flow horizontally into the stilling basin, thus preventing air entrainment and plunging action.

(c) Cumulative Effectiveness of Mitigations

(i) Construction Mitigation

Through proper siting and designing of project facilities, appropriate construction practices and carefully scheduling activities as discussed in Section 2.4(a), it will be possible to minimize adverse impacts to aquatic habitats resulting from project construction. The indirect impacts caused by increased access to harvestable fish populations can be minimized during construction by restricting personal vehicle use in the project area during construction, by providing workers with alternate recreational opportunities, and by supporting such harvest regulations as the Board of Fisheries imposes.

Aquatic habitat will be altered by removing gravel from the floodplain. These impacts will be rectified by rehabilitation practices discussed in Section 2.4(a). Where desirable, residual habitat loss can be compensated by stocking fish in gravel pits that have been rehabilitated to support desired species. At the sites to receive compensation, the level of compensation and selection of desired species will be determined on a site-specific basis in consultation with ADF&G, USFWS, and BLM.

Fuel spills and road run-off will decrease water quality in streams downhill from project roads. These impacts will be reduced over time by having a properly trained and equipped spill response team at the construction site.

The construction monitoring team will identify areas where remedial actions, such as repair, realignment or redesign, are needed.

(ii) Operation Mitigation

- Mitigations of Access and Impoundment Impacts

The primary program designed to mitigate residual impacts of the access road and reservoir is to compensate for these losses by artifically propagating grayling and introducing these grayling into suitable project and non-project area waters. The target number of grayling to be produced will be equivalent to the number lost in the impoundment and an additional increment to compensate for residual access road impacts. The primary areas considered for planting are project-area lakes and abandoned borrow pits that are capable of supporting grayling.

Where feasible, access will be provided to these stocked areas to divert harvest pressure from adjacent natural populations. Additional artifically produced grayling can be introduced into project-area streams if natural populations become depleted and population enhancement is deemed to be desirable by the ADF&G. If the carrying capacity of project-area enhancement sites is exceeded by the number of grayling available, the excess grayling will be made available for planting outside the project area. Final decisions on the distribution of residual grayling will be made in consultation with ADF&G, USFWS, and BLM.

Road access to the project area will result in increased resource use. Angling pressure could be controlled by the Board of Fisheries through harvest regulation including catch limits, restrictive capture techniques (e.g., fly fishing only and single hook), and adjustments in the open season.

- Mitigation for Downstream Impacts

The goal of the downstream mitigation program is to provide adequate habitat downstream from Devil Canyon Dam that will minimize adverse impacts on fish resources. During the development of the mitigation program, volumetric, temporal, physical and chemical needs of the anadromous fish resources between Talkeetna and Devil Canyon were evaluated. At this stage of mitigation development, the parameters were considered separately, however, continuing studies and modeling of the interrelationships of these parameters will refine and quantify the mitigation program.

Several project features have been incorporated into the design to avoid or reduce impacts. Fixed-cone valves are to be installed in the outlet facilities to prevent gas supersaturation. The multiple level power intake gates will allow water to be withdrawn from various levels of the water column over the full drawdown range. This ability to withdraw water from various levels will allow control over downstream temperatures during periods of stratification if suitable temperatures are available. Continuing reservoir thermal modeling will allow an evaluation of available water temperatures throughout the year so that a detailed release plan can be developed. The release plan will need to consider both water temperature and volume in order to minimize impacts.

The project operational flows were developed with an intent to provide a maximum flow during the summer that would not substantially affect the project economics or energy production capabilities. These operational flows will alter the physical characteristics of the sloughs, thereby reducing ease of access and available spawning area for adult salmon and increasing embryo mortality if the sloughs dewater or freeze after spawning is completed. Fry that survive may not leave the sloughs if the migration stimulus, possibly a combination of a proper temperature and flow pattern, is eliminated.

Since project operational flows cannot be provided to avoid all downstream impacts, while maintaining the desired level of power generation, certain rectifying and compensating measures are proposed. The primary rectifying measure is to modify natural slough habitats to maintain natural salmon spawning and fry production. The slough modification process is composed of a series of steps to rectify the loss of natural slough habitat. These steps are:

. Selecting a site that retains ground water flow with suitable thermal characteristics under operational flow levels. The site selection process is evaluating a number of criteria to assess the potential for the site to provide sufficient ground water flow to maintain salmon embryos through the winter and allow properly timed development.

. If groundwater flow cannot be naturally maintained, the site selection will consider areas where the ground water flow can be artificially maintained (see Figure E.3.11 for conceptual plan).

- Providing an upstream control works that will prevent the river from entering the modified slough except at extreme high flood flows. This control maintains the integrity of the spawning gravels and reduces maintenance costs (see Figure E.3.9 for conceptual plan).

- Providing a series of removable low-level flow control structures. These structures provide the water depth needed for free access and passage of adult salmon in the slough and provide the proper water depth for spawning (See Figure E.3.9 for conceptual plan).

- Provide a fry rearing and removal area. The fry rearing area is at the downstream end of the slough and concentrates the fry for rearing. The depth of water would be gradually increased as the fry rear. The fry will be fed if natural food production is insufficient to support the number of fry present. At the desired release time, the river stage, and depth of water in the slough, will be raised to a desired level, the control works opened, and the fry allowed to outmigrate with the receding flow level. If necessary, the upstream control works could be opened to encourage fry to vacate the slough (See Figure E.3.9 for conceptual plan).

- During the summer, the modified slough will be managed to provide rearing habitat for juvenile anadromous and resident species that presently utilize slough habitats.

The size of a modified slough depends on natural site characteristics, such as groundwater flow rates and size of natural features (i.e., adjacent islands). The number of sloughs modified will depend on the desired level of production.

In addition to slough modification, mainstem spawning beds will be provided as a compensation measure (see Figure E.3.10 for conceptual plan). Additional mainstem and side channel spawning areas will be provided by scarifying or cleaning compacted gravels.

3 - BOTANICAL RESOURCES

3.1 - Introduction

(a) Regional Botanical Setting

Botanical resources potentially affected by the Susitna Hydroelectric project include those in the upper Susitna River Basin (above Devil Canyon), in the downstream floodplain below Devil Canyon, in transmission corridors from Willow to Anchorage and from Healy to Fairbanks, from Watana to the intertie, and in the intertie corridor from Willow to Healy. Recent studies conducted in the upper Susitna River drainage, in the floodplain of the Susitna River downstream of Devil Canyon to Talkeetna, and in the transmission corridors describe vegetation of the region (McKendrick et al. 1982, Commonwealth Assoc. 1982). Unless otherwise cited, the descriptions that follow are from McKendrick et al. (1982).

The Susitna River system drains parts of the Alaska Range to the north and parts of the Talkeetna Mountains to the south. The vegetation communities of the region are typical of those covering vast areas of Alaska and northern Canada. They include forest and shrub communities on stream floodplains, conifer and deciduous forests on canyon slopes adjacent to the floodplains, shrub and conifer stands and tundra on benches above the canyon slopes, and tundra at higher elevations.

The floodplain downstream of Devil Canyon is nearly flat. Its predominate vegetation communities are open and closed balsam poplar stands; closed tall shrubland is important to a lesser extent. Further upstream, spruce replaces poplar in the floodplain overstory, and low shrubs become more common in the understory.

Along the east-west reaches of the river, steep canyon slopes and some adjacent areas are covered with closed spruce-hardwood forest (Viereck and Dyrness 1980). This type of vegetation is most common along rivers in the southcentral and interior regions of the state.

The southeast portion of the upper Susitna watershed has extensive flat areas covered by low shrubland and woodland conifer communities. The extensive flats in the lower Oshetna River and Lake Louise areas are spruce woodland (Viereck and Dyrness 1980).

The benches bordering the east-west portion of the river, and the area around the Maclaren River, are moist tundra. This type includes herbaceous meadows as well as shrub-dominated sites, both of which occur elsewhere in Alaska around the Brooks Range, on the Seward Peninsula, and near the Killuck Mountains.

The vegetation along the lower mountains and the lower slopes of the higher mountains is classified as alpine tundra by Viereck and Dyrness (1980). Some areas mapped as rock have pioneering species growing in crevices, but the plants provided negligible ground cover. This rock habitat is common on mountains throughout Alaska. Permanent snowfields and glaciers are found in higher regions of the watershed in the Alaska Range.

Each of the transmission corridors crosses several vegetation types. The Healy-to-Fairbanks transmission corridor includes ridges, wet flatland, and rolling hills with areas of open spruce, open deciduous, mixed forest, shrublands and wet tundra. The Willow-to-Anchorage transmission corridor passes through closed birch forest, mixed conifer-deciduous forest, wet sedge grass marshes, and open and closed spruce stands. The Willow-to-Healy transmission traverses a wide variety of vegetation types, from closed spruce-hardwood forests in the south to tundra and shrub-land in the north.

(b) Floristics

The following floristics data are summarized from McKendrick et al. (1982) and Commonwealth Assoc. (1982), where further details may be found.

(i) General

In the region including the upper Susitna River Basin, the downstream floodplain, and the intertie corridor, 295 vascular plant species, 151 genera, and 57 families have been identified (McKendrick et al. 1982) (Table E.3.W1). These workers found two hundred fifty-five species in the upper basin but only 76 downstream. Fifty-four species were found both upstream and downstream. (The downstream flora is predominantly a subset of the upper basin flora.)

The plant families in the upper basin having the most species are Compositae (Asteraceae), Salicaceae, Rosaceae, Gramineae (Poaceae), Cyperaceae, and Ericaceae. Within the non-vascular flora 11 genera of lichens (including at least 12 species) and seven taxa of mosses were identified in these areas.

In the transmission corridor from Willow to Healy, McKendrick et al. (1982) identified 128 species of vascular plants. (Most of these species were also found in the upper Susitna River basin.) Eighteen species were found only in the corridor. No floristics work had been done in the Willow-to-Cook Inlet or Healy-to-Fairbanks transmission corridors.

(ii) Range Extensions

McKendrick et al. (1982) found twenty-two vascular plant species in the upper Susitna River basin and 9 in the floodplain downstream of Devil Canyon which were outside their reported ranges (see Hulten 1968) (Table E.3.W2), but note that the upper Susitna River drainage is not well-represented in existing plant collections, and that range extensions may be expected from any new botanical surveys in the area.

Two species found in the upper basin -- Senecio sheldonensis and Danthonia intermedia -- represent appreciable range extensions. S. sheldonensis had not previously been officially reported in the state except possibly in the Skagway area. D. intermedia had been reported only in locations near upper Cook Inlet and near Skagway (Hulten 1968).

McKendrick et al. (1982) found the specimen of S. sheldonensis in a mesic midgrass community in August near upper Portage Creek. Its identity has not yet been verified. They found Danthonia intermedia in August in the grass portion of a mosaic of low birch and grass communities in the low shrub areas between the Maclaren River and the Denali Highway.

There are two other plant occurences of note reported by McKendrick et al. (1982). Potamageton robbinsii, a submerged rooted aquatic, was found in Watana Lake. There have been limited collections of this species in Alaska. Hulten (1968) reported it from Summit village south of Healy and Welsh (1974) indicated that it is known from southcentral Alaska, but is evidently rare. Picea mariana, one of the most common trees found by McKendrick et al. (1982) in the upper Susitna Basin, has been reported by Hulten (1968) to be in areas north and south of the upper Susitna River drainage, but not in the drainage. Viereck and Little (1972), however, did include the Susitna drainage in their distribution map of this plant.

Most other range extensions reported by McKendrick et al. (1982) in the upper basin are less noteworthy. Most are extensions to the north (more inland) from their previous observations. For example, Platanthera dilatata had previously been found only near the coast in Alaska. Platanthera hyperborea and Myrica gale extensions include sites between areas that were previously included in their ranges. Potentilla biflora and Pedicularis kanei Durand kanei extensions were south of their previously reported ranges.

In the downstream floodplain, McKendrick et al. (1982) found nine species outside their ranges as reported by Hulten (1968) (Table E.3.W2). One of these, raspberry (Rubus idaeus), though not reported to extend into the region by Hulten (1968), was reported by Viereck and Little (1972) to occur there. Devil's club (Echinopanax horridum) represents a slight range extension upriver. Small-fruit bullrush (Scirpus microcarpus) had been found only in four areas outside southeast Alaska. A specimen which appeared to be Arnica chamissonis (needs to be verified) represented a large extension from the Alaska Peninsula and southeast Alaska. The presence of enchanter's nightshade (Circaea alpina) was an extension inland from the coastal regions. Sweet-scented bedstraw (Galium triflorum) and thinleaf alder were minor extensions and baneberry (Actaea rubra) and northern blackcurrant (Ribes hudsonianum) were extensions from the surrounding areas into the basin.

It should be re-emphasized that many of the range extensions reported above are merely the result of more intensive botanical collections by McKendrick et al. (1982) than had been made previously, and do not represent plants growing in unexpected environments.

(c) Threatened or Endangered Species

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. Murray (1980) discusses the habitats, distributions, and key traits of most of these species. Searches for these species have recently been made in two areas -- the upper Susitna River basin (McKendrick et al. 1982) and the intertie transmission corridor between Willow and Healy (Commonwealth Assoc. 1982).

(i) Upper Susitna River Basin

Table E.3.W3 contains the plants in Murray's (1980) list believed most likely to occur in the Susitna River drainage and in the landscape to be modified by the construction of the proposed dams and associated facilities. McKendrick et al. (1982) and/or Commonwealth Assoc. (1982) searched for these in the following areas of the upper Susitna basin: 1) alpine areas near the Susinta and West Fork Glaciers; 2) lowlands of the upper basin, including Maclaren and Tyone Rivers and associated ridges, terraces, and periglacial features; 3) calcareous outcrops and promontories along the Susitna River near Watana Creek and Kosina Creek; 4) alternative access routes in the upper basin; and 5) Borrow Site A. Aerial and ground reconnaissance were made in summer in these areas by three to four botanists and agronomists.

Well-drained rocky or scree slopes were searched in alpine areas in the upper drainage basin in the steep valleys adjacent to the Susitna and West Fork Glaciers. None of the species under review was found.

Well-drained, sandy and gravely ridges and terraces in lowlands in the upper drainage basin were searched. Shores of lakes and ox-bow ponds, and peri-glacial features were commonly examined. A trip was made downstream as far as Devil Canyon and two large gravel bars within the riverbed were surveyed. None of the species under review were found in these lowland surveys.

Several of the species being sought were known calciphiles (plants that habitually grow on calcareous soils). Three calcareous areas were found. One was on the northwest flank of Mt. Watana at about 1128 m in elevation, one was on the south side of the Susitna River immediately east of its confluence with Kosina Creek, and the third was on the north side of the Susitna River about 7 km west of Watana Creek. Calciphilic plants were found on two of these sites, but none of those found were in the threatened or endangered categories.

Three sites judged by substrate characteristics to potentially support rare plants were searched along the proposed northern access route. One site was a sandy blowout area on the northwest side of Deadman Mountain; one was a series of dry ridges (probably glacial moraines or terraces) on the south side of Deadman Mountain; and one was an area of windblown ridges on the east side of Deadman Mountain. No threatened or endangered species were found at any of these sites, nor along any of the other proposed access corridors.

The vegetation in the vicinity of Borrow Site A was surveyed in July 1981. No threatened or endangered species were found.

(ii) Willow-to-Healy Intertie

The Willow-to-Healy Intertie transmission corridor was checked for the presence of Smelowskia borealis var. villosa, Taraxacum carneocoloratum, Montia bostochii and Lysimachia ciliata. Geologic and topographic maps were used to pick out potential habitats for the species. Several habitats selected were checked, but none of the plants in questions was found (Commonwealth Assoc. 1982).

(iii) Summary

In summary, the upper Susitna River basin was surveyed in selected habitat sites for species under consideration for threatened or endangered status. Access routes, Borrow Site A, and the Willow-Healy transmission corridor were also surveyed for the presence of these species. None of the species collected has been identified to be one of the listed threatened and endangered species.

No endangered species work has been conducted in the downstream area or the transmission corridors from Healy to Fairbanks and Willow to Anchorage. The changes in water flow due to the project are judged unlikely to negatively affect any endangered species because none of them (Table E.3.W3) is normally found on unstable, shifting river banks.

(d) Contribution to Wildlife, Recreation, Subsistence and Commerce

In the project area, the importance of botanical resources to people lie mainly in the contribution of plants to wildlife food and habitat, human recreational and subsistence use. Mitigation for losses of botanical resources will be concerned mainly with maintaining the existing potential of the botanical resources to support these uses.

(i) Wildlife

The structure and productivity of plant communities determine the occurrence and abundance of most wildlife species. For example, the abundance of beavers depends on good supplies of selected plants (e.g. willow) near suitable water bodies. The population levels of moose and bears appear to depend on the annual productivity of selected plant species (e.g. willow, balsam poplar, berries). The species composition and diversity of bird communities are strongly influenced by the vertical structure and productivity of the vegetation. The utility of the vegetation to wildlife is discussed in greater detail in Section 4 (Wildlife).

(ii) Recreation

The structure of botanical communities in the Susitna project area directly influences the area's recreational potential. For example, hiking, skiing, horseback travel, and travel by off-road vehicles (ORV) is more difficult in some vegetative types than in others. Open terrain (tundra, open forests, etc.) is preferred for such travel.

Scenic attractiveness is greatly influenced by vegetation community composition and distribution. Diversity in vegetation structure across the landscape enhances the attractiveness of the landscape to recreational users. The Susitna basin has an aesthetically pleasing interspersion of vegetation types. The scenic composite is enhanced by color contrast, particularly in autumn when gold and russet deciduous leaves contrast to the dark green of spruce.

The most important effects of vegetation on recreation may be indirect, in that wild game populations sought by hunters are more abundant in some vegetative types than in others. Hunting is an important recreational use of land in the Susitna project area, and hunters prefer to hunt where vegetation characteristics improve the ease of acquiring game.

(iii) Subsistence

The importance of vegetation to subsistence in the Susitna project area appears to be minimal because most of the area is relatively remote from human settlement. It is likely that the greatest influence of vegetation on subsistence is, as with recreational use, in its quality as habitat for game taken for subsistence use (caribou, moose, etc.). Some subsistence berry picking is reported.

(iv) Commerce

Historically, there has been negligible use of plant resources at a commercial level in the project area (see ADNR 1982:36). The forestry potential for most of the region is very low because stands of merchantable timber are not abundant and access is difficult. Areas within several km of the Susitna River itself are the only places forestry potential is considered high (ADNR 1982:37).

3.2 - Baseline Description

High-altitude (U-2) color infrared photographs, LANDSAT imagery, and subsequent ground-truthing were used by McKendrick et al. (1982) to map the vegetation in the Susitna project area. These workers classified vegetation according to the system presented by Viereck and Dyrness (1980). They mapped the entire Upper Susitna River Basin (Figure E.3.W1) at a scale of 1:250,000 and the transmission corridors and upper basin within 16 km of the Susitna River at a scale of 1:63,360. They mapped areas in impoundments, within 0.8 km of impoundments, in the floodplain from Portage Creek to Talkeetna, and in borrow sites at a scale of 1:24,000.

In each vegetation/habitat type in the Upper Susitna Basin and in the floodplain below Devil Canyon, measures of species composition and community structure were made by McKendrick et al. (1982). Data on elevation, slope, aspect and landform also were gathered to relate to species composition of the vegetation.

These authors estimated canopy cover of each plant species in each layer of vegetation. They defined "ground layer" to be all herbaceous species and woody species less than 0.5 m tall. The "shrub layer" included woody species taller than 0.5 m but less than 2.5 cm dbh (diameter breast height). The "understory layer" consisted of woody species between 2.5 cm and 10.0 cm dbh. "Overstory" vegetation contained species larger than 10.0 cm dbh. This classification scheme will be used herein to describe the vertical layering within plant communities in the project area.

(a) Watana Reservoir Area

Forest, tundra, and shrubland are the basic vegetation types found in the Susitna River watershed above Watana Dam. Forest communities are defined as those with at least 10% cover by tree species regardless of the trees' heights. Shrubland comunities have at least 25% cover of erect to decumbent shrubs but are not located beyond the elevational limit of trees. Tundra stands are those communities above or beyond the elevational limit of trees and are dominated by shrub or herbaceous species. These plant communities are widespread throughout Alaska and northern Canada.

The structure and distribution of vegetation types below tundra in this area are strongly influenced by past fires, evidenced by fire scars on the trees. Post-fire succession for black spruce stands typically proceeds from the initial herbaceous and shrubby stages to young black spruce stands to dense and finally decadent black spruce/moss communities (Van Cleve and Viereck 1981). Post-fire succession in white spruce stands includes the initial herb and tree seedling stage, the shrub-tree sapling stage, and the dense hardwood stage of aspen, birch, or a mixture of aspen and birch. From this point the stand proceeds through a mature hardwood-spruce seedling stage, a mixed white spruce- hardwood stage, and finally a mature white spruce stage (Van Cleve and Viereck 1981). Most of the herbaceous, shrubby, deciduous, and mixed forest communities identified and described below may be successional stages in the process of transition to black or white spruce forest.

Figure E.3.W1 illustrates the general overall distribution of vegetation in the upper Susitna River basin, and Table E.3.W4 gives the percentages of cover by each type in the Watana Reservoir area. The principal types are spruce forests; tundra; tall and low shrublands; herbaceous; unvegetated areas; and wetlands.

(i) Forests

Forest vegetation types are located at the lower elevations of the upper basin (Figure E.3.W1). The average elevation of forest areas sampled by McKendrick et al. (1982) was 523 m.

Forests were divided into subtypes according to the dominant trees (conifer, deciduous, or mixed). "Deciduous" and "conifer" types had at least 75% of the tree cover provided by either deciduous or coniferous trees, respectively. "Mixed types" had lesser percentages of each.

Each forest subtype was further classed as "woodlands," "open," or "closed," depending on percent tree canopy cover. The "woodland type" stands contained between 10% and 25% tree cover. "Open" stands contained 25% to 50% tree cover, and "closed" stands had over 50% tree cover.

Forested communities in the Watana Reservoir area are similar to those described by Viereck (1975). Black spruce generally occurs in wetter sites than white spruce, and spruce occurs on colder sites than do deciduous or mixed forests. Deciduous and mixed forest stands are usually earlier successional stages of the conifer stands (Viereck 1970, 1975; Hettinger and Janz 1974). Closed forests occur on warmer sites than do open forests.

- Spruce Forest

Spruce stands are dominated by either white spruce (*Picea glauca*) or black spruce (*Picea mariana*). These forests contain a well-developed ground layer with a high percent cover (Tables E.3.W5 - E.3.W8). The layering structure of black and white spruce stands is similar, except that white spruce stands usually have a greater overstory cover (Tables E.3.W6 and E.3.W7).

A few cores of large trees taken by McKendrick et al. (1982) indicated that large white spruce ranged from 34 to 78 years in age and large black spruce from 77 to 171 years old. Several white spruce stands examined appeared to be recovering from past disturbance, perhaps fire; black spruce stands appeared less recently disturbed.

Open spruce stands are usually found on slopes or flatlands along the rivers at elevations averaging 487 m. The cover of the white spruce trees is concentrated in the overstory layer, but most of the black spruce tree cover is contained in the shrub layer (Tables E.3.W6 and E.3.W7). Canopy cover of the ground layer of vegetation in the open spruce forests normally exceeds that of the trees themselves. Black spruce stands contain low shrubs, such as crowberry (*Empetrum nigrum*), northern Labrador tea (*Ledum decumbens*), bog blueberry (*Vaccinium uliginosum*), and mountain cranberry (*V. vitisidaea*) in the ground layer. Prickly rose (*Rosa acicularis*) and bluejoint (*Calamagrostis canadensis*) are the most important ground layer species in open white spruce stands (Tables E.3.W6 and E.3.W7).

Cover of feather mosses in open stands of both black and white spruce approximates that of the trees. Low shrubs, such as crowberry, northern Labrador tea, bog blueberry, and mountain cranberry account for much of the woody ground layer. Important herbaceous species include bluejoint and horsetails (Equisetum spp.) (Tables E.3.W6 and E.3.W7).

All woodland spruce stands surveyed by McKendrick et al. (1982) were black spruce. Unlike open spruce stands, woodland stands are composed of scattered, stuned trees, and the overstory is almost negligible (Table E.3.W8). This vegetation type is usually found on the relatively level benches where soils are poorly drained. The trees are usually too small to qualify for the overstory layer because trunks are <10 cm dbh. In these woodland stands, sphagnum mosses, not feather mosses, are the most important cover species; important ground layer species include sedges (Carex spp.), woodland horsetail, and low shrubs similar to those found in the open spruce stands (Table E.3.W8).

- Deciduous Forests

McKendrick et al. (1982) found that balsam poplar (Populus balsamifera), paper birch (Betula papyrifera) and trembling aspen (Populus tremuloides) stands comprise the deciduous overstory vegetation of the Susitna basin. These stands usually have a greater overstory cover than spruce stands, because individual deciduous trees produce more foliage cover than do individual conifer trees. Deciduous forests are restricted mostly to the steep, often south-facing slopes and floodplain banks along the river (Figure E.3.W1). Elevations average 582 m, with closed stands occurring at average elevations of 560 m and open stands at 625 m.

Deciduous forests have an especially well-developed ground layer. Important woody species in the ground layer include crowberry, northern Labrador tea, bog blueberry, and mountain cranberry. Open stands appear to have more woody cover in the ground layer than do the closed stands, but closed stands have more herbaceous components.

Balsam poplar is usually the first tree in the successional stage of vegetation development on alluvial deposits. The balsam poplar trees provide about three-fourths cover in the overstory with relatively unimportant understory and shrub layers (Table E.3.W9).

Closed paper birch stands occur on steep, usually south-facing slopes that have typically been subjected to recent disturbance as described by Hettinger and Janz (1974) for northeastern Alaska. The layer structure is similar to the closed balsam poplar stands -- about three-fourths overstory cover, a well-developed ground layer, and relatively unimportant shrub and understory layers (Table E.3.W10). Frequently the overstory has a few scattered white spruce.

Trembling aspen stands are few and are generally found on the upper portions of quickly draining, dry, south-facing slopes. The general structure is similar to other closed deciduous stands in that there are well-developed overstory and ground layers, but poorly developed shrub and understory layers (Table E.3.W11).

- Mixed Conifer-Deciduous Forest

Work of McKendrick et al. (1982) shows that the mixed conifer-deciduous vegetation type has average overstory cover intermediate between that for spruce stands and that for deciduous stands. This forest type is typically dominated by white spruce and and paper birch.

Elevations for mixed conifer-deciduous forests average 466 m, with closed stands having a mean elevation near 425 m and open stands occurring around 482 m. Most of the larger stands are found on slopes downstream from Tsusena Creek (Figure E.3.W1). These are successional stands which developed as spruce replaced deciduous trees.

Cover in these vegetation/habitat types is almost complete, with a well-developed ground layer containing important amounts of bluejoint, bunchberry, woodland horsetail, and *Ptilium* (Tables E.3.W12 and E.3.W13). Overstory cover in closed mixed stands is about 60% and that in open mixed stands is about 38%. The height of the overstory is sometimes up to 20 m. Dbh's of individuals in these two-species overstories range from 15 to 30 cm.

Cores from larger trees indicate that birch trees in mixed stands average about 90 years old or older. Rotten centers precluded accurate aging in older birch trees. White spruce ages range from 50 to 204 years with most trees older than 100 years.

Plant species composition and abundance differs between open and closed stands. The shrub layer is more important in the relatively open stands, mostly because blueberry willow (*Salix novae-angliae*) is more abundant there than in closed stands.

(ii) Tundra

Tundra communities usually occur above the present limit of tree growth (Figure E.3.W1). McKendrick et al. (1982) found most of the well-vegetated communities to occur on flat to gently sloping areas. Sparser vegetation occurs on steep or rocky terrain. Although tundra species composition is highly variable, four distinct subtypes occur in areas large enough to map -- wet sedge-grass tundra, mesic sedge-grass tundra, herbaceous alpine tundra, and closed mat and cushion tundra.

Wet sedge-grass tundra communities occur at an average elevation of 587 m in wet, depressed areas with poor drainage. They have almost complete vegetation cover, with most species occurring in the ground layer, but up to 10% cover in erect shrubs (Table E.3.W14). The shrub layer, when present, contains cattered individual willows (Salix spp.). There is usually a large amount of organic matter in soils of wet sedge-grass communities, and sometimes a thick organic layer exists on top of mineral soil.

Mesic sedge-grass tundra is prevalent at higher elevations (mean elevation = 1372 m) on rolling terrain with well-drained soils. The soils are well-developed in some areas, but in others the soil is interspersed with rocks. Vegetation cover is usually between 50 and 75% of the area (Table E.3.W15). All vegetation is in the ground layer and species are usually less than 30 cm tall.

Two types of herbaceous alpine tundra are found in the Upper Susitna River Basin; although only one, herb-sedge, predominates in areas large enough to map. Herb-sedge communities appear at elevations of around 1295 m, near glaciers (particularly the West Fork Glacier) on gentle, fairly well-drained slopes with relative well-develoepd soils. Vegetation cover in this type is nearly 100 percent.

The other type of herbaceous alpine community occurs in small, isolated rocky areas. Small forbs and sometimes shrubs grow in the pockets of mineral soil imbedded between the rocks.

The fourth major type of tundra community is the mat and cushion tundra, found at high elevations (1013 m) on dry, windy ridges (Figure E.3.W1). Vegetation covers about 75% of the area and is usually less than 20 to 30 cm tall (Table E.3.W16). Lichens and low mat-forming shrubs are major constituents. Soils are shallow and coarse.

(iii) Shrubland

Shrubland vegetation types are the most prevalent upland vegetation types in the upper Susitna River basin. Including approximately 65 plant species, shrublands generally occupy areas at higher elevations than forest communities, but at lower elevations than tundra types.

- Tall Shrub Types

Tall shrub communities are dominated by Sitka alder (Aldus sinuata or Alnus crispa var. sinuata) and are found mostly on steep slopes above the river or sometimes above the flat benches at an average elevation of 573 m (Figure E.3.W1). Many of these stands are 2 to 4 m in height. Approximately 25 species have been identified in the alder stands.

Alder stands frequently occur as stringers through other vegetation types along the slopes by the river. Frequently alder exists 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 have almost complete vegetation cover; the ground layer and understory account for most of the cover (Table E.3.W17).

- Low Shrub Types

Low shrub vegetation is common in the upper Susitna River basin. Communities are found on the extensive, relatively flat benches (mean elevation = 781 m), where soils are frequently wet and gleyed, but usually without standing water. Community dominants are usually 1.0 to 1.5 m tall. The type is dominated by birch and willow (Tables E.3.W18 and E.3.W19).

Birch shrub stands are usually dominated by resin birch (Betula glandulosa). The most important associated species in these stands is bog blueberry. Mosses and lichens also contribute to plant cover. In some stands, there is a buildup of soil and debris around the bases of each birch shrub clump, creating a large amount of microrelief. Sometimes the stands are dense, like a thicket; others stands have large openings between individual shrubs. Scattered black spruce contribute almost 10% cover in some stands.

Willow stands are usually in wetter areas than are birch shrub stands. Diamondleaf willow (Salix planifolia subsp. pulchra) dominates some stands forming thickets along small streams at high elevations. Because of the wetness, these communities are usually less botanically diverse than birch shrub stands. Willows frequently have soil and debris built up at the bases of the stems, with standing or running water in the troughs.

Species associated with willow stands in the Susitna basin are similar in some cases to those noted by Hanson (1953) in northwestern Alaska, by Hettinger and Janz (1974) in northeastern Alaska, and by Viereck (1966) near Muldrow Glacier. Northern Labrador tea and bog blueberry are common.

(iv) Herbaceous

Two herbaceous community types are found in the upper basin. Grasslands dominated by bluejoint are present on level to sloping areas at lower elevations along the river and along the Portage Creek drainage (Figure E.3.W1). Herbaceous pioneer communities are present on recently vegetated gravel and sand bars where soils have little organic matter and often consist of many cobbles.

(v) Unvegetated Areas

Three classes of unvegetated area are depicted on the maps by McKendrick et al. (1982) (Figure E.3.W1) -- water, rock, and snow and ice. Lakes and streams are included in the water category. Lakes are generally found along flat benches and range in size from small ponds to large lakes such as Big Lake (approximately 450 ha). Rock is bedrock or deposited geologic materials supporting little or no vascular vegetation. Rocks occur as outcroppings at high elevations, as steep cliffs along the river, or as unconsolidated gravel in newly deposited river bars. Snow and ice include permanent snowfields and glaciers; these are most common at the northern end of the study area in the Alaska Range, and some occur near the sourthern boundary in the Talkeetna Mountains.

(vi) Wetlands

A summary of the dominant aquatic species and factors influencing their location in and around many of the water bodies in the Upper Susitna Basin is presented in Figure E.3.W2. Bur reed and yellow pond lily probably contribute more to total cover than do all other species combined. Yellow pond lily, a submerged species with large floating leaves, is particularly prominent and forms vast beds in several water bodies. It is absent along the edges of ponds but appears to grow best at depths ranging from 0.6

to 2.1 m, frequently forming a band around ponds and lakes between the shallows and deep water. Bur reed, in contrast, frequently dominates the shallows of the ponds from 0.15 to 0.60 m in depth. Horsetail, mare's tail, and bladderwort are also common in these shallows. Horsetail is common on rocky bottoms where little other vegetation occurs. Bladderwort appears prominent in shallows having a mud bottom or a bottom of organic matter.

Along the edges of water bodies, sedges probably contribute more to total cover than all other edge species combined. It is the prevalent species of the pond shallows, along the pond periphery, and also on floating mats when they are present.

Watana Lake is unique in that is is dominated by pondweed (Potamogeton robbinsii), a submerged rooted aquatic species that grows in water from about 1.2 to 2.4 m in depth. The reason for the lack of other vascular plants in Watana Lake and the presence of Potamogeton robbinsii is not understood. (See 3.1(b)(ii) - Range Extension for further discussion of this plant.)

Lakes and ponds with gently sloping substrates have more aquatic plants, both submerged and emergent, than do water bodies with steeply sloping substrates; but above 945 m in elevation, there is usually sparse aquatic vegetation cover regardless of the substrate morphology. Rocky bottoms support less aquatic vegetation than do mud or sand bottoms.

Floating mats of vegetation are sometimes a part of the associated emergent wetland. These mats are dominated by sedge, sphagnum moss, and common bank species.

Wetlands cover large portions of the Upper Susitna River Basin, including riparian zones, ponds and lakes on upland plateaus, and wet tundra. Wetland areas of particular importance in the project area include Upper Brushkana Creek, Upper Deadman Creek, the area betwee Lower Deadman Creek and Tsusena Creek, the Fog Lakes area, the Stephan Lake area, Swimming Bear Lake, and Jack Long Creek. Lakes and ponds have been surveyed and their vegetation characterized. Further studies are being conducted on the classification and mapping of wetlands.

(b) Devil Canyon Reservoir Area

All of the vegetation types found in the Watana reservoir area are also found in the Devil Canyon reservoir area. The Devil Canyon area has been mapped and described by McKendrick et al. (1982). Table E.3.W20 gives the percentage of cover for each community type in the Devil Canyon reservoir area. Figure E.3.W1 illustrates the spatial distribution of the vegetation types.

Conifer forests (3.8% of the reservoir area) are less common in the Devil Canyon reservoir area than in the Watana reservoir area. They are found mainly on the north-facing slopes of the canyon and on some of the adjacent benches.

Deciduous (mostly birch) and mixed conifer-deciduous forests cover the south-facing slopes of the canyon and both sides of the canyon below Devil Creek, extending up into the valleys of Portage Creek and Indian River. Balsam poplar stands, found on the floodplain, cover 18% of the Devil Canyon reservoir area.

Tundra vegetation occupies a large portion (41%) of the Devil Canyon reservoir area. Mountains north and south of the river rise sharply to hundreds of meters above river level. The upper areas of these mountains (over 975 m) are covered with mat and cushion/sedge grass vegetation.

Shrubland is found on 28% of the reservoir area. Open tall shrubland is found at elevations intermediate between forests and tundra. Birch and willow shrub are found on some of the upper benches.

Grasslands are found along Portage Creek and in the Susitna River floodplain (Figure E.3.W1). Rock, water and ice cover 9% of the reservoir area. There is much less wetland area in the impoundment area of the Devil Canyon Dam than in the Watana impoundment. For more detailed descriptions of the vegetation community types, percent cover, and vertical distribution of plant species, refer to Sections 3.2(a)(i-vi).

(c) Talkeetna to Devil Canyon

The Susitna River from Devil Canyon to Talkeetna flows mostly through a steep canyon that opens out near Talkeetna. The floodplain vegetation is strongly influenced by water and ice during floods. Scouring by ice and water during spring breakup and by high water during summer floods account for much of the vegetation dynamics in the floodplain.

Willow and balsam poplar are common early-successional species on the floodplain of this river. They occur on the most recently-deposited river bars. As the pioneer communities mature, balsam poplar becomes dominant. The oldest, most stable areas are usually covered with birch-spruce forest.

(i) Early Successional Stands

Early successional communities account for 5-10% of the vegetated land on the floodplain. They are usually dominated by horsetail (Equisetum) and/or dryas (Dryas drummondii) in the ground layer and balsam popular and/or willow in the shrub layer. Characteristically, these communities have little total vegetation cover with greater than 50% bare gound (Table E.3.W21). Plant species in these types generally have rhizomes, or horizontal underground stems, which may extend for many meters and are effective in binding loose sand and silt. Dryas is important in stabilizing gravelly sites.

In most stands, balsam poplar and willow occur at greater densitities than other woody species, but alder has a relatively rapid growth rate, and it begins to overtop willow and balsam poplar within 2 or 3 years after its establishment.

These balsam popular and willow stands may last up to 10 years from the last major disturbance. Aging of these stands is difficult because floods frequently bury several years' plant growth in silt. Balsam poplar about 50 cm in height might have 10 years of growth since the last major silting and another 10 years in the buried silt layer. This cycle may be repeated a number of times before vegetation succession advances to a later stage.

Vegetation on these sites is slow-growing until sufficient silts and sands are deposited by wind and water to provide a parent material for soil development.

(ii) Mid-Successional Stands

Mid-successional types account for about one-fifth of vegetated land in the Susitna Basin floodplain. Deposition of sands and silts that raises the elevation of sites above the level of frequent flooding are necessary for transition of early successional vegetation to mid- successional stages. Thinleaf alder, or balsam poplar that has developed into tall shrubs or trees, dominates these stands. The alder type is the first phase and appears to last from 10 to 25 years after stabilization. Balsam poplar appears to dominate the vegetation 25 to 55 years after stabilization, but stands of this type are much less frequent than the alder-dominated stands. As noted earlier, alder overtops balsam poplar during the transition from early- to mid-successional stands. However, after about 20 years, the balsam poplar that remains quickly doubles its height, thereby overshadowing the alder and developing into the immature balsam poplar trees of the mid-successional stage.

In both alder and balsam poplar stands, there is essentially no bare ground. As balsam poplar assumes greater dominance, its density and that of thinleaf alder and feltleaf willow decline from that found in alder stands, since the balsam poplar trees become larger; but Sitka alder, prickly rose, and highbush cranberry increase in density (Table E.3.W22).

(iii) Late Successional Stands

As the balsam poplar stands of mid-succession mature, white spruce may appear in the canopy. Mature balsam poplar stands probably are established by about 75 years after stabilization and exist for probably 30 more years. Eventually, balsam poplars become decadent, leaving space for development of more balsam poplar or spruce and birch, if no distrubances interrupt the process. Which factors cause development of the birch-spruce stands and which promote continuation of the balsam poplar are still unclear.

Mature and decadent balsam poplar stands occur on 25 to 40% of the vegetated floodplain; mixed stands of birch and spruce occupy 23 to 32% of the area. McKendrick et al. (1982) found mature and decadent balsam poplar stands to collectively average 90% total vegetation cover. They found birch-spruce communities to have 42% cover of white spruce in the overstory (Table E.3.W23).

Birch-spruce types have the greatest variation in stand structure of the vegetation types found on the floodplain. There is some evidence that these stands are self-perpetuating. Upon overmaturity, the birch overstory appears to fall, making the spruce more susceptible to wind-throw and thereby allowing a pure birch shrub-alder-highbush cranberry-prickly rose community to increase. The shrub community then progresses again to the birch-spruce forest conditions.

(d) Talkeetna to Cook Inlet

Vegetation in the floodplain below Talkeetna has a similar successional sequence to that above Talkeetna. It consists primarily of bottomland spruce-hardwood forests (Commonwealth Assoc. 1982). The islands and river bars are somewhat more stable due to the width of the floodplain, which reduces ice jam damage and the severity of flooding. This increase in stability increases the average age and successional stage of the vegetation present in the floodplain.

Separate mapping of this area has not been undertaken because of the minimal impact that the project is expected to have on vegetation below the confluence of the Susitna with the Chulitna and Talkeetna Rivers (see Section 3.3).

(e) Transmission Stubs and Intertie

(i) Healy to Fairbanks

The classification system used to map the northern transmission corridor (McKendrick et al. 1982) is the same as that used in the upper basin (see Viereck and Dyrness 1980). The corridor crosses three distinct physiographically and phytosociologically distinct 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 conifer-deciduous, and open deciduous forest types. The flat area is predominantly low shrub with sedge-grass and open and closed spruce types. Most f the spruce trees are relatively short, except along the streams.

The Tanana flats area extends from just beyond the Nenana River crossing to the Tanana River. This section has a mosaic of wet vegetation types including open spruce stands with larch, low shrub, and wet sedge-grass. Locations of many types appear to be a consequence of old stream meanders and drainage patterns. Some patches of deciduous forest stands occur. Dry streambeds have stringers of other vegetation, such as low shrub, through them.

The section from the Tanana River to Fairbanks passes through rolling hills covered predominantly with open deciduous forest. Small areas of spruce are less common than in the Tanana flats section. The mixed woodland patches in this section are generally cutover areas. Many of the closed spruce areas produce very short shrub-like trees or shrubs.

Most spruce areas between the Tanana River and Fairbanks contain only spruce; few have larch. About half the areas in the Tanana flats section contain larch as well. Spruce (presumably black spruce) occurs in low, poorly drained areas. Spruce in better-drainage locations may be either black or white spruce but existing maps (McKendrick et al. 1982) show the vegetation only as spruce. The black spruce-larch type, confined in Alaska to the interior, is generally found only on wet lowland sites with shallow permafrost (Viereck and Dyrness 1980).

Forest types account for almost 78% of the 111,000 hectares of the corridor, with open forest types being the dominant form (Table E.3.W24). Open spruce covers 28% of the area, open deciduous 11%, and open mixed conifer-deciduous 11%.

(ii) Willow to Cook Inlet

The Willow-Cook Inlet transmission corridor passes through three principal kinds of plant communities -- (1) closed birch and mixed conifer-deciduous forests, (2) wet sedge-grass marshes, and (3) open and closed spruce stands (Table E.3.W25) (McKendrick et al. 1982).

Birch and mixed forests are most abundant. These forests can have high quality birch, white spruce, and balsam poplar trees. However, many sites have had poor regeneration and developed either a woodland/shrubland or woodland/ grassland aspect. Birch is the predominant deciduous species. Localized stands of balsam poplar are associated with the active river floodplain (Willow vicinity).

Wet sedge-grass marsh is the second most common vegetation type in this area. Most of these areas are quite extensive and associated with diverse networks of ponds, lakes, and meandering streams. These areas support little other vegetation except for scattered islands of black spruce and low shrubs on drier sites.

White spruce, common in most of interior Alaska, is less common in this part of the Susitna Valley. The vegetation map of this corridor does not identify spruce to species. However, most closed and open spruce stands in areas dominated by mixed conifer deciduous forest are probably white spruce. Spruce stands skirting wet sedge-grass or low shrub areas may be white or black spruce or mixtures of the two. Most woodland spruce stands are black spruce.

The Willow-Cook Inlet corridor includes approximately 38,000 hectares (Table E.3.W25). It passes through relatively flat terrain that is 67% forested, predominantly with conifer-deciduous forests. Approximately 24% of the area is small and large wet sedge-grass meadows.

(iii) Willow to Healy

The Willow-to-Healy intertie corridor is covered by interior forests, muskeg, shrub communities and tundra. White spruce and paper birch dominate the drier forested landscapes; black spruce is primarily located on the poorly drained sites. Additionally, balsam poplar and white spruce develop on the floodplains. Within or adjacent to these areas about thirty species of willow and several species of alder occur in the understory or in thickets with little or no overstory.

The southern two-thirds of this corridor contains forested areas; the northern portion consists mainly of open woodland, shrubland and tundra. The corridor possesses fewer glaciers and ice fields than is common in similar sized areas in the region (Commonwealth Assoc. 1982).

(iv) Dams to Intertie

The transmission corridor from the dams to the intertie has not been separately mapped. But from work of McKendrick et al. (1982), one can see that vegetation types include tall shrub on steep embankments, open spruce forests on the slopes and benches, and mixed and birch forests on gentle slopes and benches. Higher elevation types include mat and cushion tundra and sedge-shrub tundra. Areas covered by each type is presented in Table E.3.W26.

3.3 - Impacts

Impacts of the Susitna Hydroelectric Project on vegetation are of two general kinds -- (1) loss of all vegetative cover; and (2) change in the nature of vegetative cover (i.e., alterations in plant community types). The first kind of impact is considered adverse; while the second kind is either adverse or beneficial depending upon its effect on wildlife. The following discussions treat both kinds of impact.

(a) Watana Development

(i) Construction

- Vegetation Removal

Construction of the Watana development will result in the direct removal of vegetation within an area of approximately 144 km^2. Within the dam, spillway, and impoundment areas, about 12,667 ha of vegetation will be removed by construction and clearing operations. Included are 10,818 ha of forest that is composed primarily of large stands of both woodland and open black and white spruce, as well as some open mixed forest types. The camp, village, airstrip, and borrow areas will affect an additional 1742 ha, most of which is shrubland or black spruce forest.

Table E.3.W27 lists the area of each vegetation type to be directly removed by the Watana development, and compares each value to the total area of that vegetation type within the Upper Susitna Basin. Approximately of the open birch stands, and all large closed birch stands in the upper basin will be removed by the Watana development. The relative loss of other types is small when compared to their availability in the basin. For example, only 3.4% of forested areas, 0.1% of tundra types, and 0.4% of shrubland cover types will be directly removed by the development.

- Vegetation Loss by Erosion

Erosion is a persistent problem at dam construction sites in northern latitudes (Baxter 1977, Baxter and Glaude 1980). Erosion may be promoted by the following:

. Destabilization of till due to clearing of vegetation;
. Blowdown of trees near cleared areas;
. Thawing of permafrost;
. Desiccation of exposed soils; and
. Changes in drainage patterns.

Slope stability studies by Acres American (1982) indicate that areas particularly vulnerable to vegetation loss through erosional effects include side slopes of the canyon from the south abutment of the Watana Damsite to Vee Canyon, along Watana Creek, and the Oshetna-Goose Creek area. Existing vegetation patterns in these areas reflect a mosaic of disturbance and regeneration of plant cover.

- Vegetation Damage by Wind and Dust

Blowdown of trees is a recognized problem in cleared areas (Todd 1982). Near reservoirs, it is promoted by increased winds due to a greater fetch as areas are cleared (Baxter and Glaude 1980, Brown 1972). Since northeasterly winds predominate in the project area most of the year, the greatest blowdown potential is on the south side of the Watana damsite near the spillway.

Wind-generated dust is expected to be a problem during the construction phase because of the large areas that will be cleared for the impoundment and borrow areas, and increased wind fetch as a result of clearing.

Accumulations of thick dust on vegetation can potentially retard snowmelt (Drake 1981). The direct effect of dust on plants varies with plant species and the chemical composition of dust. For example, densities of cottongrass (Eriophorum spp.) are likely to increase, but stiff clubmoss, sphagnum moss and lichens such as Cladina apparently decrease in abundance when exposed to dust (CRREL 1980).

- Effects of Altered Drainage

Local alteration of drainage patterns surface water regimes may result from clearing, ditching, and other construction activities. Berms constructed on shoulders of construction areas may block drainage patterns, causing waterlogging of soils or shifts of surface flow to adjacent drainages (CRREL 1980). Resulting changes in surface water regimes will cause plant communities to shift accordingly. The time required for these changes to occur, and the extent of the change, will depend on the extent of hydrologic change and on plant successional dynamics, many of which are poorly known (Neiland and Viereck 1977).

- Effects of Change in Albedo

Cleared soils usually absorb more solar radiation than do vegetated soils and consequently thaw sooner in spring and deeper over the summer. Conversely, with less insulation they freeze earlier and deeper in the winter. Resulting changes in surface hydrology will cause plant communities to change as discussed in the preceding paragraphs.

- Indirect Consequences of Vegetation Removal

Methods of vegetation removal may have indirect impacts on other vegetation. Spruce budworm disease, which occurs in areas adjacent to the Susitna watershed (Hegg 1970), may be more likely to invade the area if spruce trees are cut but not removed or burned. Clearing may also enable other insects and decay organisms to increase in abundance (Kimmey and Stevenson 1957).

The extent of topsoil removed during clearing in areas outside the impoundment will affect succession by determining nutrient availability, soil moisture-retention capacity, and seed and sprout availability. The more topsoil that is retained or returned, the more rapidly restoration of the original vegetation type may be achieved. Invariably, however, the first plants to naturally reestablish themselves in disturbed areas will be early successional plant species. These species are characteristically light-demanding, xerophytic, deep-rooted and non-specific as to soil type.

- Effects of Increased Fires

The increased numbers of people in the area may cause increased incidences of fires. Fire has been a natural factor shaping plant communities in the area, so increased fires will cause changes in plant communities similar to those that can already be observed there.

Because successional patterns following project-related fires are more likely to manifest themselves during the operations phase, they are treated in Section 3.3(a)(ii).

(ii) Filling and Operation

The Watana facility is scheduled to begin operation in 1993. Some construction-related impacts such as dust will diminish, but other problems such as erosion will continue. The most conspicuous operation-related changes in vegetation will be downstream as a result of streamflow regulation, but less drastic changes may be caused by micro- and mesoclimatic changes, increased fire incidence, and increased off-road vehicle (ORV) use. In many instances, vegetation will respond to these disturbances through characteristic successional recovery patterns. The following subsections describe operation-related changes and the successional patterns of communities as they recover from development induced change.

- Vegetation Succession Following Removal

On sites where vegetation has been removed, natural plant succession will occur unless prevented by inundation or facility maintenance. Successional patterns expected in forests, shrublands, and tundra are discussed below.

. Forest Areas and Shrubland

Within forest and shrubland areas, newly cleared sites with largely intact mineral and organic soils will naturally revegetate with grass and herbaceous plants native to the original community (Conn and DeLapp 1982a,b). In interior Alaska, characteristic early successional herbs and shrubs are bluejoint reedgrass, field horsetail, prickly rose, bluebell, bunchberry, northern bedstraw, Labrador tea, American twinflower, blite goosefoot, pale corydalis, American dragonhead, fireweed, crazyweed, and rough cinquefoil. Early successional trees are willow, aspen, and poplar.

From 6 to 25 years after clearing, willow and/or alder will typically dominate areas that were originally forest or shrubland (see reviews of forest succession by Neiland and Viereck 1977, VanCleve and Viereck 1981). Soon thereafter a tree canopy of young black spruce, willow and alder will develop. Dense stands of spruce with well-developed moss and lichen components will not develop for 50-100 years.

. Tundra

Clearing of tundra and concurrent removal of topsoil will, except in certain rocky alpine sites, typically result in higher soil temperatures and, if permafrost is present, a deeper thaw (Bliss and Wein 1972, Hernandez 1973, Gersper and Challinor 1975, Chapin and Shaver 1981). Either of these conditions may lead to the development of a different plant community from that originally present and, possibly, a very long restoration period. But if topsoil is retained, recovery to the same community type can be rapid. The topsoils contain most of the available nutrients, rhizomes, and seeds required for rapid recolonization (see discussion by Chapin and VanCleve 1978). One to several centuries may be required for recovery from disturbance where the topsoil is lost (Brown et al. 1978).

Although natural successional trends of tundra are far less predictable than for forested areas, the following sequence is likely to occur. The first vegetation types to reestablish in moist or wet tundra (with the organic layer retained) are likely to be cottongrass species and, if buried seed is present, Bigelow sedge on wet sites. Bluejoint reedgrass may predominate on drier sites (see Chapin and Chapin 1980, Chapin and Shaver 1981, Gartner 1982). Grasses, such as arctic bluegrass, may also invade dry sites (Gartner 1982). As might be expected, non-native plants may establish themselves if seeds are supplied. Non-native plants may delay, but will not prevent reestablishment of native species.

Within 5 to 10 years after revegetation begins, at least 50% and often 100% vegetation cover is expected on all sites on which the original organic layer was retained.

Native woody and herbaceous species characteristic of adjacent areas will also begin to invade within 10 years; possible species include willows, bog blueberry, mountain cranberry, northern Labrador tea, shrubby cinquefoil, prickly rose, Oxytropis campestris, lupine, green alder, and dwarf and resin birch. Reestablishment of normal densities, however, may require several decades.

- Effects of Erosion and Deposition

If the drawdown zone of the Watana impoundment is typical of that of other northern reservoirs, it will remain unstable until bedrock or gravel/cobble/boulder substrates are encountered. Shoreline recession is likely with consequent loss of vegetation (Baxter and Glaude 1980). Although some of the evolving shoreline above the drawdown zone will be readily colonized by early seral stages such as grasses and herbaceous species, stabilization of this upper shoreline may require 30 years or more (Newbury and Malaher 1972).

After the reservoir is filled, the water will warm adjacent hillsides, causing permafrost to melt and slides to occur. On the south side of the Watana impoundment, the permafrost layer is 60-90 m thick and is within 1°C of thawing. Numerous slides and land slumpages are therefore likely on this side of the reservoir. If these slides are small and the organic soil layers have not been lost, encroachment by rhizomatous species may enable rapid recolonization. If large slides occur, a full cycle of forest succession on melted permafrost may ensue, leading to black spruce and bog vegetation.

Following beach (mudflat) development, flooding of upland areas may occasionally occur as a result of water displacement from slumpage (Kerr 1973) or from high flows. This occasional flooding of adjacent areas will likely stimulate new vegetation growth. Progradation of deltas into the reservoir at a number of creek tributary mouths is likely since deposition will occur when fast creek currents empty into slow-moving reservoir water. These deltas may eventually be vegetated in the same manner as downstream floodplain areas (see discussion below).

- Effects of Altered Downstream Flows

Because plant community development on floodplains is strongly regulated by peak streamflows, reduction of peak flows in the Susitna River to approximately 40% of pre-project conditions will have a profound effect on floodplain communities downstream of the Watana and Devil Canyon Dams. Large amounts of floodplain will be relatively exempt from flooding, and hence from flood-regulated vegetation succession.

Many of the banks exposed by the reduced water flows will consist of coarse gravels and cobble. Alluvial banks in the Devil Canyon reservoir area may also be eroded as a result of the Watana Reservoir. Because most of the sediment load of the Upper Susitna River will be deposited in the Watana Reservoir, the sediment carrying capacity of the river will be much greater than the available sediment load some distance downstream of the dam. Thus, some of the alluvium deposited during flood stages and by wind will be eroded, leaving a predominantly rocky substrate. Few plants other than *Dryas* will grow on these rocky areas until an adequate soil layer is formed.

Where alluvium is present, the pattern of floodplain succession described by Viereck (1970), Van Cleve and Viereck (1981), and Neiland and Viereck (1977) will occur. This pattern is typical of vast areas of interior Alaska, and has been found to generally apply to the Susitna Basin (McKendrick et al. 1982). Predicted river floodplain succession is depicted in Figure E.3.W3. Some deviations from this pattern may be observed. For example, the expected abrupt diminishment in flows will preclude development of "salt crust" and associated successional species, such that this stage in plant succession may be bypassed.

The effects of regulated flows on vegetation will change as one proceeds downriver, primarily because channel configurations are different and peak flow levels less modified downstream. Potential effects on vegetation will be discussed separately for the river reaches between Watana and Devil Canyon, Devil Canyon to Talkeetna, Talkeetna to the Yentna River, and from there to Cook Inlet.

. Watana to Devil Canyon

This reach of the river is mostly a single channel with armored banks and is structurally similar to the channel in the Devil Canyon-Talkeetna reach. Warm water releases from the dam will prevent ice formation on the river in winter and ice scour in spring. Summer peak flows will be reduced. The elimination of ice scouring and the reduction in peak summer flows will hasten the encroachment of vegetation on newly-exposed areas with adequate soils. Also the open-water area in winter may promote rime-ice formation on adjacent vegetation, and the warmer water temperatures may alter the timing of plant phenology, but drastic vegetation changes as a consequence are not expected.

. Devil Canyon to Talkeetna

The Susitna River in this reach has mostly a single channel or split channel configuration. Vegetational encroachment is currently controlled by the bankfull flow (recurrence interval of about 2 years) and ice scouring. The channel is armored with boulders and cobbles, and is relatively stable.

Bredthauer and Drage (1982) expect narrowing of the main channel under post-project conditions. Abandonment of side channels in multi-channel reaches is also expected. These changes, however, will require many decades to occur. A reduction of suspended and bed sediment loads within the river is expected, and vegetation will not invade areas until a soil veneer has been formed over the cobble-sized material forming the main channel perimeter.

The active floodplain between Devil Canyon and the Chulitna confluence covers 3220 ha; vegetated islands cover 636 ha of this figure. Comparisons of aerial photos taken in 1951 with those from 1980 indicate a few changes in bank lines and island planform, but generally the channel delineation in this reach is stable (Bredthauer and Drage 1981). At the pre-project maximum flow of about 51,000 cfs, the water surface area (based on output from the Corps of Engineers HEC model) is about 2760 ha, and thus 460 ha within the floodplain are above the water level. Mature balsam poplar on the islands cover 411 ha, whereas tall shrubs cover an additional 183 ha. Thus, islands now covered by mature poplar and tall shrub are the only areas remaining above the water level at this peak flow. The post-project maximum flow in August of about 21-22,000 cfs will have a surface area of about 2100 ha; therefore, 1120 ha will be above the water level. Approximately 593 ha of the above-water area is presently covered by mature poplar and tall shrub types, allowing for 520 ha of new long-term vegetative colonization. Assuming a 10-year period for soil formation, and the floodplain successional sequence described in Section 3.2(c), the vegetation on these 520 ha will probably consist of immature balsam poplar and alder at the end of the license period, or alternately, a <u>Dryas</u>-young meadow transitional community where little soil accumulates.

Vegetation encroachment is also currently influenced by ice scouring, and some bank erosion occurs during ice-jam events at breakup. Post-project ice formation in this reach will be similar to present conditions since most of the frazil ice in this reach is formed at the point where the river gradient flattens after leaving Devil Canyon, and the river water will have cooled to 0° before entering the canyon. However, post-project breakup may have a lesser effect on vegetation because the river stage will be much lower during breakup, and the armored channel will confine the ice effects. As vegetation begins to encroach on the main channel, however, ice scouring will probably remove some vegetation each spring.

. Talkeetna to Yentna River

There is a dramatic change in the morphology of the Susitna River from a split channel to a braided channel at the confluence of the Susitna, Chulitna, and Talkeetna Rivers. The flows contributed by each of these rivers at the confluence are 40 percent each for the Chulitna and Susitna Rivers, and 20 percent for the Talkeetna River. The Chulitna contributes most of the sediment load at this point.

Downstream of Talkeetna, large changes in channel position and form presently occur whenever the river attains bankfull stage. At this stage, the active gravel floodplain is subject to movement, with considerable local scouring and filling. Under post-project conditions, the bankfull flood will have a recurrence interval of about once every 5-10 years, as opposed to the present 1-2 year interval (Bredthauer and Drage 1982). Thus, the active gravel floodplain may gradually develop a vegetative cover, and the minor subchannels may become inactive. However, flooding events from the Chulitna and Talkeetna Rivers will maintain some instability in the development of riparian communities.

The Delta Island reach is a very unstable and complex channel network. Bredthauer and Drage (1982) stated that "project-induced changes in flow and sediment regime realized at this reach will be diluted by contribution from tributaries and by the Susitna satisfying its sediment load by reworking the wide floodplain alluvial deposits. Basic changes in the overall channel network are not expected".

It thus appears that some vegetation will colonize this reach between Talkeetna and the Yentna River, but that bankfull floods each decade will cause vegetation recession. Fewer areas of rocky substrate exist in this reach, so early successional stages of willow, balsam poplar, and alder will be present between these flooding events. Ice scouring does not greatly affect vegetation in this reach due to the multi-channel configuration which allows flows to bypass any jams, and so no ice-related changes in vegetation are expected. Because of the annual variation in the timing and level of peak flows from the Chulitna, Talkeetna, Kashwitna, and other rivers, it is not possible to predict the area expected to be colonized by vegetation in the long-term as was done for the reach above Talkeetna.

. Yentna River to Cook Inlet

The Yentna River contributes about 40 percent of the mean annual flow that enters Cook Inlet from the Susitna River. Below this confluence, few measureable changes are expected in the vegetation that could be related to the project. As Bredthauer and Drage (1982) state, "the dilution effect of major and minor tributaries as well as the balancing of changes by the Susitna River system should mask any measurable changes that could occur as a result of the project for several decades". The tidal influence of Cook Inlet on the delta vegetation will also reduce possible effects of the project on vegetation to a minimum.

- Climatic Changes and Effects on Vegetation

Reservoirs act as a heat source or sink, warming and cooling less rapidly than the surrounding terrestrial substrate. These effects may delay the normal spring warming and fall cooling of adjacent environments and so affect the phenology and distribution of nearby vegetation. Spring air temperatures in the immediate vicinity of the reservoir will be cooler on the average than at present. The cumulative effects of a cooler spring environment on the entire plant community are unclear. Phenology studies are now in progress to determine the pattern of greenup near the proposed impoundment.

The Watana impoundment should act as a heat source in fall, maintaining slightly warmer air temperatures than normal. The possible effects of this on vegetation are likewise unclear.

Another thermal effect of the Watana impoundment will be its moderation of diurnal changes so that nearby nighttime temperatures during May and June will be higher and daytime temperatures will be lower than prior to development.
Average fall temperatures near a lake of similar size to the Watana reservoir were characterized by a 5.5°C lower maximum and 2.2°C higher minimum than temperatures away from the lake (Baxter and Glaube 1980). Temperature effects likely would not extend beyond 2.5 km downwind of the water mass. The effects of these thermal changes on the vegetation are, again, difficult to assess.

The development of extensive fog banks near the Watana impoundment may also affect vegetation. Fog banks tend to be persistent at reservoir sites after breakup (Buckler 1973, Baster and Glaude 1980), and can result in the deposition of copious quantities of hoar frost on trees and shrubs within 3 km of shore. Buckler (1973) reported that ice crystals 5-7 cm in length were found on vegetation close to a reservoir when temperatures below -23°C created steam fog.

- Effects of Increased Human Use

During the construction of the Watana facility, construction personnel and their families will have greater access opportunity than usual to a number of areas in the Upper Susitna Basin. The major human use impacts will probably be associated with use of off-road vehicles (ORVs) and accidental fires.

. Off-Road Vehicles

The effects on vegetation of ORV use varies with season, soil moisture and depth the presence or absence of permafrost, vehicle weight, frequency of use, and other factors (Chapin and Van Cleve 1978, Sparrow et al. 1978, Fancy 1982).

The ground layer of vegetation is more susceptible to damage by ORVs than are other layers. The plants are most susceptible to damage in summer. In winter, snow and ice layers minimize damage to the underlying vegetation and the organic mat. Dry habitats are relatively immune to damage by ORVs. A few passes of light track vehicles over relatively dry well-drained soils may result in slight compaction of the organic and/or plant layer, a net soil temperature gain, and deeper thaw of the active soil layer. The typical result is minor subsidence and an influx of ground water.

Tundra and wetlands, especially sites with underlying permafrost, are the most vulnerable habitats. Repetitive off-road traffic or use of heavy vehicles in moist areas is likely to remove vegetation and also the underlying organic mat. This would cause soil temperature increases, deeper thaw, subsidence to one meter or more, groundwater input, and severe erosion that may last 5 to 50 years or more (Hok 1969, Rickard 1972, Lawson et al. 1978, Chapin and Shaver 1981). Quagmires may form as a result of ponding of surface water (Sparrow et al. 1978) or gully formation may result. Near the Denali Highway, Sparrow et al. (1978) observed gullies formed after ORV use as wide as 6 to 8 m and up to 3 m deep, with severe side erosion and cave-ins, as well as active transport of sediment downhill. A similar effect was noted when fire-lines were established on Wickersham Dome, near Fairbanks (Lotspeich 1979). The above effects will be most severe where ground ice content is high (Bliss and Wein 1972). Natural restoration of the organic layer of tundra soils may require more than a century (Chapin and Van Cleve 1978). However, some grasses, such as blue-joint reed-grass, may be able to rapidly invade mineral substrates (Gartner 1982).

. Fires

Tundra vegetation would probably recover within 8 years from most fires. In the short term, increased productivity of browsable shrubs such as willow, aspen, and birch is likely as a result of the release of soil nutrients (Figure E.3.W4).

In shrubland and forest, a variety of successional patterns might result from a fire, depending on vegetation type, soil moisture and temperature, time of year, and post-fire weather patterns (Figure E.3.W5). For example, some willow species, while highly adapted for reseeding burned areas, produce seeds that are viable for only short periods of time in the spring or fall (Zasada and Viereck 1975, Zasada and Densmore 1977). A dry period following a burn would most likely lead to the initial establishment of horsetail, fireweed and blue-joint reedgrass, particularly if a thick organic layer remains.

Bog blueberry, mountain cranberry, prickly rose, and raspberry would be expected to proliferate following light fires where these species are already established. On the other hand, a heavy fire would destroy blueberry and cranberry species, but would enhance seed germination of roses and raspberries (Densmore and Zadsada 1977, Densmore 1979).

Fires on steep slopes result in increased runoff due to vegetation loss, and may cause mud or landslides. In other areas thermokarst topography and gullies may result from fires (Viereck and Schandelmeier 1980).

(b) Devil Canyon Development

(i) Construction

- Vegetation Removal

Because of the narrow, steep configuration of Devil Canyon, vegetative losses will be substantially less than for the Watana Dam. Approximately 2305 forested ha and 70 shrubland ha will be inundated or cleared (Table E.3.W28). An additional 223 ha will be altered or lost as a result of the camp, village and borrow areas. As discussed in the previous section, natural revegetation of some distur- bed sites will probably occur. The probable successional sequences, reviewed in section 3.3(a)(ii), also apply to the Devil Canyon region.

- Vegetation Loss by Erosion

The most likely source of vegetation by erosion at the Devil Canyon site will be rock slides along steep banks, especially on the south side of the reservoir. Although most rockfalls will occur at elevations of 274-396 m and so will be below the eventual fill level, some slides may also occur above this zone. Only sporadic concentrations of permafrost have been found in Devil Canyon. Resulting erosional problems and vegetation loss through permafrost melting should be minimal.

- Vegetation Damage by Wind and Dust

Such wind-related phenomena as tree blowdown are less likely at the Devil Canyon site than at the Watana site because the maximum fetch is far less at the Devil Canyon site. Dust will be generated by clearing of the Devil Canyon impoundment area. But because the impoundment area is in a narrow valley that is more protected from wind than the Watana impoundment area, resulting impacts to vegetation are expected to be relatively minor.

- Effects of Altered Drainage

Current projected borrow areas impinge on a number of small lakes and ponds south of the Devil Canyon site. Excavation in these areas may result in the creation of new aquatic or bog habitat with ensuing development of bog vegetation (see section(3.3(a)(i)).

The steep configuration of the dam area will severely limit other changes in drainage patterns or water table levels. Any downslope cuts made during construction may, however, promote active gully formation and associated vegetation loss.

. Effects of Change in Albedo

Clearing of the Devil Canyon dam site will result in a warming of underlying soils prior to filling. Since permafrost is not generally present, impacts on adjacent vegetation will be minimal.

. Indirect Consequences of Vegetation Removal

Indirect effects of different clearing methodologies were reviewed previously for the Watana site (Section 3.3(a) (i)). These effects are also applicable to the Devil Canyon area, although the steep configuration of the canyon may make recontouring and topsoil replacement efforts less effective.

(ii) Filling and Operation

The Devil Canyon impoundment should fill in about two months. No appreciable downstream effects should be evident during filling. Above the dam, filling will result in diminished dust and summer and perhaps will slightly alter microclimate, especially on the windward side of the reservoir.

Because the drawdown zone for the Devil Canyon impoundment will be less than one meter during most of the year, and shorelines are steep, the rise and fall of the water table will probably affect vegetation only in a narrow band adjacent to the reservoir. The consolidated, rocky character of the substratum will in most cases limit water intrusion and soil waterlogging and few shifts toward wet or bog vegetation are likely.

Relatively few new impacts on vegetation are expected during operation of the Devil Canyon dam. The old large landslide at river mile 175 could move after filling, temporarily blocking river flow and flooding upstream areas. This could cause a loss of mid- and late-successional vegetation in areas such as the mouths and floodplains of Fog and Tsusena Creeks.

Meso- and microclimatic effects on vegetation will be very small and probably well within the range of normal variation, due to the relatively small size of the reservoir.

- Vegetation Succession Following Clearing

The same general vegetational succession patterns will occur on cleared, unsubmerged lands of the Devil Canyon area that were described for the Watana site (see 3.3 (a) (ii)). However, due to the steep, rocky character of Devil Canyon a much greater mosaic of vegetation types may develop. On some slopes, loss of soil may result in shifts to low-lying alpine type communities, dominated by *Dryas*, rather than a gradual return to shrubland and forests.

- Erosion and Deposition

Due to the geological character of the Devil Canyon region, erosional/depositional changes affecting vegetation will be minimal following filling of the reservoir.

- Downstream Effects

Downstream effects of reservoir operation on vegetation will be the same as for the Watana dam, except that the Devil Canyon operation will greatly diminish winter ice in the Devil Canyon to Talkeetna reach. Warm water released from the dam in winter will result in an open-water stretch at least as far as the Chulitna confluence. Steam fog from this open water in winter could cause frost buildup on vegetation along the river (Buckler 1973). The consequences to vegetation of frosting are not clear.

(c) Access

(i) Construction

Approximately 230 ha (34 m x 67 km) of mixed tundra types of vegetation will be cleared for access. The vegetation adjacent to the access road will be subject to indirect effects including dust deposition, erosion, leaching of nutrients in recently drained regions, and waterlogging in areas of blocked drainage. These effects are all discussed in more detail in 3.3(a),(i) and (iii).

When the Devil Canyon dam is built, an additional road segment will connect the Devil Canyon and Watana sites along a corridor north of the river. Construction of this road entails clearing of an additional 60 km (approximately 200 ha) of roadway, as well as adding 23 km (78 ha) of railroad right-of-way between Devil Canyon and Gold Creek on the south side of the Susitna River. Spruce and mixed forests, tall and low shrubland, and tundra vegetation types will all be crossed.

Many of the same impacts experienced in clearing the Watana and Devil Canyon impoundments (Section 3.3(a), (i) and (b), (i)) will occur in this access segment. These include erosion, dust deposition, and drainage changes.

(ii) Operation

Use of the access roads will result in continued dust- and erosion-related effects on the vegetation bordering the access road. In addition, access roads will facilitate increased human disturbances, including ORV use and a higher incidence of fire, as well as possible clearing and development related to other projects. These disturbances and their impact on vegetation are discussed in detail in Section 3.3(a)(ii).

In contrast to the access roads, the proposed rail connection from Gold Creek to Devil Canyon will minimize off-road access and fire incidence. The rail connection will primarily traverse spruce and mixed deciduous type forests.

(d) Transmission Corridors

(i) Construction

Transmission corridors constitute another source of vegetation loss and/or disturbance (Table E.3.W29). Woodland and open black and white spruce communities (962 ha) and open and closed conifer-deciduous forest (1172 ha) constitute the main vegetation types that will be disturbed.

Wetlands (113 ha), tundra (203 ha), and shrubland (646 ha), are included in the proposed rights-of-way. In all the above cases, the vegetation types affected represent small fractions (less than 4.2 percent) of the total available vegetation types within the corridors. Of this portion only a negligible fraction of the vegetation will be totally eliminated by intermittent placement of control stations, relay buildings and towers. The remaining vegetation will be subject to selective clearing of trees and tall shrubs. Thus low-lying vegetation and small shrubs will remain largely undisturbed. Such cleared areas have the potential of increased browse production by willow and birch shrubs following over-story removal.

(ii) Operation

After establishment of the transmission corridors, periodic maintenance via selective clearing or trimming will be required. Such manual clipping may stimulate leaf and twig growth of willow and other browse species (Wolff 1978, Chapin et al. 1975). On the other hand, evergreen shrubs such as Labrador tea and other woody shrubs are likely to show increased mortality if damaged in the process of clearing (Chapin 1980, Chapin and Shaver 1982). But the potentially most damaging aspect of operation may be increased ORV use in the rights-of-way (see Section 3.3(a)(iii)).

(e) Impact Summary

This section summarizes the important impacts of the Susitna Hydroelectric Project on vegetation. It also presents the impact issues in order of their priorities of importance.

(i) Watana Reservoir Area

The immediate vicinity of the Watana Reservoir will be the region most adversely affected by the Susitna project. In addition to the 14,409 ha of plant cover that will be removed or cleared within the impoundment and associated use areas, an unknown area of vegetation will also be lost as a result of mass land slumpage from permafrost melting along the south side of the reservoir. Changes in the water table and erosional processes are likely to increase the relative abundance of bog vegetation. Increases in dust during construction, changes in local micro-climates during operation, increases in ORV use, and changes in the incidences of fires may affect vegetation to a lesser extent.

(ii) Devil Canyon Reservoir Area

Because of the narrow, steep configuration of the valley and the smaller size of the impoundment, Devil Canyon will affect a smaller area of vegetation than will Watana. During construction, 2598 ha, primarily forests, will be inundated or cleared for the impoundment and facilities. During filling and operation, dust problems will moderate, erosional processes will occur less frequently, and mesoclimatic change is likely to be negligible. Rock slides pose the greatest threat as a source of additional vegetational loss and one large slide at river mile 175 may also cause some upstream flooding, with accompanying floodplain successional events at new tributary mouths.

(iii) Talkeetna to Devil Canyon

Downstream floodplain vegetation will increase in the area of floodplain it covers, and more of it will progress to late succession as a result of fewer flood episodes and decreased ice scouring following dam construction. Because of the armored condition of the Susitna channel between Talkeetna and Devil Canyon, however, much of the newly exposed river banks will have insufficient soil development to allow immediate establishment of vegetation other than pioneering communities. Areas where sufficient alluvium is available will develop into the medium and tall shrub stages during the license period.

(iv) Cook Inlet to Talkeetna

The confluence of the Chulitna and Talkeetna rivers and other streams south of Talkeetna, and the strong tidal influence on the lower reaches of the Susitna River are expected to obscure effects resulting from diminished flows caused by the dams. Annual flooding by the Chulitna and/or Talkeetna rivers is likey to maintain much of the downstream vegetation in the floodplain in successional stages even without contributions from the Susitna.

(v) Access and Transmission Corridors

Access roads and railroads will remove several hundred ha of primarily tundra vegetation types. Additional small areas of vegetation at roadside margins will be affected by dust, changed surface water regime, and road maintenance activities. The areas of each vegetation type lost and modified are small in comparison to the total areas of each type that exist in the regions traversed by the roads.

Transmission corridors will modify up to a few thousand ha of vegetation. The greatest changes will come in forest types, where the overstory must be cleared to construct and maintain the rights-of-way. As with roads, the area of each vegetation type that will be affected is small in comparison to what exists regionally.

(vi) Prioritization of Impact Issues

In this section, impacts to vegetation are discussed in order from most to least important. Losses of vegetation are judged important in proportion to total acreage lost and in indirect proportion to amounts of each type present regionally. Plant community changes are judged to be less important than losses per se. As yet, there is no basis for evaluating whether community changes are "good" or "bad".

- Direct Losses of Vegetation

. Watana

Direct losses for the Watana project include 12,667 ha of vegetation for the dam, impoundment and spillway. An additional 1742 ha have been designated for use as camp, village, air strip, and borrow areas. These potential losses account for only 1 percent of all vegetation in the Upper Susitna Basin, but 3.6 percent of the vegetation present in a 16-km-wide area spanning the Susitna River from Gold Creek to the mouth of the Maclaren River. More importantly, substantial losses of certain vegetation types will be sustained during construction of the Watana Dam. Losses of forested areas may total 8.3 percent of the 16-km-wide area. Losses of open and closed birch forest will be particularly large, greater than 20 percent for the 16-km wide area. The losses of these forest types will mean substantial habitat losses for some wildlife, especially black bears, moose, pine marten, beavers, passerine birds, and raptors.

. <u>Devil Canyon</u>

Direct losses for the Devil Canyon project will include 2376 ha of forests, tundra and shrubland. Negligible amounts of tundra and shrubland (<.05 pecent) will be cleared, but 0.7 percent of all forested lands in the upper basin (1.8 percent of the 16-km-area) will be affected. Because of the steepness of Devil Canyon, these losses are relatively small compared to Watana Canyon and comparatively less important for wildlife. Again, however, appreciable quantities of closed birch forest (18.6 percent of the 16-km-area) will be eliminated.

. <u>Access Roads</u>

The Watana access road will result in a loss of approximately 230 ha of mixed tundra vegetation types. Additional losses of about 200 hectares for access roads and 78 ha for rail will be utilized for access to the Devil Canyon facility, should this be built. These routes will span spruce forests, tall and low shrubland and tundra vegetation types. In relation to possible losses from other aspects of the project, these direct losses are small.

. <u>Transmission Corridors</u>

Of the total 3483 hectares of vegetation on rights-of-way for transmission lines, only a small fraction (10 percent) need be subject to initial clearing. A median strip for transport of personnel and materials, plus smaller areas for placement of control stations, relay buildings and towers, will need to be cleared, whereas other portions of the transmission corridors will only require selective clearing or top-cutting of tall trees and shrubs.

- <u>Indirect Losses of Vegetation</u>

Substantial additional losses of vegetation may occur due to erosion, permafrost melting and subsequent land slides and slumpage, ORV use, blowdown of trees and other causes (see Section 3.3(a)(i)). While some of these losses will be short-term with typical vegetational succession ensuing, or with shifts to new vegetation types for that area, longterm vegetational losses enduring for 30 to more than 100 years may occur on sites of continual erosion, land slumpage, or ORV use. The amounts that will be lost because of these factors are small compared to amounts inundated by the reservoirs.

. Watana

Indirect losses of vegetation are projected to be greatest at the Watana site, where large areas on the south side of the impoundment are underlain by 200-300 feet of permafrost at near melting temperature. Also, because of the expected large size of the reservoir, other erosional processes such as wind erosion, together with effects of dust, may cause very localized vegetation loss, especially in wind-exposed areas.

. Devil Canyon

The smaller, steeper nature of Devil Canyon will severely limit indirect losses of vegetation. Except for the possibility of one massive flow near river mile 175, rock slides occurring above the impoundment represent the greatest threats and these will result in only small scale losses.

. Access Roads

Alternations of vegetation adjacent to access roads will occur principally where drainage patterns have been changed. Berms along road shoulders will result in swamping or waterlogging of poorly drained soils, with a corresponding shift to depauperate bogs. In other areas drainages may merge, break through berms and roads, and cause erosional losses of vegetation. Increased utilization of ORVs along access roads and road maintenance may damage adjacent areas.

. Transmission Corridors

Little indirect loss is likely as a result of direct clearing or construction, but uncontrolled ORV access could affect vegetation on and adjacent to corridors. Forests, shrublands, tundra and wetlands are dispersed along this area.

- Alteration of Vegetation Types

In many instances, natural succession of cleared or disturbed areas not subject to inundation will result in vegetation type changes. For example, primary herbaceous and weedy vegetation and secondary shrub growth may follow clearing of sites. There may be development of fast-growing algal species and floating vegetation in shallow areas of the impoundment(s). Vegetation succession trends following man-caused fires are generally predictable.

. Downstream Floodplain

The most important alteration to result from the dam(s) will be downstream between Talkeetna and Gold Creek, where annual spring and summer flooding and spring scour by ice jams will be ameliorated. As a result, some of the previously pulse-stabilized communities will mature. The willow and balsam poplar shrub will change to mature balsam poplar and thence to spruce. Within the license period, the development of vegetation on newly exposed banks and islands will proceed only to the medium and tall shrub stages.

. Watana

One area of potentially important impacts is tundra vegetation surrounding the Watana Reservoir. Disturbance may cause warming of the soil, melting of the permafrost, and deepening of the active layer. In well-drained areas, this may result in increased growth and productivity by the existing plant community, but in waterlogged areas a shift to bog vegetation is likely. If the organic layer is lost during disturbance, long-term losses of vegetation may result.

Most disturbed forests and shrub area disturbed near the reservoir will recover naturally. The ensuing patterns of vegetational succession will be accelerated if the organic layer is retained and if root suckers or seeds of vegetation remain.

. Devil Canyon

Outside the actual impoundment and dam site, very few alterations of vegetation types are anticipated at Devil Canyon. Forest types will be subject to minor alterations, primarily near borrow sites G and K, and near camp and village sites. Likewise, changes in drainage, waterlogging of soil or permafrost melting will be highly localized because the soil is generally very rocky and well drained, with only sporadic occurrences of permafrost. The smaller, steeper character of Devil Canyon will also act to limit micro-climatic and mesoclimatic alterations.

. Access Roads and Railroads

The access roads between the Devil Canyon and Watana sites and between Watana and the Denali Highway, as well as rail construction between Devil Canyon and Gold Creek, will necessarily alter drainage patterns and may induce dust-related alterations in vegetation at roadsides. The effects of altered drainages have been summarized above.

. Transmission Corridors

Selective clearing or top-cutting of tall vegetation will result in local shifts in plant types from trees to shrubs. Wet and moist tundra areas and their peripheries will be more susceptible to waterlogging by vehicular traffic with subsequent development of bog and/or black spruce species in place of cottongrass and shrub species.

3.4 - Mitigation Plan

(a) Watana Development

(i) Construction

The direct removal of vegetation within a total area of approximately 14,409 ha will result from construction of the Watana Dam, impoundment area, and ancillary project facilities (e.g., access roads, airstrips, camp, village, material sites). For project features outside of the Watana impoundment area, mitigative features have been incorporated into engineering design and construction planning to avoid or minimize the impact of vegetation removal during construction. Facilities have been sited on a case-by-case basis to minimize clearing requirements, both by choice of unforested or sparsely forested locations and by consolidating structures to disturb the minimum area of ground surface. The construction camp and village have been located together on an unforested site immediately adjacent to the Watana construction area (Exhibit A). Equipment and vehicle use will be confined to gravel roads and pads. Off-road or all-terrain vehicle use will be prohibited. Service roads will be established along planned connecting corridors to channelize transportation activities.

Minimal forest clearing will be necessary to establish the limited infrastructure of temporary roads, fuel and equipment storage areas, and other support facilities joining the construction site with the camp and village. The entire affected area of dam and ancillary facilities, including the emergency spillway, will be confined to a radius not exceeding about 3,000 meters.

Facility siting has avoided wet areas to the maximum extent consistent with logistic requirements. Both the main camp and the village site have been selected to provide well-drained land with existing slopes of 2 to 3 percent. Siting has minimized the necessity for fill placement in wetlands, in accordance with the guidelines of Section 404 of the Clean Water Act. Minimizing fill placement has correspondingly reduced gravel extraction volume demand and related vegetation cleaning requirements. Where fill placement is necessary, as for the construction camp and equipment maintenance area, gravel will be placed directly on the vegetative ground cover, without removal of organic overburden.

Where construction activities require removal of the organic layer and topsoil, these materials will be stockpiled for use in subsequent site rehabilitation measures. Overburden stockpiles will be sited in stable, well-drained locations and bermed to contain runoff. Depleted or non-operational upland borrow pits will be used as overburden storage areas where feasible.

Inorganic excavated material suitable as aggregate or fill will be used for construction purposes, for rehabilitation of depleted material sites, or for solid waste disposal site maintenance. Where such use is not feasible, excavation spoil will be hauled to the impoundment area and disposed of in designated locations which will eventually be inundated. Vegetation outside of the impoundment area will not be disturbed for spoil disposal purposes.

Gravel extraction for construction of the earthfill dam, cofferdams, access and service roads, and facility foundation pads will be the major cause of vegetation removal other than clearing and flooding of the impoundment area. Where haul distances are feasible, gravel for roads, pads, and other ancillary facilities will be obtained from borrow areas inside the future Watana impoundment (proposed Borrow Sites D, J, or L). Borrow material from Susitna River floodplain or first-level terrace locations downstream from the Watana Dam site, or from any other river or stream, will not be used for ancillary facility construction.

Active floodplain, first-level terrace, or streambed sites outside of the Watana impoundment area will be cleared and excavated only in cases where a specific type of material required for construction of the Watana Dam itself is not available within a feasible haul distance inside the impoundment area. For example, geotechnical investigations have shown that the nearest feasible source of concrete aggregate and filter material suitable for dam construction is Borrow Site E (Acres 1980-82 Geotechnical Report). This site encompasses about 325 ha of first-level terrace extending about 3600 meters along the north side of the Susitna River. Vegetation is almost entirely closed coniferous forest with minor areas of alder, shrub, and tundra. The potential excavation area includes the mouth and 1.5 kilometers of Tsusena Creek, and the mouth and about .75 kilometers of Bear Creek. Elevation across the site varies from about 427 meters near river level to about 515 meters along the northern boundary of the site. More than half of Borrow Site E is outside the proposed 441-meter limits of the future Devil Canyon Reservoir.

Borrow Site E will be developed by pit excavation using drag lines, in accordance with established guidelines (U.S. Fish and Wildlife Service 1982; U.S. Army Corps of Engineers 1982). Precise material volume requirements and excavations limits for the site have not yet been established. However, gravel will be extracted from narrow, variable-depth pits, with maximum depth of excavation ranging from about 38 meters in the southwest corner of the site to about 6 meters in the northeast corner (Acres 1980-81 Geotechnical Report). Pit excavation, as opposed to the clearing and scraping of large areas of terrace, will minimize requirements for vegetation removal and facilitate rehabilitation for wildlife habitat enhancement.

(ii) Filling

There is no way to avoid vegetation loss from filling of the impoundment area. Partial compenstion is being planned, however, for vegetation components important as wildlife habitat. For example, loss of moose winter browse may be compensated through habitat enhancement measures or the acquisition of replacement lands where future development which might otherwise occur will be prohibited (Section 4.4).

The Watana Reservoir filling schedule has been adjusted to minimize impacts of vegetation removal. Clearing of vegetation within the impoundment area will proceed systematicaly in stages over a three-year period during the winter months. Access routes to the clearing zones will be kept within the future reservoir. Clearing will be confined to the area to be inundated during each following year, so that uncleared vegetation will not be flooded. This practice will help reduce uprooting of uncleared trees and shrubs from erosion, blowdown, thaw, and slumping.

Because clearing will be conducted following dam construction, downstream siltation from erosion runoff will be minimized through settling within the impoundment. However, it is expected that downstream siltation will increase as a result of reservoir clearing. This impact is discussed further in Exhibit E, Section 2, Water Resources.

Cleared slash and debris will be stockpiled and burned under continuous supervision during the same clearing season. Prompt burning will help to prevent the spread of spruce budworm and other insects or decay organisms. It is not anticipated that merchantable timber will occur in quantities sufficient to justify removal for sale.

Outside of the impoundment area, impacts of vegetation removal will be partially rectified by site rehabilitation and reduced over time by the gradual reestablishment and succession of native vegetation. Disturbed areas will be graded to contour and evenly covered with organic overburden and topsoil previously stockpiled for this purpose. Fertilizer high in phosphorus (e.g., 10-20-10 or 8-32-16, N-P-K) will be applied at a rate sufficient to supply 85 to 110 kilograms of nitrogen per hectare.

Following the spreading of organic overburden, topsoil, and fertilizer, the site surface will be scarified to a depth of 10 centimeters using a rake towed by a mini-Rolligon-type vehicle. This procedure will mix the organics with the underlying mineral soil, aerate the mixture, and lightly compact the surface. During the second and third growing seasons, followup applications of fertilizer will be made at one-half to one-third the original rates.

Where erosion potential or aesthetic considerations can be demonstrated not to be involved, site rehabilitation will emphasize application of organics and nutrients and minimize seeding. This practice will encourage the reinvasion of native species from the surrounding parent population. For lightly-disturbed sites with intact topsoil, fertilization alone should be sufficient to facilitate revegetation.

Sites with high erosion or visual impact potential will be fertilized and seeded with fast-growing native grasses appropriate to the climate and geography of the Susitna Basin. To minimize erosion, all sites will be rehabilitated by the first growing season following removal of structures and equipment.

(iii) Operation

Reductions in spring breakup and summer peak flows, channel width, and sediment deposition will decrease cyclic variations in the successional stages of riparian vegetation downstream from the Watana Dam site, especially in the reach upstream from the confluences of the Chulitna and Talkeetna Rivers. Successional stages of riparian vegetation associated with the active floodplain will be monitored yearly. In the event that successional variability is found to decrease, with later stages becoming dominant, periodic controlled flooding will be implemented to help maintain primary and secondary successional stages.

Following construction of the Watana Dam, permanent staff and facilities will be required to support project operation and maintenance. Housing and ancillary structures for about 130 staff and their families will be built on land previously disturbed by the temporary village. Clearing and construction in undisturbed areas will be avoided.

Gravel will be required for road maintenance and other purposes during project operation. To minimize the expansion of existing borrow areas or the establishment of new ones, abandoned cofferdams, service roads, airstrips, foundation pads, and other gravel structures will be used as material sources for operation and maintenance purposes. These structures will be rehabilitated only if such use is not anticipated during the life of the project.

(b) Devil Canyon Development

(i) Construction

The mitigative approach discussed for construction of the Watana Dam, impoundment, and ancillary facilities will apply also to Devil Canyon development. In addition, two features have received particular attention:

- Disposal of spoil produced during construction of the Devil Canyon saddle dam; and

- Design and placement of the railhead facility and railroad extension relative to Jack Long Creek and associated wetlands.

Depleted or nonoperational portions of Borrow Site G will be used for disposal of spoil produced during construction of the saddle dam at Devil Canyon. Borrow Site G will be the aggregate source for construction of the concrete arch dam and will be excavated prior to saddle dam construction.

Designated containment areas will be established within the borrow area to accommodate spoil produced by saddle dam site excavation and by extraction and processing of rock-fill material at Quarry Site K, approximately 1.2 kilometers to the south (Exhibit A, Section 7.2). Borrow Site G, at about Elevation 303 meters, will be about 138 meters below the surface level of the Devil Canyon reservoir. Therefore, spoil disposal necessary for saddle dam construction will not require clearing of vegetation outside the impoundment area.

The railhead facility at Devil Canyon will consist of a poured concrete pad approximately 800 meters long and 240 meters wide, accommodating the main track, two sidings, and areas for equipment, offloading, and storage. The Jack Long Creek drainage and associated wetlands occupy a swale immediately south of the construction camp and village, imposing difficult constraints on the siting of the railroad extension alignment and railhead.

To minimize removal of riparian vegetation, fill placement in wetlands, and direct physical disturbance to Jack Long Creek, the terminal portion of the railroad extension has been kept as high on the hillside south of the creek as possible. It generally follows the transmission line corridor at the 500- to 550-meter contour level, and terminates on relatively flat ground at an elevation of about 454 meters. This alignment and siting keeps the railroad extension and railhead facility on higher ground well out of the Jack Long Creek drainage.

(ii) Filling and Operation

Mitigative measures implemented during filling and operation at Devil Canyon will be similar to those planned for the Watana development. All construction facilities will be dismantled and removed, and disturbed terrain rehabilitated. Permanent staff required for operation and maintenance will be housed at the Watana permanent village. Borrow Site G will be completely within the impoundment; the primary rectification objective for Quarry Site K will be to ensure sediment-free drainage over clean rock surfaces into Cheechako Creek.

(c) Access

(i) Construction

The project access route has been designed to traverse relatively unproductive upland tundra, minimizing wetland crossings and avoiding closed forest along the Denali Highway-to-Watana segment, and keeping north of the Susitna River in unforested shrub or tundra between Watana and Devil Canyon. The open forest and wetlands of the Fog Lakes and Stephan Lake areas south of the Susitna River

Merchantable timber cleared along this segment will be sectioned and hauled to Gold Creek for public consumption. Slash and debris will be gathered and burned to minimize the spread of spruce budworm or other organisms as a potential result of clearing.

A major objective of access road alignment and design has been to avoid or minimize fill placement in wetlands, in accordance with guidelines established by Section 404 of the Clean Water Act and the Alaska District, U.S. Army Corps of Engineers (1982). A flexible design speed, varying between 40 and 55 miles per hour, has been incorporated to allow short-radius vertical and horizontal curves. This approach facilitates site-specific alignment adjustments to avoid sensitive features, and minimizes fill requirements in complex terrain.

Where permafrost conditions permit, routing emphasizes sidehill cuts to avoid low-lying wet areas and maximize potential for balancing cut and fill quantities. Where bermed constructon capable of blocking sheet flow cannot be avoided, equalization culverts or serial bridging will be employed. Emphasis on side borrow techniques will minimize the need for material sites away from the alignment, and correspondingly minimize vegetation clearing requirements.

(ii) Operation

Public access will create a potential for disturbance to vegetation during project operation. Use of off-road or all-terrain vehicles by hunters has already produced extensive vegetation removal and soil disturbance in the Butte Lake area, where vehicles are driven directly onto the tundra from the Denali Highway. Management provisions will be required to prevent a similar impact from occurring along the Denali Highway-to-Watana and Watana-to-Devil Canyon segments of the project access route.

The Alaska Power Authority is reviewing management options for avoiding or minimizing access-related disturbances to vegetation during the life of the project. These options range from total prohibition of public access to restriction of off-road or all-terrain vehicle use within the project area. Interagency agreement will be required to implement policies affecting the public lands of the area. For example, the Denali Highway is under review by the Bureau of Land Management for inclusion in the National Scenic Highway System (R. Ward and M. Wrabetz 1982). The project access route may also be eligible for this designation, which would entail restrictions on off-road vehicle use and other potentially disturbing activities initiated from the access road.

The Susitna Hydroelectric Project Recreation Plan is presented in Exhibit E, Section 7. A major objective of the Recreation Plan is to establish patterns of public access that will minimize and localize access-related impacts through the use of trails and designated camping areas. The Recreation Plan is consistent with fish and wildlife habitat protection priorities established for the project. In addition, the phased design of the Recreation Plan will ensure that implementation will be gradual and based on monitoring of fish, vegetation, and wildlife impacts as well as recreational user needs. Implementation of each phase will be subject to interagency review and concurrence.

(d) Transmission

(i) Construction

The transmission corridor from Watana to the Intertie is the shortest feasible route, and crosses mostly upland tundra. Where forest occurs, the route largely follows forest-tundra and forest-shrub transition zones where clearing requirements will be minimal. Construction of the transmission lines will not involve removal of organic overburden, ground cover, or shrub vegetation; soil disturbance will be limited to installation of anchor points for transmission tower cable supports. All transmission- related construction between Watana and the Intertie junction at Gold Creek will occur during winter months when an adequate snow pack exists to support ground equipment and vehicles. Only flat-tread Nodwell-type or ballon-tired Rolligon-type vehicles will be used. Where winter access is not feasible or snow-free conditions are required, helicopter-supported construction will be used.

Additions to the existing Healy-to-Fairbanks and Willow-to-Anchorage transmission corridors, and to the Willow-to-Healy Intertie, will be made adjacent to the established lines except where constraints of land ownership or use require re-routing. Where new routing is required, alignment alternatives are designed to minimize crossings of active floodplains, streams, and wetlands. Alignments avoid lakes and parallel streams by a minimum 150 meters of undisturbed terrain. Transmission towers will not be placed in active floodplains.

Winter construction procedures will be followed for transmission line additions routed through previously undisturbed areas. Where winter access is not feasible or snow-free conditions are required, helicopter-supported construction will be used.

(ii) Operation

The primary environmental objective for transmission corridor operation and maintenance is to avoid creating new or alternative access routes for all-terrain vehicles. To achieve this objective, all operation and maintenance activities will be implemented without road support, except where suitable roads already exist. Operation and maintenance tasks will therefore require winter scheduling or helicopter support.

In keeping with the objective of avoiding public access by transmission corridors, vegetation clearing will not be a routine feature of transmission line maintenance. Trees that present a hazard to power lines or prevent access to transmission towers for maintenance or repair will be cut. Woody shrub and herbaceous vegetation in previously undisturbed areas will not be cleared during maintenance. The use of herbicides will be prohibited.

4 - WILDLIFE

4.1 - Introduction

Populations of many wildlife species inhabit the Susitna project area. The importance of each population for purposes of the Susitna project depends on the abundance of individuals in the population and/or the contribution of the population to recreation, subsistence or commerce. Species classified as threatened or endangered are considered particularly important. The emphasis of this report is on those wildlife resources that are more important than others for one or all of these reasons.

(a) The Vertebrate Fauna

Birds and mammals are the wildlife groups of interest in this study. Kessel et al. (1982) encountered 135 species of birds in the Susitna Basin above Devil Canyon; 82 species occur along the Susitna River floodplain below Devil Canyon. Sixteen species of small mammals--shrews, rodents, hares and porcupines--are known to occur in the upper Susitna basin. Moose, caribou, Dall sheep, brown bears, black bears, wolves and wolverines are big game species that occur in the project area. Furbearers include the beaver, muskrat, river otter, mink, pine marten, red fox, lynx, coyotes, and short-tailed and least weasels (Gipson et al. 1982). Scientific names of bird and mammal species are listed in Appendices E.E and E.F.

(b) Threatened or Endangered Species

No threatened or endangered species of wildlife have been recently encountered in the Susitna project area. White (1974) observed two peregrine falcons in 1974 along the Susitna River in the Devil Canyon impoundment area. Kessel et al. (1982) observed no peregrine falcons or other threatened or endangered species during their studies. The potential presence of peregrine falcons is discussed in greater detail in Section 4.2(c), (i).

(c) Species Contributing to Recreation, Subsistence and Commerce.

All big game species contribute to recreation, and some of big game harvest would appropriately be called subsistence. All the furbearers contribute to some extent to commerce of fur trappers in the region. Few birds are hunted in the region. In theory, birds contribute to non-consumptive forms of recreation such as bird-watching, but in fact, the area is too remote to attract many people who come solely to see birds.

Moose, caribou, black bears and brown bears are the most abundant big game species and are given highest priority. Sheep, wolves and wolverine are regionally less abundant and are assigned secondary importance. Furbearers are considered less important than big game species. Beavers, marten and muskrat are common enough to be readily available to trappers and have limited economic importance. Otter, mink, red foxes, coyotes, lynx, and weasels are given low priority.

Birds and small mammals have historically contributed little to recreation, subsistence or commerce in the project area. In addition, they each represent a large number of regionally abundant species of which few can be assigned priority over others. As a consequence, each species can receive limited treatment relative to big game and furbearer species with more obvious priorities of importance.

4.2 - Baseline Description

(a) Big Game

(i) Moose

Studies of moose in the Susitna Basin were conducted in two discrete areas; 1) the upper Susitna basin, including all parts of the watershed upstream of the Devil Canyon damsite, and 2) the lower Susitna basin, including the major valley of the Susitna River from Devil Canyon downstream to the river mouth at Cook Inlet.

Studies in the upper and lower Susitna basin have addressed different aspects of moose ecology. The differences in approach primarily reflect the differences in topography and vegetation in each portion of the basin, as well as differences in the development scenarios and potential impacts in the two areas. Consequently, comparable information on moose in all areas of the Susitna basin is not always available. The following discussion of moose ecology in the Susitna basin provides a summary of the current state of knowledge for moose in the upper and lower basins. Similarities and differences in various aspects of moose ecology that may be influenced by the Watana-Devil Canyon projects will also be discussed.

Most of the information contained in the following discussion is based on studies by Ballard et al. (1982a) in the upper Susitna Basin and Modafferi (1982) in the lower Susitna basin. Additional references are cited as necessary.

- Distribution

Moose occur throughout the Susitna River drainage and are one of the most economically-important wildlife species in the region. Within the Susitna basin, moose tend to be most abundant in the upstream area east of and including Tsusena and Kosina creeks and within the main Susitna valley downstream of Montana Creek to the river mouth at Cook Inlet. Low numbers of moose appear to presently inhabit the area between Devil Canyon and Talkeetna.

. Seasonal Movements

Moose in many northern areas undergo regular seasonal movements or migrations (see LeResche [1974] and Coady [1982] for a review). LeResche (1974) described migrations for moose as regular annual movements that involve return to at least one common area each year.

In some areas such as the North Slope of Alaska (Mould 1979) or northern Minnesota (Van Ballanberghe and Peek 1971), migratory movements may involve distances of only 2-10 km with little change in elevation. Migrations in mountainous areas usually involve large changes in elevation. In interior Alaska, moose spend the summer at low elevation, move to high elevation during fall and early winter, and return to lower elevations during mid- to late winter (Bishop 1969). Horizontal differences between ranges may be as little as 2 km (Knowlton 1960) or as great as 170 km (Berry 1961). Migration in moose appears to be an adaptation for optimizing survival through utilization of the seasonally most-favorable habitats available (Coady 1982).

Weather conditions, particularly snow depth and structure, are one of the most important factors associated with moose migration (Coady 1974, LeResche 1974). Winter severity may also influence the distance moved by individuals as well as the proportion of moose in a population that migrate to different areas. For example, during a winter of low snow in southcentral Alaska, some groups of moose overwintered on summer ranges while other groups migrated to adjacent winter range (Van Ballenberghe 1977). During winters of deep snow, however, almost all of the moose migrated from the summer range to low elevation winter ranges.

In the upper Susitna basin, some groups of moose exhibit seasonal shifts in distribution. Other groups undergo very limited seasonal movements and remain in low elevation riparian and forest communities year-round. Similar types of migratory and non-migratory movements have been observed in other moose populations in Alaska (LeResche 1974). Ballard et al. (1982a) delineated thirteen subpopulations of moose in the upper Susitna basin on the basis of seasonal movement patterns.

Over 2700 radio-locations obtained from 207 moose during the period from October 1976 through August 1981 indicated that most moose in the upper Susitna basin moved to lower elevations during late spring and early summer; mean elevations of relocations for April and May were 785 m and 805 m, respectively. As summer progressed, moose moved to higher elevations and commonly remained there throughout the winter period. The highest mean elevation of 901 m occurred in December.

These trends in elevation are quite different from seasonal patterns observed during previous studies in the upper Susitna and Nelchina River basins. Van Ballenberghe (1978) and Ballard and Taylor (1980) both observed that moose tended to occupy areas at 762-914 m elevations during the summer and moved to elevations of 548-671 m during the winter. Ballard et al. (1982a) attributed the use of higher elevations by moose during 1980 and 1981 to mild winters, and suggested that high winds and temperature inversions resulted in reduced snow depths at higher elevations. Browse was consequently more accessible in these areas than at lower elevation areas.

Use of regional areas within the upper Susitna basin by moose also appears to be influenced by slope. Slopes were classified into four broad categories: flat - 0 to 10°, gentle 11 to 30°, moderate 31 to 60°, and steep - 61 to 90°. During both summer (May to August) and winter (November to April), 91 percent of the moose relocations occurred on flat and gentle slopes. The aspect of the slope, however, did not appear to influence moose locations.

Detailed information on the distribution of moose in the lower Susitna basin is limited to the current studies being sponsored by the applicant. In general, riparian habitats are at least seasonally important to moose in all reaches of the lower Susitna River. Winter ranges for moose throughout the lower Susitna basin are located in riparian areas. Riparian communities are also commonly used as calving areas by moose north of Talkeetna, as year-round habitat for moose in the Delta Island area, and as transition range for moose south of Talkeetna. (Moose in the area south of Talkeetna appear to utilize seasonal ranges on both sides of the river valley.)

. Special Use Areas

Because movement patterns, calving areas and breeding areas of moose may be traditional (Van Ballenberghe 1977), and because the Susitna project could interfere with use of these sites, it is important to identify special use areas prior to development. Accordingly, portions of the upstream and downstream moose studies have attempted to locate concentration areas during the calving period and the rut.

Calving Areas. Parturition generally occurred between May 15 and June 15 in the years 1977 to 1980. To determine if calving concentrations occurred in or adjacent to the proposed impoundment areas, all observations of radio-collared cow moose in the upper Susitna basin between 15 May and 15 June during 1977 to 1980 were assessed. Although this method includes some cows which were not observed with calves, it does provide locations of areas where cows probably calve. (This error is likely small because calf mortality immediately following birth is high [Ballard and Taylor 1980, Ballard et al. 1981] and many parturient cows would consequently not be observed with calves.)

Cow moose were distributed throughout the upper Susitna basin but several concentrations of radio-collared cow moose were observed. These included: Coal Creek and its tributaries; the Susitna River from the mouth of the Tyone River downstream to a point several miles downstream from Clarence Lake Creek; Jay Creek to Watana Creek; the area in the vicinity of the mouths of Deadman and Tsusena creeks; Fog Creek to Stephan Lake; and opposite Fog Creek to Devil Creek. Low shrub and open spruce habitats were the most common cover types in the vicinity of these concentrations. The importance of these sites as traditional calving areas is not known.

Within the lower Susitna basin, calving concentrations north of Talkeetna occurred in cover types different from those used south of Talkeetna. Radio-collared females in the area north of Talkeetna generally moved to riparian or island habitats during the calving period. Cottonwood was the predominant cover type in the vicinity of most relocations during the calving period.

In contrast, radio-collared cow moose in the Susitna valley south of Talkeetna generally left the overwintering riparian areas by late April and did not return to these areas until well after the calving period. A possible calving concentration was observed in the vicinity of Trapper Lake but most cow moose were widely dispersed at varying distances from the Susitna River. On average, cow moose were located 14.7 km from the river during the calving period. However, several females calved on the river islands and remained there throughout the year. Cow moose in the area south of Talkeetna were generally observed in cover types more typical of calving habitat in other areas of Alaska (e.g., Rausch 1958; Bailey and Bangs 1980); a mosaic of spruce and alders interspersed with muskeg bog meadows was the most common cover type near relocations.

A common feature of calving habitats in the lower Susitna basin is their close proximity to water. Although the presence of water may be an important attribute of calving sites, it is more likely that cow moose seek these areas because of the availability of newly-growing herbaceous vegetation (LeResche and Davis 1973; Modafferi 1982). Such vegetation would provide lactating cows and newborn calves with a readily-available source of easily digestible, highly nutritious forage (Weeks and Kirkpatrick 1976; Fraser et al. 1980).

Avoiding predation (Ballard et al. 1980) or insect harassment (Mould 1979) may be a secondary consideration to forage availability in the selection of calving sites. Open muskeg areas would provide relief from insect harassment because of air movement, but air movement also may carry moose scent to predators such as black or brown bears or wolves. The relative openness also negates concealment from predators. Riparian habitats which are less open than muskeg would afford little relief from insect harassment but would provide considerably more concealment from predators and decrease the amount of windborn scent.

Breeding Areas. Breeding concentrations in the upper Susitna basin were determined by assessing the locations of all radio-collared cow moose between 20 September and 20 October during 1977 to 1980. Most cow moose occupied upland sites away from the proposed impoundment areas. Concentrations occurred in the following areas: Coal Creek to the big bend in the Susitna River, Clarence Lake, uplands between Watana and Jay Creeks, Stephan Lake to Fog Lake, and the uplands above the mouth of Tsusena Creek. Other concentration areas away from the proposed impoundments include northwestern Alphabet Hills, the Maclaren River, and the area above the mouth of Valdez Creek.

In the lower Susitna basin, few moose were observed in riparian habitats during the breeding period. With the exception of moose that remained in riparian communities or on the river islands throughout the year, most moose were located farther from the Susitna River during the rut than during the calving period. Cow and bull moose were located on average 15.5 km and 24.8 km, respectively, from the river. Use of specific cover types during the breeding period was not assessed.

. River Crossings

Because the impoundments of the Watana and Devil Canyon dams may create a barrier to local or seasonal movements of moose, it is important to determine where moose commonly cross the Susitna River in the vicinity of the proposed impoundments and the importance of these crossing sites as traditionally-used areas.

Between October 1976 and December 1981, 33 radio-collared moose made a minimum of 73 crossings of the upper Susitna River. Of 40 river crossings by radio-collared animals during 1980-1981, all occurred during the months of May through November. Distributions of the crossings were: May - 20%, June - 7.5%; July - 12.5%, August - 12.5%, September - 25%, October - 12.5%, and November - 10%.

Track surveys on 24 March 1981 provided observations of an additional 73 crossings of the Susitna River by moose. Based on both crossings by radio-collared animals and on track sightings, crossings of the Susitna River occurred throughout the proposed impoundment areas. However, crossings tended to be concentrated in several major areas along the Susitna River; these included the mouth of Fog Creek downstream to an area near Stephan Lake, from the mouth of Deadman Creek upstream for approximately 5 miles, Watana to Jay Creeks, and from Goose Creek to Clearwater Creek. The relative importance of these major crossing areas, particularly during seasonal migrations, is not known.

Information on movements of radio-collared moose in the upper Susitna basin between October 1976 and mid-August 1981 suggest that some of the above crossing concentrations may be associated with migratory movements. In general, movement patterns of most moose approximated the drainage pattern of creeks and tributaries of the mainstem rivers. Consequently, most movements in the upper Susitna basin involve a north-south movement pattern. Crossing sites for these generalized movements that occurred within the proposed impoundment areas include the lower portion of Watana Creek, the Jay-Kosina creeks area, and the movement corridor along the Susitna River.

- Habitat Use

. Cover Requirements

Because moose are largely dependent on woody browse during winter and late spring, their distributions are more closely associated with the distribution of commonly-utilized browse species than with other environmental factors (Coady 1982). However, the minimum requirements of moose for winter food and cover appear to be satisfied by a great diversity of habitat types across North America, suggesting that moose are adaptable to a variety of conditions.

Habitat use by moose is most extensive during the summer and fall and is gradually restricted during the winter (LeResche et al. 1974). Lowland and upland climax shrub communities are heavily utilized during summer and fall. By early winter, moose commonly move to upland and lowland seral communities. During winters of deep snow, upland seral communities are abandoned in favor of lowland areas.

In western North America, shrub communities are the most important winter habitats for moose (LeResche et al. 1974). In particular, riparian willow (Salix sp.) stands provide high quality winter range (however, moose highly prefer some species of willow over others). Maximum use of these areas occurs during mid- to late-winter and during severe winters. Areas of coniferous forests adjacent to riparian communities provide bedding areas and cover and so enhance the value of these shrublands for moose.

Riparian communities are perhaps the most important shrub habitats for moose (Coady 1982). Because riparian areas are self-renewing through alluvial action, they provide permanent seral habitats. Important seral shrub habitat is also created by fire, clear-cutting, and other disturbances that remove climax vegetation cover (LeResche et al. 1974, Davis and Franzmann 1979). However, because moose avoid large clear-cut areas (Hamilton and Drysdale 1975), widescale removal of mature forest cover can result in a reduction of moose habitat, despite the increase in shrub growth. Following fire in Alaska, the optimum age of browse growth is less than 50 years and moose utilization of these areas usually peaks 20-25 years after burning (LeResche et al. 1974).

Site-specific information on habitat use by moose in the Upper and lower Susitna basin was based on aerial assessments of the dominant vegetation species in the vicinity of each moose relocation. Although this method of evaluating habitat use provided some information on the relative importance of different forest cover types, two problems were apparent.

The first problem is associated with diurnal differences in habitat use by moose. Linkswiler (1982) showed that habitat use by moose in Denali National Park was strongly associated with the time of day. In general, it appeared that moose rested in forested areas during the day and became active in more open cover types during the early morning and evening. Observations of habitat use in the Susitna basin consequently may not accurately reflect the importance of some habitats to moose for activities such as feeding or nursing, except during the winter when habitat use is not greatly influenced by time of day.

The second problem associated with the assessment of moose habitat use during aerial surveys is that overstory cover types may not accurately reflect habitat components, such as browse availability, that strongly influence use by moose. For example, Ballard et al. (1982a) indicated that the upper Susitna and Nelchina river basins contain approximately 24 species of willow (Salix sp.), yet moose commonly utilize only several species of willow as browse (Wolff 1976). Because the distributions of willows and other shrubs are not directly related to forest cover types, assessments of habitat use by moose on the basis of forest cover types is probably misleading. Further studies of habitat use that measure variables important to moose are needed.

Habitat Use in the Upper Susitna Basin. Spruce cover types were the areas most frequently used by radio-collared moose in the upper Susitna basin during the period October 1976 to August 1981, with sparse- and medium-density, medium-height black spruce comprising 35 percent of the total observations. Assuming that Linkswiler's (1982) results apply to the Susitna basin, these habitats likely represent bedding or resting habitats. The combined areas of conifer forest and shrubland account for only 59 percent of the total area in the upper Susitna basin, but based on the aerial surveys, received over 90 percent of the year-round use by moose.

Moose use of upland shrub habitats corresponded closely with observed elevational movements of moose in this part of the Susitna basin. Moose were rarely observed in upland shrub habitats just prior to calving in April when they tended to be at low elevations. Use of the upland shrub habitat increased during the summer and peaked in October when 43 percent of all moose observed were in upland shrub habitat. High proportions of moose were observed in upland shrub habitat throughout the winter. As discussed earlier, the high use of this cover type during the winter is likely the result of mild winter conditions and consequently may not accurately represent moose habitat affinities during more severe winters.

During calving in May, moose in the upper Susitna basin were most commonly observed in sparse-to-medium-density, medium-height spruce habitats. These lower elevation habitats may be selected by parturient females because of the availability of escape cover and the early green-up of the vegetation. Habitats such as birch, alder and dense spruce cover types were not commonly used during the calving period.

Habitat Use in the Lower Susitna Basin. Habitat affinities of moose in the lower Susitna basin differed among the areas south of and north of Talkeetna and, in some cases, appeared to be influenced by both the sex of the animal and the season. Because these results are based on a relatively small number of relocations for a small number of moose, differences in habitat use among male and female moose and among seasons may not be significant.

During mid-March to mid-October 1981 (the sample period for all relocations in the lower Susitna study area), male moose (N=2) north of Talkeetna were most often observed in non-riparian communities dominated by alder, birch and/or spruce cover. Neither of these animals were observed in riparian communities. In contrast, most female moose north of Talkeetna were observed in riparian communities during the calving period. Cottonwood, alder, and willow were the dominant cover types at most relocation sites. During the summer period, most females in this area utilized non-riparian habitats, primarily those dominated by alder, birch and/or spruce. Females tended to remain in non-riparin communities during the breeding period and were most common in areas dominated by alder, sedge/grasses and/or spruce.

Male and female moose in the area south of Talkeetna were observed most often in non-riparian communities characterized by alder, birch and/or spruce habitats. During the calving period, cow moose tended to utilize birch and spruce cover types most, whereas during the summer and breeding period, birch, spruce and alder cover types were used frequently.

Twenty percent of the observations of females in the southern portion of the lower basin were in riparian habitats where alder, birch, spruce and/or cottonwood were the predominant cover types.

. Food Habits

Moose are primarily browsers, feeding predominantly on deciduous woody browse during winter months and on emergent and herbaceous plants as well as leaves and leaders of shrubs and trees during the summer (see Peek 1974 for a review). Food habits of moose are strongly influenced by browse availability and, as a result, it is difficult to summarize food habits for moose within large regional areas. In particular, moose feeding habits appear to change in relation to the species composition and relative abundance of browse in different habitats or within similar habitats of varying successional stages (Coady 1982). Snow depths and densities can also influence browse availability and, in turn, utilization of browse by moose (Coady 1974).

Data on browse availability and browse utilization for the upper Susitna basin are now being analyzed, but are probably similar to those from other areas in interior Alaska. Rumen content analyses of moose from the Fairbanks area indicated that moose depended on a diet of primarily deciduous woody plants (Cushwa and Coady 1976). Willow, paper birch, trembling aspen, and alder, in decreasing order, were the most frequently consumed browse species. Wolff (1976) observed a preference by moose in the Tanana River valley for willows and balsam poplar. Diets of moose in the upper Susitna basin may be similar to moose in the Fairbanks area except that trembling aspen is not readily available in the upper Susitna valley.

Chatelaine (1951) examined rumen contents of moose obtained from kills along the Alaska railway and from hunter kills in the lower Susitna valley in the Talkeetna-Houston area. Willows, paper birch, cottonwood, and trembling aspen constituted most of the winter diet. Shrubs such as alder, wild rose, and high-bush cranberry were rarely consumed. A similar analysis by Shepherd (1958) also indicated that the winter diet of moose in the lower Susitna valley was composed primarily of willows, paper birch and trembling aspen. However, because both of these studies involved moose from non-riparian habitats at some distance from the Susitna River, they probably do not accurately reflect the diets of moose overwintering in riparian communities and on river islands in the Susitna River. In particular, trembling aspen is not present in riparian communities and so would be unavailable to moose as a winter forage.

Browse availability and utilization measurements were obtained from a number of riparian sample sites along the Susitna River during 1980 (Arneson 1981). Five browse species were considered: willows, balsam poplar, paper birch, highbush cranberry, and wild rose. A mean of 1.4 browse plants/m^2 was recorded for all habitat types in the Susitna River valley between Portage Creek and the Delta Islands. Browse species were most utilized in equisetum/willow and medium-tall poplar/willow/alder habitats and least utilized in medium-dense climax poplar/spruce and sparse-climax birch/spruce.

Percent utilization of willow and poplar was greatest in habitats where they occurred less frequently. Birch was seldom found on floodplain habitats, but where it occurred near the river, it was well utilized (26.9%). Highbush cranberry and rose were found mostly in tall or climax habitats but were less abundant than willows. Utilization of highbush cranberry and rose was also less than willows.

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 high quality browse were not used by moose every winter; moose sign on some islands indicated heavy use in the past but no use during the winter of 1979-1980.

. Home Ranges

Moose population studies in both the upper and lower Susitna Basins involved biotelemetry assessment of local and seasonal movements and home ranges. A considerable volume of information on home range locations, sizes and distance relationships to the proposed impoundments or river channel was obtained. The following discussion of home ranges will concentrate on the numbers of home ranges that may be potentially affected by the impoundments in the upper Susitna basin and by modification of riparian communities in the lower Susitna basin.

The Upper Susitna Basin. To determine the number of moose that seasonally and annually occupy areas within or immediately adjacent to the impoundment areas, Ballard et al. (1982a) delineated a 28.7 km zone (the average length of the annual home ranges of 162 radio-collared moose in the upper Susitna basin for which 4 or more observations had been made during 1980-1981) around the impoundment area. Based on total home range polygons for 168 radio-collared moose, Ballard et al. (1982a) found that 19 had home ranges that fell outside the 28.7 km zone. Of the 149 moose with home range polygons either partially or entirely within this zone, 79 moose had home range polygons which were either partly or entirely contained within an area that encompassed the proposed impoundments and an arbitrarily-selected 8 km wide zone adjacent to the impoundment. Based on an estimate of 4500 moose for the upper Susitna basin, up to 2402 moose may have home ranges that completely or partly overlap the proposed impoundment area and the area within 8 km of the impoundment. A number of problems concerning equal catchability of animals, sampling intensity, and emigration/immigration of animals admittedly may bias the results of the above analysis (see Ballard et al. 1982a). However, the analysis does provide an approximation of the number of moose that could conceivably be affected by the proposed impoundments and facilities.

Lower Susitna Basin. The concern for moose in the lower Susitna basin that has been most commonly expressed is that altered water levels in the Susitna River may result in changes in the species composition, density, vigor and quality of riparian habitats. Information from the present moose biotelemetry studies in the lower Susitna basin is not adequate to reliably assess the number of moose that may be affected by changes in riparian communities.

Moose in the area upstream of Talkeetna and on the west side of the river were commonly relocated either within the river downstream of Talkeetna (i.e., river islands) or within 1.6 km of the river (most of this area would presumably be riparian communities) (Table W30). In contrast, moose on the eastside of the river downstream from Talkeetna did not commonly frequent the river or riparian areas. However, because of small samples, the above use patterns should be considered preliminary. Biotelemetry studies of moose in these riparian communities are continuing, so that the number of moose potentially influenced by these changes can be better assessed.

- Population Characteristics

. Historical Population Trends

Although moose population studies specific to much of the upper Susitna basin were not initiated until the late 1970's, the Alaska Department of Fish and Game has been conducting annual aerial censuses in Game Management Unit (GMU) 13 since 1955. Portions of GMU 13, specifically Count Area (CA) 6, CA 7 and CA 14, occur partly or entirely within the upper Susitna River basin (Figure W6). Historical descriptions of moose populations within GMU 13 are provided by Rausch (1969), Bishop and Rausch (1974), McIlroy (1974), and Ballard and Taylor (1980).

During the 1950's, moose populations in GMU 13 increased rapidly and reached high densities about 1960. After the severe winter of 1961-1962, the population declined and continued to decline with severe winters occurring in 1965-66, 1970-71, 1971-72, and 1978-79. Fall cow-calf ratios, as well as several other indices of population productivity declined sharply and reached a record low for the basin in 1975. Sex and age composition data for CA 7 and CA 14 have basically exhibited the same patterns described for the unit. Since 1975, the moose population appears to have increased slightly or remained stable even though calf survival has remained relatively low.

. Population Estimates - Upper Susitna Basin

In order to obtain accurate estimates of moose population sizes in portions of the upper Susitna basin, Ballard et al. (1982a) intensively surveyed CA 7 and CA 14 during 5-8 November 1980. Moose populations in all portions of the upper basin were not surveyed because of deteriorating snow conditions and the high costs of intensively surveying such a large area. During the aerial surveys of CA 7 and CA 14, a total of 743 moose were observed within 26 sample areas comprising 948 km^2, or an equivalent of 39 percent of the two count areas combined.

Table W31 summarizes the calculations utilized to estimate the fall moose population in CA's 7 and 14 east of Jay and Kosina creeks during the late winter 1980. Of the 2447 km^2 census area, 35 percent was classified as low moose density, 38 percent as medium moose density and 27 percent as high moose density. Based upon census data, each stratification was estimated to contain the following number of moose/km^2 low - 2.91, medium - 4.78, and high - 9.65. The estimated total fall population for CA's 7 and 14 was 1986 ± 371 (90% CI).

Because all moose would not be observed at a survey intensity of 1.7 minutes/km^2, portions of 10 sample areas were randomly chosen and were resurveyed at a sampling intensity of approximately 4.6 minutes/km^2 in an effort to generate a sightability correction factor. Based on comparisons of total moose counts during both sets of surveys, it was estimated that 98 percent of the moose were observed during the first surveys, yielding a correction factor of 1.03. The corrected population estimate for CA 7 and CA 14 was 2046 $\pm$ 382 (90% CI), of which 22 percent were calves.

Ballard et al. (1982a) were unable to intensively census the portion of the upper Susitna study area west of Delusion and Kosina creeks because of deteriorating snow conditions, but a rough estimate of moose numbers in this area was obtained during a short survey on 29 November 1980. Stratification of the survey area indicated that of the 2150 km^2 considered, 1456 km^2 were classified as low density, 663 km^2 as medium density, and 31 km^2 as high density moose areas. Based on this stratification, a crude population estimate of 1151 moose was obtained.

Similar calculations to those described above were used to estimate the number of moose in CA 6. Population estimates for this area were derived separately because a migratory group of moose is known to overwinter near the mouth of the Oshetna River. During the survey on 9 November 1980, a total of 205 moose were observed. Of the 1217 km^2 stratified, 528 km^2 were classified as low moose density, 536 km^2 as medium moose density, and 153 km^2 as high moose density areas. If it is assumed that the moose stratum densities in CA's 7 and 14 are equivalent to those in CA 6, a rough estimte of 830 animals is obtained. The estimated number of moose in the upper Susitna basin study area, excluding the far southeastern portion of the drainage, was 4027 during November 1980.

Because of cost constraints and deteriorating snow conditions, no population estimates were obtained for a number of areas in the eastern portion of the upper Susitna basin (the western Alphabet Hills, the Lake Louise flats, and the Tyone and Sanona Creek drainages).

. Population Estimates: Lower Susitna Basin

Estimates of moose density in the lower Susitna basin are based on six aerial surveys conducted only in riparian communities within four zones along the lower Susitna River (Figure W7) (Modafferi 1982, unpubl. data). Surveys were flown in early December 1981 and early April 1982. Because estimates are expressed as moose per river km, they are not equivalent to estimates for the upper Susitna basin (e.g., moose/ha).

During the six surveys, an average of 267 moose were observed per survey (range of 82 to 309). Estimates of moose densities (Table W32) indicate that moose were generally most abundant along the Susitna River during early March. During all surveys, moose densities were consistently higher downstream of Montana Creek than between Devil Canyon and Montana Creek.

. Population Structure

Upper Susitna Basin. Information on the population structure of moose in a portion of the upper Susitna basin (GMU 13) is available since 1955; summaries of a number of population ratios such as cow:calf ratios and sex ratios are summarized for CA 6, CA 7 and CA 14 in Tables W33 to W35. In all three counts areas, the number of males per 100 females has declined substantially since 1955. Similar declines in the number of small (presumably young) moose, calves and twin calves per 100 females also have been observed. These consistent declines suggest that moose productivity in the upper Susitna valley has declined over the past 25 years. Recent declines in productivity have been attributed largely to brown bear predation of young calves (Ballard and Spraker 1979, Ballard et al. 1980, Ballard et al. 1981).

Lower Susitna Basin. Information on the sex and age composition of moose in the lower Susitna basin was obtained during the surveys described earlier for population estimates. Because composition surveys in the upper Susitna basin only included information during the late fall of each year, only sex and age composition data from the first survey in the lower Susitna basin (9-10 December 1981) will be considered (Table W36). Males tended to be less abundant than females and with the exception of Zone III (Montana Creek to the Yentna River), numbers of male moose per 100 females did not appear to differ greatly among zones. The estimates shown, however, may not be accurate because some antlerless males may have been classified as females. Comparisons of the number of calves per 100 females for the lower Susitna basin (48.8) and the upper Susitna basin (32.2; based on estimates from the census surveys) suggest that moose populations in the lower Susitna basin may be slightly more productive than moose in the upper basin.

. Mortality Factors

Moose populations in several areas of Alaska, including GMU 13 (which includes part of the upper Susitna basin) have undergone population declines in recent years (McIlroy 1976). A series of several severe winters during the 1970's was believed to have resulted in these declines, and low annual recruitment associated primarily with poor calf survival prior to November has been suggested as the predominant factor maintaining these populations at low levels (Ballard et al. 1980). Predation of moose calves by wolves and brown bear is believed to be the most important factor contributing to low calf survival. Other factors such as decreasing range quality, low bull:cow ratios, and periodic severe winters are thought to be less important influences on calf survival (McIlroy 1974).

Intensive studies of moose populations in the Nelchina River basin were undertaken by the Alaska Department of Fish and game during the mid-1970's to determine which factors were most important in determining calf survival. Studies by Van Ballenberghe (1978) and Ballard and Taylor (1978) suggested that bull:cow ratios were not a major influence on population productivity. Several measures of physical condition of moose also suggested that moose in the Nelchina basin were in good physical condition and that deteriorating range conditions were not a problem (Franzmann and LeResche 1978). Furthermore, artificial reductions in wolf populations resulted in no large increases in calf survival suggesting that although moose were an important component of wolves' diets, wolf predation on moose was not a major factor in declining productivity (Ballard and Spraker 1979). What became apparent, however, was that brown bear predation of young moose calves was a major source of calf mortality (Ballard and Taylor 1978, Spraker and Ballard 1979). A recent study of moose calf mortality in the Nelchina basin (Ballard et al. 1980) showed that of 136 calves radio-collared shortly after parturition, 55 percent died of natural causes by the following November. Brown bear predation of moose calves accounted for 79 percent of the natural deaths.

Mortality of newborn moose calves in the upper Susitna basin during 1980 and 1981 was high. By 1 August 1980, 23 (77%) of the calves were missing. Rates of 1980 calf loss were compared with those observed in 1977 and 1978 (Figure W8). Although causes of moose calf mortality were not determined in 1980, the pattern of loss was quite similar to that observed in GMU 13 during 1977 and 1978 where predation by brown bear accounted for a high proportion of the natural calf deaths (Ballard et al. 1981).

Calf mortality was not directly monitored during 1981 but indices of calf production suggest that brown bear predation may again have accounted for a large proportion of the natural deaths. Of the 46 sexually mature cow moose which could have produced calves, 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 again quite similar to that of 1977, 1978, and 1980 when predation by bears accounted for most of the losses.

Although predation by brown bears does appear to be the major cause of calf moose mortality during the summer and fall periods, winter severity is likely an important factor in determining productivity and survival. Ballard et al. (1981) found that snow depths from the Monahan Flats area was significantly correlated with subsequent fall calf:cow ratios in CA 3 of GMU 13. During the period from 1970 to 1978, 45 percent of the variation in cow:calf ratios could be attributed to snow depth. Assuming that snow depths are an adequate index of winter severity, the strong relationship between cow:calf ratios and snow depths suggest that over-winter conditions and their influence on the condition of pregnant cows are an important factor in determining calf survival, and hence, population productivity. As discussed earlier, winters during the two years of study of moose populations in the upper Susitna valley have been mild. Consequently, it has not been possible to obtain site-specific information on the influence of severe winter conditions on population productivity, habitat use, or browse utilization.

Information on mortality rates of adult moose in the Susitna basin is limited. Ballard and Taylor (1980) examined mortality rates of adult females based on the loss of radio-tagged cows in the upper Susitna basin during 1976- 1978. During the three-year study they estimated that annual adult cow mortality averaged 6 percent.

Because only two years of data from ongoing moose studies in the lower Susitna basin is available, information on natural mortality is limited. During population censuses conducted during December 1981, January 1982 and February 1982, the percentage of calves in the population declined consistently. It is not know, however, if the decline in the percentage of calves was the result of calf mortality or redistribution of age and sex classes of moose in the study area (e.g., an influx of older animals from adjacent wintering areas). No instances of predation of calves or adult moose were observed during 1981 or early 1982. Modafferi (1982) suggests, however, that most predation which does occur in the lower Susitna basin is probably attributable to brown bears and black bears. Both species of bear occur throughout the lower Susitna basin, whereas wolves, another major predator of some moose populations, are rare.

. Dispersal

Limited evidence obtained during the radio-tracking program suggest that young moose from the upper Susitna basin may disperse into other major drainages in the region. One male calf was observed to move 75 km from Swimming Bear Lake to Coal Lake. Another male calf moved from near the mouth of Watana Creek to the upper reaches of Windy and Clearwater creeks north of the Denali Highway.

This information suggests that moose populations in other drainages removed from the Susitna drainage may be partly dependent on the immigration of Susitna moose. Information on population sizes in the Susitna basin during 1980 and 1981 similarly suggest that a portion of the increase in numbers of adult moose may have been the result of immigration from other areas. During 1980, 178 calves and 766 adults were observed in CA 7. In 1981, a total of 1006 adults were observed. Even if all of the 1980 calves had survived (which is unlikely), the increase is 21.1 percent greater than expected. Although sampling errors might account for a major portion of this difference, immigration from adjacent areas may partly explain this increase in adult moose.

Evidence from moose studies in areas adjacent to the lower Susitna basin suggest that the lower Susitna population is discrete from those in adjacent drainages. Moose tagging studies in the Matanuska River valley (Rausch 1971) and in the Peter-Dutch Hills (Didrickson and Taylor 1978) found that emigration from these areas to the Susitna basin was extremely low to nil. Recent studies of moose in the lower Susitna basin (Modafferi 1982) have not yet obtained sufficent data to adequately examine dispersal of moose from the region.

(ii) Caribou

Caribou in the area affected by the proposed Susitna hydroelectric project are members of the Nelchina herd. This 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 21,000 animals (approximately 6% of the total statewide caribou population of 325,000).

Despite the great interest by hunters in harvesting Nelchina caribou (6,662 applications for 1600 permits in 1981), the range remains relatively inaccessible. Human development is largely limited to the peripheries and consists primarily of the Alaska Railroad, Parks Highway, Denali Highway, Richardson Highway, Trans-Alaska Pipeline, and Glenn Highway.

Caribou studies for the Susitna project were conducted by Pitcher (1982). All data in this section not otherwise cited were obtained from that source.

- Distribution and Movement Patterns

  The Nelchina herd occupies an area of approximately 51,800 km^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.

  The Nelchina herd has been studied by the U.S. Fish and Wildlife Service since 1948, and by the Alaska Department of Fish and Game. During this time, it has remained essentially within the area outlined above; however, with the exception of the calving area, seasonal use of particular areas has varied.

  Early records indicate that the herd wintered (January to March) in the upper Nenana River area in the early 1930's and in the Talkeetna Mountains in the late 1930's (Skoog 1968). From 1950 - 1955 the herd wintered from the Little Nelchina River and Glennallen Highway north through the Lake Louise flats to the Denali Highway. As the herd increased in size through the later 1950's and early 1960's, its winter range also increased in size, encompassing the upper Nenana River area, Monahan flats, Talkeetna Mountains and extending east across the Richardson Highway (Hemming 1971). The most recent studies, of radio- collared caribou in 1981 and 1982, indicate that the main portion of the herd wintered (1) on the Lake Louise flats and the middle portion of the Gakona and Chistochina River drainages, and (2) in the western foothills of the Alphabet Hills, areas distant from the proposed impoundment (Pitcher 1982 pers. comm.).

  Since 1949, the first year for which records are available, Nelchina caribou have utilized an area of about

1,000 mi^2 in the northern Talkeetna Mountains for calving (Skoog 1968, Hemming 1971, Bos 1974). Although the precise areas used have varied, calving has taken place between Fog Lakes and the Little Nelchina River between about 3,000 and 4,500 feet elevation. The only deviations have been during years with extremely heavy snow accumulations when some calving took place during the migration to the traditional calving grounds (Lentfer 1965, Skoog 1968, Bos 1973). In 1980 and 1981 calving took place between May 15 and June 10 in the drainages of Kosina Creek, Goose Creek, Black River and Oshetna River (Figure W9) (Pitcher 1982).

The primary migratory route in 1980 and 1981 from winter range on the Lake Louise flats to the calving grounds in the eastern Talkeetna Mountains was westward across the flats 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, and presumably also a small portion of the main herd, 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).

During spring migration and calving there is some segregation of sex and age groups. Although yearlings and barren cows lag somewhat behind parturient cows, they also move to the calving area, remaining scattered along its periphery (Skoog 1968). Radio-collared Nelchina bulls were found in a wide variety of locations, mostly in transit to summer ranges during calving in 1980 and 1981 (Pitcher 1982).

Historically, the female-calf segment of the Nelchina herd has summered primarily 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 (June 11 through July 31) 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 (August 1 through September 31) was a time of considerable movement and dispersal by both cows and bulls. Compared to the obvious segregation in June and July, it appeared that 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 flats, 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 flats, and the Alphabet Hills.

Historically, Nelchina caribou have rutted in a number of locations; however, the Lake Louise flats 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 on the northern Lake Louise flats. 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-Alaska Pipeline by 10 October.

- Subherds

Eide (1980) suspected that subherds with separate calving areas existed in several areas of the Nelchina range. He based this conjecture on reports of sightings of groups with young calves in these locations during all seasons including the calving period. Locations of these possible subherds were the Watana Creek Hills (upper Susitna-Nenana drainages), the upper Talkeetna River, Chunilna Hills, Alaska Range and Gakona River. The first three of these suspected subherds use areas fairly close to the proposed impoundments and several caribou in each were radio-collared by Pitcher (1982). Relocations of these animals are shown in Figure W10.

The resident subherd in the Upper Susitna-Nenana area (Figure W10) was estimated in 1981 to contain about 1000 caribou; 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 herd. Pitcher (pers. comm) censused the caribou population in October 1982 for the area north and west of the Susitna River above Gold Creek, including the Clearwater Mountains. The western and northern boundaries were the Parks Highway and the Alaska Range. Five days were required to complete the census because of periods of bad weather, and thus caribou movements during the census may have complicated the counts. Also, about 10% of the main Nelchina herd moved through the southeastern portion of the census area, further complicating the data. Pitcher estimated that 2500 caribou were in the count area, based on an actual count of 2077 caribou and his subjective impressions of sightability and area coverage.

During early May 1980, four adult females and one adult male were radio-collared from this subherd. 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, producing two calves in 1980 and two in 1981. The bull summered in the Clearwater Mountains, then joined the main Nelchina herd during the rut on the Lake Louise flats.

The Chunilna Hills group appears to be a resident subherd numbering fewer than 340 animals. One radio-collared bull remained in the Chunilna Hills from April to November 1980 when it shed its collar. Two females were collared in the spring of 1981, both of which subsequently gave birth to calves in the area. No overlap with radio-collared animals from the main herd or other subherds was noted, although one female did move across the Talkeetna River.

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 another resident subherd, probably of fewer than 400 animals, and having some spatial overlap with the main Nelchina herd. 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 W10). 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.

- Habitat Use

At one time or another during their annual movements, Nelchina caribou probably use most of the vegetation types in the Susitna area. However, Pitcher (1982) found caribou mostly in spruce forest, shrubland, herbaceous vegetation types and bare substrate types, with virtually no use of mixed or deciduous forests.

Nelchina caribou show considerable variation in habitat types used seasonally, and types used most by bulls are different from types used most by cows (Table W37). Bulls tend to use spruce forests more than cows at all seasons except autumn whereas cow use of tundra-herbaceous types is greater at all seasons than bull use. These differences are likely a reflection of the tendency of bulls to remain much longer in the forested wintering areas and to summer at lower elevations than cows (see Figure W11). Use of shrubland is similar for cows and bulls overall but differs seasonally. Bulls tend to use this habitat most in summer and autumn whereas cows use it most during spring, calving and summer (Pitcher 1982).

As mentioned, differences between bulls and cows in habitat use were partly related to differences in elevation. The sexes occurred at about the same elevations during autumn, the rut, and winter but females were consistently found at higher elevations during spring migration, calving and summer (Figure W11).

The food habits of caribou vary seasonally with available plant forage (Skoog 1968). In spring and summer grasses, sedges and the buds of willow and birch are important and a wide variety of forbs are eaten as they become available. Except during years of late snowmelt when new growth is slow to appear, lichens are unimportant in the spring diet. In late summer mushrooms are an actively sought, but minor diet item. During autumn browse becomes less important but sedges and grasses remain major diet items and lichens assume greater importance. Through the winter the diet of Nelchina caribou consists of about equal portions of graminoids and lichens (Skoog 1968).

- Population Characteristics

The Nelchina herd was estimated to consist of about 40,000 animals when first surveyed in 1955. Subsequently the herd grew to 71,000 in 1962, decreased to about 7700 in 1973 and currently numbers about 21,000 (Table W38). The management plan for the Nelchina herd (ADF&G 1976) calls for maintenance of the herd at about 20,000 adult animals through harvest of the annual increment.

The sex and age composition of the Nelchina herd remained almost the same from fall 1980 to fall 1981. Cows and bulls older than one year comprised 49.1% and 29.9%, respectively, of the herd in October 1981. Calves comprised 21.1% or 42.9 calves per hundred females one year and older (Pitcher 1982). The proportion of bulls was high compared to the proportion observed in earlier years, a finding that would be expected in a growing population that had previously had a low proportion of males (Bergerud 1980).

Skoog (1968) estimated the overall pregnancy rate of Nelchina caribou to be 72% for females one year and older from 1957 to 1962. Full reproductive potential was not realized even in the fully adult age classes. Only 13% of yearling females were pregnant compared to 61% of two-year-olds and 89% of females three years and older. In 1980 and 1981, the proportion of calves in the post-calving aggregations averaged about 56 calves per 100 females one year and older. These data suggest that considerable calf mortality occurs shortly after birth. Pitcher (1982 pers. comm.) estimated that calf survival to 11 months was 43% for 1980 calves and 60% for 1981 calves. Survival rates for older caribou (>1 year) were 93.5% for females and 87% for males.

Survival rates of caribou are influenced by many factors including disease, parasitism, weather, accidents, food availability, predation and hunting. Parasitism and disease may kill a few caribou each year in the Nelchina herd but these are not major mortality factos. Wet, cold weather during calving can result in high levels of calf mortality which Skoog (1968) believed could ultimately control caribou population levels. This is a factor, however, that is more likely to affect coastal herds and more northerly herds than the Nelchina herd (Skoog 1968).

Accidents are not a major cause of mortality but deserve special mention because they are a factor that could be directly increased by the Susitna development. Caribou have been observed to fall through weak ice and drown, to drown when unable to climb out of water flanked by perpendicular walls of overflow ice (especially calves), and to die after falling and breaking bones when traversing glare ice (Skoog 1968). The potential for the Susitna development to increase this type of mortality is discussed in Section 4.3(a), (ii).

The major factors that are believed to control caribou mortality and ultimately population levels, both in Alaska and elsewhere, are food availaility and predation (including hunting). In mainland North America the population density of most caribou herds appears to be much less than the maximum that the range could support and, indeed, in many herds is much less than the range has historically supported (e.g., LeResche 1975, Parker 1972, Bergerud 1980, Table W38). Food availability in winter, because of snow cover, is likely to be more critical than availability in summer and many early workers speculated that declines in caribou numbers in North America in the early 1900's were caused by winter forage (mainly lichen) destruction by forest fires (Scotter 1967). However, evaluations of more rigorous analyses (e.g., Henshaw 1968; Kelsall and Klein 1979; Klein 1967; Roby 1980; Bergerud 1974) show that starvation or even observable debilitation in caribou during winter are rare except in populations insulated from predators and prevented from dispersing to unoccupied habitats (cf. Klein 1968; Scheffer 1951; Leader-Williams 1980).

Skoog (1968) believed that neither overgrazing nor fire had greatly affected the Nelchina range in the early 1960's. The herd was considerably larger than now and food availability is unlikely to be a major factor affecting survival of the present herd.

Several authors have presented evidence that caribou numbers are effectively controlled by predation. For example, Kelsall (1968), Parker (1972), Miller and Broughton (1974), and Davis et al. (1980) all report evidence that caribou numbers have declined as predator (mainly wolf) numbers increased, or that caribou numbers have increased as predator numbers decreased. Bergerud, in two reviews (1974, 1980), demonstrates convincingly that where capable predators (wolves, bears, lynx) are common and hunting by man is insignificant, caribou populations are effectively regulated by predation.

Since the introduction of firearms to North America, hunting has probably been the major cause of population declines (Bergerud 1974, Calef 1980). Calef (1980) reported that in some herds in the Northwest Territories hunter kill is in excess of annual recruitment. Doerr (1980) isolated excessive hunting as the primary cause of population declines in the Nelchina and Western Arctic herds in Alaska.

Hunting and wolf predation probably account for about equal portions of the annual mortality of the present Nelchina herd. Table W39 shows the level of hunter harvest for 1972 to 1981. During that time, hunter harvest in years for which herd size data are available has varied form 1.4% to 9.6% of the herd. Hunter harvest was about 4% in 1981.

Wolf predation has varied with the size of the wolf population. Skoog (1968) estimated that wolves took 1.1 - 2.6% of the herd from 1957 - 1962. More recently Ballard et al. (1982) estimated wolf predation rates varying from 7 - 10% of the herd in 1973 to 2 - 3% in 1981.

The average mortality rate for caribou one year and older of both sexes in 1981 was 9.8%. If Ballard et al's (1982) estimate of 2 - 3% mortality applies to adults as well as calves (as they suggest), then wolf predation combined with hunter harvest (3.9% --- Table W39) account for 60 - 70% of the annual adult mortality in the Nelchina herd.

(iii) Dall Sheep

Dall sheep studies were conducted in the upper Susitna River basin during the summer of 1980, spring and summer of 1981, and spring of 1982. The study area includes all drainages flowing into the Susitna River from Gold Creek to Kosina Creek on the south to the Denali Highway on the north. Survey efforts were confined to areas of known or suspected Dall sheep habitat within this area (Figure W12). (Ballard et al. 1982b). These areas contain semi-open, precipituous terrain, with rocky slopes, ridges, and cliffs (Lawson and Johnson 1982).

- Distribution

There are three general areas in the upper Susitna basin that have steep rocky slopes at sufficient elevation to be potential Dall sheep habitat. The first of these areas is north of the Susitna River between the proposed Devil Canyon and Watana dam sites. Aerial surveys were conducted in this area in the Portage Creek and Tsusena Creek drainages (Figure W12). The second potential site for Dall sheep was in the mountains between the Susitna and Talkeetna Rivers, extending eastward from the Fog Lakes to Kosina Creek. The third area was north of the Susitna River, to the east of Watana Creek. This area was established as a population trend count area for Dall sheep by ADF&G in 1967 (Figure W12).

Aerial surveys to determine the seasonal distribution and abundance of Dall sheep in the areas described above were conducted on July 22-23, 1980, on March 13 and 25, 1981, between May 13 and June 24, 1981, on July 28, 1981 and on March 23, 1982. The date, location, number, sex, and age of sheep were recorded for all sightings.

A total of 72 sheep (7 legal rams, 12 lambs and 54 unidentified) were counted in the Portage Creek and Tsusena Creek drainages in July 1980. Four sheep were seen north of Portage Creek, two east of Tsusena Creek, and the other 66 were seen in the headwater regions of Tsusena Creek. The only previous ADF&G survey in this area was a 1977 count of 91 sheep (8 legal rams, 18 lambs, 65 others). The 1977 survey included the Jack River drainage (north of Tsusena Creek), which was not surveyed in 1980. All of the sightings were far from the proposed impoundments and access roads.

During July 1980 only eight sheep (1 ram, 7 unidentified) were observed in the Watana Mountain-Grebe Mountain area. Earlier observations in 1977 suggested that at least 34 sheep were present on Mt. Watana. Numerous observations of sheep in the Terrace Creek area (a southern tributary of Kosina Creek) have been made, but none were observed during the 1980 survey.

On March 25, 1981 a winter distribution survey was conducted in the same area surveyed in July 1980. Twenty-two sheep were sighted and two groups of 3-4 tracks were seen. If data collected during the summer 1980 survey and this survey were representative of the sheep population, they would indicate that sheep were migrating into the area during winter. All sheep observations were located on the southern extreme of the count area, well away from the impoundment. Therefore, impacts of the impoundments on these sheep populations would appear to be minor.

The Watana Hills area has been surveyed for Dall sheep by ADF&G yearly since 1967. The data from the 1980 and 1981 surveys show the same general patterns as previous surveys (Table W40). 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. The small number of legal rams counted could reflect the rather high (13) sport harvest taken from this area in 1980 (Tobey, pers. comm.). Although the 1981 count was relatively high, it is suspected that the population has remained stable or perhaps increased slightly.

The winter distribution of sheep in the Watana Hills area was surveyed in March of 1981 and 1982. Eighty-seven sheep were sighted in 1981, and 77 in 1982, all on south-facing slopes. Geist (1971) suggested that south-facing slopes are an important part of Dall sheep winter range. They provide maximum exposure to winter sun, and frequently have shallower snow than slopes with different aspects. Fewer sheep were observed than in the summer surveys, probably because of poor observability due to snow cover and/or movement of sheep from the area.

Mineral licks are known to be important for Dall sheep and are a common component of spring ranges. Heimer (1973) suggested that they be considered a critical habitat requirement. The sheep in the Watana Hills area have been observed frequenting a mineral lick along the lower elevations of Jay Creek, at an elevation of about 671m.

The Jay Creek mineral lick was overflown from May 6 through June 24, 1980; the number, sex and age of the sheep recorded are shown in Table W41. Sheep were sited on 28 of 33 occassions (85%). The largest single group observed was 15, representing approximately 7 percent of the observed Watana Hills summer population, and approximately 17 percent of the observed winter population.

Sheep were observed frequenting other locations adjacent to the Jay Creek mineral site. On May 23 and 25, 1981, groups of 6 and 12 rams, respectively, were observed scraping and eating soil on the ridge located on the east side of Jay Creek at an elevation of 692m, directly opposite the main lick area (Table ___). Since only rams were observed on these 2 occassions, the observation could represent a preferential use of certain areas by sex or age class. Also, on 3, 12, 13, 15, 17 and 19 of June, sheep of different age classes were observed at an area approximately 2 miles upstream from the main mineral area (Table ___). This area also appears to be mineralized.

In an aerial survey of summer distribution on 28 July, 1982, no sheep were observed at the Jay Creek area. However, 10 ewes and yearlings were observed actively utilizing a known mineral lick in the drainage of the east fork of Watana Creek, approximately 7 miles north of the Jay Creek site.

The mineral lick was also visited by ADF&G biologists on May 9, 1981. Sheep usage of the area ranged from the Jay Creek streambottom (610m) to the top of the bluff (747m) and for an undetermined distance away from the bluff. Signs of heavy moose utilization were evident as well.

(iv) Brown Bears

Most of the site-specific information for brown bears in the Susitna basin was obtained from recent studies by Miller and McAllister (1982). Additional site-specific information was obtained from studies in the upper Susitna and Nelchina River basins during 1979 (Miller and Ballard 1980; Spraker et al. 1981).

- Distribution

Brown bears or grizzly bears (the former term will be used throughout this report) are widely distributed and abundant in most parts of Alaska. Brown bears appear best adapted to natural, relatively open, undisturbed areas with good cover and an abundance of perennial succulent herbs and/or fruit-bearing shrubs (Mealy et al. 1981). The omnivorous food habits of brown bears as well as their non-gregarious social structure and high degree of mobility allow them to utilize resources in a large number of habitats throughout an expansive area (Knight 1972). Because of their opportunistic nature, brown bears appear to be able to adapt to a variety of man-caused disturbances in their habitat. However, experience has amply demonstrated that brown bear abundance is usually incompatible with human presence; resulting human-bear interactions commonly have resulted in the extermination of brown bears from settled areas through intensive hunting, trapping and/or poisoning programs.

Brown bear research in the upper Susitna and Nelchina river basins has been ongoing since 1978 (Ballard et al. 1980, Spraker et al. 1981). Most studies were initially concerned with the effects of brown bear predation on moose but more recent studies have concentrated on all aspects of brown bear ecology (Miller and McAllister 1982). No site-specific information is available on brown bear in the lower Susitna basin, where their densities are relatively low. Within the upper Susitna basin, brown bears generally are most abundant in open tundra habitats during most of the late spring and early fall periods. Many brown bears appear to utilize lower elevation spruce habitats during the early spring. Current information suggests that brown bears in the upper Susitna basin are abundant and that populations are young and productive.

. Seasonal Movements

The brown bear's omnivorous feeding habits, social structure, behavioral interactions and winter denning requirements necessitate extensive movements throughout large areas (Craighead and Mitchell 1982). It appears that the utilization patterns of large geographic areas by brown bears is largely dependent on the spatial and temporal availability of food. Information from a number of areas in Canada and the United States suggests that brown bears establish traditional movements to exploit dependable sources of food. Often these food sources are only seasonally available for short periods of time. Extensive traditional movements are common in many populations of brown bear (Pearson 1976; Reynolds 1979; Craighead 1980).

Based on relocations of radio-collared brown bears in the upper Susitna basin during 1980 and 1981, Miller and McAllister (1982) documented regular seasonal movements of brown bears that appeared to be associated with regional and elevational differences in food availability. Movements of brown bears from the upper Susitna basin to Prairie Creek during July and August were perhaps the most noteable regional movements observed during the study. These regular seasonal movements of brown bears appeared to be associated with high concentrations of spawning king salmon in Prairie Creek during this time of year.

Although bad flying conditions prevented complete documentation of the number of brown bears that move from the upper Susitna basin to Prairie Creek, local residents report that high concentrations of brown bears occur in the area during the salmon run. Although a large number of animals may utilize this food source, it is not clear if brown bears are dependent on the supply of salmon. For example, moderately dense brown bear populations exist in the Nelchina basin without access to salmon (Miller and Ballard 1982). As suggested by Miller and McAllister (1982), Prairie Creek salmon may be an important buffer when other food sources such as berry crops are less available. All of the radio-collared brown bears that moved to the Prairie Creek area 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.

Movements of brown bear in the early spring also appeared to be related to elevation and the availability of new plant growth. With the exception of sows with cubs, it appeared that most brown bear moved to lower elevations on or near the Susitna River following emergence from over-wintering dens. This was attributed to the relatively earlier melt-off of snow, particularly on south-facing slopes, and the subsequent availability of over-wintered berries and new plant growth. Carcasses of winter-killed ungulates and newborn calves in these areas also would provide food for brown bears. Radio locations of brown bears in the upper Susitna basin during the springs of 1980 and 1982 indicated that, excluding sows with newborn cubs (which remained at higher elevations), 62% and 52% of the radio-collared animals, respectively, moved to areas on or adjacent to the Susitna River. Females with new born cubs remained at high elevations throughout the year. Brown bears were at the lowest mean elevations during June to August.

Although some of the regional and elevational movements of brown bears in the upper Susitna basin may be related to forage availability, it has been suggested recently that these movements are most closely associated with brown bear predation of moose and caribou calves (Miller and McAllister 1982). Use of lower elevation areas by brown bears may be directly related to the greater availability of young calves there but may also be related to overlapping use by ungulates and brown bears of more readily available forage at these lower elevations. Directional movements by 4 radio-collared brown bears to and from the calving grounds of the Nelchina caribou herd suggest that brown bears may move to calving areas primarily because of the availability of calves.

. Denning

Brown bear dens in the upper Susitna basin were on moderately-sloping southern exposures, and were generally dug in gravelly soils either in tussock or shrub habitats. (Use of vegetation types for denning is discussed below). None of the bears in this study re-used den sites. Brown bear den sites ranged in elevation from 710-1570 m with an average elevation of 1274 m.

Radio-collared brown bears in the upper Susitna basin entered dens in early October 1980 and in late September-early October 1981. During the spring of 1981, most bears emerged from their dens in late April-early May.

- Habitat Use

Brown bears in other areas of Alaska and northern Canada utilize a wide range of vegetation communities. Although brown bears do occupy open habitats such as tundra or grasslands, they appear to prefer areas in relatively close proximity to timbered areas (Knight 1972).

Habitat affinities of brown bear in the upper Susitna basin were based on the predominant vegetation types in the vicinity of each relocation of the radio-collared bears. Brown bear use of spruce vegetation types, which are concentrated around and in the proposed impoundments, was highest in May and June (Table W42). Bears tended to move to shrublands at higher elevations later in the summer. In winter (October-April), 71% of the observations were in the "other" category (i.e., snow or rock).

Comparisons of the use of vegetation types by brown bears during the spring and the remaining portion of the year indicated that brown bears used spruce forests significantly more often during the spring than during other times of the year (Miller and McAllister 1982). As discussed earlier, sows with newborn cubs tended to remain at higher elevations; of 68 observations of sows with cubs, only 1 occurred in spruce habitats. Shrublands were most commonly used by sows with cubs (49 percent of the observations) followed by "other" habitats (35%), tundra (10%), and riparian communities (4%).

. Food Habits

Studies of the feeding habits of brown bears indicate that the species is omnivorous, feeding on a wide range of plants and animals. Although plant material may commonly comprise a major portion of the diet, it appears that brown bears prefer high protein animal food (Craighead and Mitchell 1982).

Based on dietary studies of brown bears in interior Yukon (Pearson 1976) and in Yellowstone National Park (Craighead and Sumner 1980), it appears that brown bears most commonly utilize graminoids and forbs during the spring and early summer. As berries and fruits become more available, these also are incorporated into the diet. Brown bears will eat carrion, if available, and may also kill ungulates or other large mammals. Small rodents such as ground squirrels are most often consumed during the late summer.

As discussed earlier, brown bear are attracted to both natural and artificial food sources, particularly if food is abundant and readily available. Some brown bear populations traditionally form aggregations to feed on salmon during the major fish runs (Stornorov and Stokes 1972).

Information on the diets of brown bear in the upper Susitna basin is limited. Overwintering berries and new green shoots of grasses and forbs are consumed during the early spring. Winter-killed ungulates as well as moose and caribou calves also are eaten. King salmon likely comprise much of the diet during the salmon run in July and August. Berries such as *Vaccinium* sp. are likely consumed throughout the late summer and fall period.

One of the most noteable results of the brown bear studies in the upper Susitna basin is recognition of the importance of moose calves in the spring diet of brown bears. Ballard et al. (1981) found that of 123 radio-tagged moose calves, 55 percent had died of natural causes by November (following their birth) and that 79 percent of all natural mortalities were caused by brown bear predation. Relocations of 23 radio-collared brown bears that were intensively monitored (twice/d) during the spring 1978, showed that 14 of the 23 bears regularly relocated were observed at least once on a moose calf kill (Ballard et al. 1981, Spraker et al. 1981). During the latter study, a total of 37 calf moose, 28 adult moose, 4 unidentified moose, 3 caribou and 6 other species of mammals were killed by brown bears yielding a total of 1 kill/5.6 observation days (1 moose/6.3 observation days). The lower kill rate of 1 kill/10.2 days given by Miller and McAllister (1982) is probably an underestimate due to less monitoring of radio-collared animals (compared to Ballard et al. 1981) and is based on only 3 moose calves, 2 adult moose, and 3 unidentified species.

The average home range size of male brown bears in the upper Susitna basin is 790 km^2 (n=14); for females it is 316 km^2 (n=19) (Miller and McAllister 1982).

. Home Range

Comparisons of the home range sizes of brown bears in the upper Susitna basin with brown bears in other areas indicate that bears in the Susitna basin have relatively large home ranges (Table W43). Only home ranges of bears from northwestern Alaska (a relatively unproductive population) were larger. On the basis of this information, Miller and McAllister (1982) suggested that home range size and brown bear densities are inversely related and that both are a function of the distribution and abundance of food resources. The large home ranges of brown bears in the Susitna basin, therefore, may reflect relatively low primary productivity of food items that are important to brown bears and/or a patchy distribution of important food items.

As discussed previously for moose, home range analyses are useful in assessing the number of animals that may be affected by the proposed impoundments. Miller and McAllister (1982) examined the relationships between the home ranges of radio-collared brown bear during 1980-1981 and three areas that included: (1) the proposed impoundment, (2) a 1.6 km zone around the proposed impoundments, and (3) a zone occupying areas 1.6 to 8 km from the proposed impoundments.

The mean overlap of the home ranges of 19 brown bear with the impoundment was 5% (range of 0-25%), for the 1.6 km zone it was 15% (0-48%), and for the 8 km zone it was 52% (0-100%). These figures under-represent the actual use by brown bears of the area in and adjacent to the impoundment area because the home range figures used in calculating the percent overlap are the total annual home ranges. Seasonal use by brown bears, particularly during the spring, is more intensive.

Analyses of the proximity of relocations to the proposed impoundments similarly show that brown bears selectively use areas that are close to the Susitna River, particularly during the spring period. Comparisons of the number of bear relocations in the impoundment areas as well as in the two "impact" zones discussed earlier, indicate that use in the actual impoundment area was greater than expected during all periods (almost four times greater during the spring) and that use of the outermost zone (1.6 to 8 km) was less than expected (Miller and McAllister 1982).

- Population Characteristics

. Population Size

Brown bear population estimates are extremely difficult and expensive to obtain because of the wide-ranging behavior of most individuals and their use of some habitats where visibility is obscured. Crude estimates of population sizes may be obtained from radio-tracking studies of home range size.

Miller and Ballard (1980) calculated a rough density estimate of 1 bear/41-62 km^2 in the Susitna River headwaters during 1979. This estimate suggests that brown bear densities are intermediate between densities in southern and coastal Alaska and the Brooks range (Table W44). Based on an estimate of one bear/41 km^2, the upper Susitna basin would have a population of approximately 206 brown bears. It was the opinion of Miller and McAllister (1982) that brown bear densities in this area were likely to be higher than this estimate.

. Population Structure

Information on the sex and age structure of the brown bear population in the upper Susitna basin was available from GMU 13 harvest data during 1970 to 1980, the 1979 study of brown bears in the upper Susitna and Nelchina River basins (Miller and Ballard 1980), and from capture data from the recent brown bear study (Miller and McAllister 1982) (Table W45).

The sex ratio of brown bears in the upper Susitna basin generally appears to be close to equality. The sex ratio of radio-collared animals was not representative of the actual population ratio because large males tended to loose collars more easily than females, but the data suggest that mortality is similar for both male and female adult bears.

The age composition of brown bears captured in the upper Susitna basin during 1980-1981 was 19.6% cubs, 11.8% yearlings, 12.7% two-year olds, 15.7% three- and four-year olds, and 39.2% adults. The moderately high percentages of young animals in the Susitna brown bear population suggest that the population is young and productive. The age composition observed in the Susitna population during 1980-1981 is very similar to the age structure of grizzly bears in Yellowstone National Park during 1959-1967, when the bear population was rapidly increasing (Craighead and Mitchell 1982).

. Productivity

The mean litter size for brown bears in the upper Susitna Basin was 2.3 (range of 1 to 3), based on nine litters of newborn cubs observed with radio-collared females since 1978 (Miller and McAllister). The mean litter size for the basin is comparable to those in highly productive brown bear populations on Kodiak Island and on the Alaska Peninsula, and is higher than litter sizes in the relatively unproductive Brooks Range brown bears (Table W46).

Of 10 cubs in 5 known litters produced in the upper Susitna basin during 1981, 3 (in 3 litters) were lost during the summer of 1981. One of these losses may have been capture-related although Tait (1980) has suggested that abandonment of litters of single cubs may be an adaptive strategy for brown bears. Physical evidence (lactation) suggests that another bear may have had a litter in 1981, but cubs were never observed; they may have been lost prior to the recapture of this bear during summer 1981. Two cubs in a litter of 3 were lost in 1979 studies as were 2 yearlings or cubs in a litter of 3 in the same year. No other losses from yearling or 2 year-old litters were observed suggesting that offspring mortality is concentrated on cub classes. Causes of cub losses have not been determined but predation by male brown bears is considered most probable.

Comparisons of the reproductive rates of brown bears in the upper Susitna and Nelchina basins with reproductive rates of other brown bear populations indicate that the Susitna-Nelchina basins support some of the most productive brown bear populations in Alaska (Table W47).

. Dispersal

Miller and McAllister (1982) believed that dispersal of sub-adult brown bears, both to and from the study area, was probably common. Several instances of dispersal by radio-collared brown bears were recorded. One male, originally tagged as a 2-year old in 1978 on the Susitna River north of the Denali Highway, was recaptured and radio-collared near Clarence Creek on the Susitna River. Another 2-year old male was captured near Deadman Creek during the spring of 1981 and moved downstream (88.5 km) to the vicinity of Moose Creek. During the fall the same animal moved back to the area in the vicinity of the villages of Sherman and Curry. The importance of dispersal in maintaining brown bear population levels in the Susitna River basin and in adjacent river drainages is not known.

. Sport Harvest

ADF&G harvest data for brown bear in GMU 13 are presented in Table W48. From 1973-1980, harvests averaged 64/year (44-84). The mean age of brown bears taken during the period 1973-1980 has been 6.5 years (6.3 for males and 6.8 for females). This relatively young age suggests that many GMU 13 hunters are not selecting for large trophy bears. Of 656 bears that have been harvested and aged in GMU 13 during the period 1970-1980, 10% were yearlings, 29% were 2 years-old or less, 41% were 3 years old or less, and 52% were 4 years-old or less (unpublished ADF&G data, cited in Miller and McAllister 1982). In recent years, sport hunters have applied pressure to extend brown bear seasons and bag limits in GMU 13. This pressure has largely resulted from research showing that brown bears are a major predator on moose calves (Ballard et al. 1980, 1981). In addition, Miller and Ballard (1982) suggest that there may be a harvestable surplus of brown bears in GMU 13.

(v) Black Bears

All site-specific information on black bear populations in the Susitna basin was obtained from the recent study by Miller and McAllister (1982) during 1980-1982. Most of the data for 1981-82 was for the upper Susitna basin (above the Devil Canyon dam site), but the studies now underway are also focusing on bears downstream of Devil Canyon.

- Distribution

Black bears are the most common and widely distributed of the three bear species in North America. They occur in most areas of Alaska as far north as the Brooks Range. Black bears are highly adaptable and are able to utilize a wide variety of habitats. Like brown bears, they are omnivores and their ranges and diet respond to regional and temporal changes in food availability. Prime black bear habitat can be generally characterized by relatively inaccessible forested terrain, thick understory vegetation and abundant sources of plant foods such as succulent herbs and forbs, berries, and fruits (Pelton 1982).

Black bears appear to be moderately abundant in the upper Susitna basin. However, because of the limited distribution of suitable habitats, black bears generally occur only in a narrow fringe of forested habitat along the Susitna River.

- Seasonal Movements

Based on relocations of 53 radio-tagged black bears during 1980-81, Miller and McAllister (1982) described the probable seasonal movements of black bears in the upper Susitna basin as follows. In years of normal or abundant berry crops, many bears move to somewhat higher country adjacent to the spruce habitats along the river in later summer, returning to their spring and early summer home ranges near the river to den. Most of these late summer movements are upstream (east) and in a northerly direction. In years of subnormal berry crops, most individuals make more extensive movements, moving long distances upstream or downstream in search of acceptable foraging areas or areas where salmon are available. These movements occur primarily along the main Susitna River indicating that it is a main transportation corridor. Most individuals making these extensive movements return to their former home ranges, but some do not. In late summer and fall, particularly during poor berry years, these extensive movements of black bears may bring them in close contact with brown bears, possibly resulting in increased mortality of black bears through interspecific predation.

Females with newborn cubs are exceptions to this general pattern of seasonal movements. Females with cubs make less extensive movements than other bears regardless of the berry crop.

- Denning

Distributions of den sites of black bears in the Susitna basin indicate that dens occur most commonly in steep terrain along the main Susitna River and its tributaries. However, the band of acceptable denning habitat appears to become narrower and more confined in upstream areas where dens are restricted to the immediate vicinity of the Susitna River.

Black bear dens in the Susitna basin were generally located on moderately-sloping hillsides; the mean slope of 15 dens located during 1980-1981 was 36° (range of 18°-53°). Half of the dens were located on south-facing slopes; the remainder were on east- to north-facing slopes.

Black bears in the upper Susitna basin generally denned at elevations between 457 m and 762 m. Of 16 den sites found in the vicinity of the proposed Devil Canyon impoundment, only one den was below the maximum impoundment level of 442 m; the average elevation of these 16 dens was 663.9 m (range 454 - 1322.8 m). Of the 13 den sites found in the vicinity of the proosed Watana impoundment, 9 would apparently be flooded at an impoundment elevation of 671 m; the average elevation of these 13 dens was 664 m (range 549 - 838 m). Two black bears denned downstream of the Devil Canyon site during 1981.

Of the 14 dens located during 1980-1981, 8 were in natural cavities and 6 were excavated. All of the dens in natural cavities and one of the excavated dens had been re-used during the winter of 1980-1981 and four of the dens were used again during the winter of 1981-1982. In contrast, black bears on the Kenai Peninsula were found to rarely re-use dens during successive years (Schwartz and Franzmann 1981). Miller and McAllister (1982) suggest that the relatively high re-use of dens by black bears in the Susitna basin may indicate a scarcity of acceptable den sites and/or habituation.

Radio-collared black bears in the upper Susitna basin entered dens in mid-September to mid-October 1980 and exited dens in early April to mid-May 1981. During the fall 1981, black bears entered dens about two weeks earlier than in the fall 1980, probably as a result of the 1981 berry crop failure (Miller and McAllister 1982).

- Habitat Use

Habitat use by black bears in the upper Susitna basin appears to be similar to general use patterns reported elsewhere in North America, where black bears most commonly inhabit forested areas with dense understory vegetation (Jonkel and Cowan 1971, Fuller and Keith 1980). Of 908 aerial observations in the Susitna basin, black bears were most often located in shrubland (42.7% of observations), and spruce (39.4%) habitats (Table W49). Use of spruce habitats remained high throughout the year but was much less prevalent during the summer months. During August, black bear were often present in shrubland habitats adjacent to the spruce forests. This use of shrubland areas was thought to be related to seasonal increases in the availability of ripening berries. Use of spruce habitats appeared to differ among male and female bears; of 126 locations of female bears during the summer period, 43% occurred in spruce habitats, whereas of 125 locations of males, only 30% occurred in spruce habitats.

An examination of habitat use by black bears within the proposed impoundment area for the Watana dam showed that deciduous forests and shrublands were used significantly more often than expected. Other habitat types were used approximately in proportion to their availability. In the deciduous forest cover type, closed birch and open birch forests accounted for all of the locations. Similar habitat associations were observed in black bear populations in northern Alberta (Fuller and Keith 1980). A large proportion of birch forest types in the upper Susitna basin will be flooded by the proposed Watana impoundment.

- Food Habits

Throughout their range in North America, black bears consume primarily grasses and forbs during the spring, soft mast (fruits and berries) of trees and shrubs during the summer and a mixture of hard and soft mast during the fall. Only a small portion of black bear diets typically consist of animal matter and then primarily in the form of insects or carrion. Spring is generally a period of food scarcity and bears may often subsist on remaining fat reserves (Rogers 1976). Prefered, high-quality foods of black bears are generally more abundant during the summer and animals develop most of their fat reserves during this period.

Little site specific information is available on the feeding habits of black bears in the Susitna valley.

As discussed earlier, berry crops are an important component of the late summer diet, and movement of black bears into shrubland habitat is thought to be related to the availability of berries in these areas. Although plant foods may constitute the stable diet during most of the year, black bears may also prey on moose calves during the spring (Miller and McAllister 1982). During intensive radio-monitoring of black bears during 22 May - 22 June 1981, one male bear was observed on 1 calf moose kill and 1 adult caribou kill. Later in July, the same bear was observed on a kill of a radio-collared adult moose. It is not known if the bear had killed these animals or if it was scavenging a kill of another predator. The importance of ungulate predation to black bear populations in the upper Susitna basin is being addressed in ongoing studies.

- Home Range

During 1980, the mean home range size of 20 black bears in the upper Susitna basin was 31 km^2 (16 km^2 for 10 females and 46 km^2 for 10 males). During 1981, however, the average home range size was 218 km^2 (200 km^2 for 11 females and 234 km^2 for 12 males). Although the large increase in home range size between years may be partly related to the greater number of observations of bears during 1981, Miller and McAllister (1982) suggest that the larger home ranges may reflect the relatively poor berry crop during 1981 and the subsequent need for black bears to move greater distances to find suitable foraging areas. The observation of black bears north of the Denali Highway (a rare occurrence) during 1981 supports the suggestion that black bears made atypically long movements during the summer 1981 (Miller and McAllister 1982). Comparisons of home range sizes of black bears on the Kenai peninsula (16.7 km^2 for females and 98 km^2 males) (Schwartz and Franzmann 1981) with those of black bears in the Susitna area suggest that home ranges of black bears in the upper basin are large.

The proximity of black bear home ranges to the proposed impoundments suggest that black bear distributions are closely associated with lower elevation habitats along the Susitna River. Miller and McAllister (1982) delineated two zones around the proposed impoundment areas (one included all areas within 1.6 km of the impoundments and the other included all areas 1.6-8.0 km from the impoundments) to assess the potential effects of the impoundments and associated development on black bear populations. The mean overlap of 27 black bear home ranges with the impoundment areas was 14% (0-45%). Overlap in the two adjacent zones was 50% (0-100%) and 122% (56-195%) for the 1.6 km and the 1.6-8.0 km zones, respectively.

- Population Characteristics

  . Population Size

Miller (pers. comm.) attempted a black bear census in August 1982 using radio-collared bears and the Lincoln Index method. The study area included all black bear habitat in the upper basin east of High Lake; areas west of High Lake were not included because thick vegetation hindered sightability. During the survey flights, 38 black bears were sighted of which 9 were marked. The population was known to contain at least 21 marked bears, and thus an estimate of 90 bears (95% CI = 50-170) was derived. Miller (pers. comm.) felt that this estimate was too low, and the technique will be repeated again in spring 1983.

  . Productivity

Black bear populations in the upper Susitna basin appear to be productive and healthy (Miller and McAllister 1982). This suggests that although the Susitna area is close to the northern limit of this species, the habitat is adequate, even if limited in extent.

Eight litters with a total of 16 cubs were observed with radio-collared females during 1980 and 1981. Five of these litters were not observed until June - August and may have experienced some losses by this time. Because of this bias, the observed litter size of 2.0 cubs/litter may be a slight underestimate. The observed litter size for 7 litters of yearling black bears was 1.9.

Litter sizes in the Susitna basin appear to be similar to those reported for other parts of North America. The mean litter size for black bears on the Kenai Peninsula was 1.9 cubs/litter (based on radio-collared animals) (Schwartz and Franzmann 1981). Erickson and Nellow (1964) reported an average litter size of 2.15 for black bears in Michigan and 2.0 for Alaska (the exact locale was not identified). Jonkel and Cowan (1971) documented litter sizes of 1.5-1.8 cubs/litter for a relatively unproductive black bear population in Montana over a several year period.

Although cub production appears to be quite high in the Susitna basin, cub loss also is high. Based on only four litters that were observed prior to June 1981, 4 of 9 (44%) cubs were lost. No losses of litters were observed on the Kenai Peninsula (Schwartz and Franzmann 1981). The high rates of cub loss in the Susitna basin are believed to be related to the vulnerability of cubs to predation by brown bears and to the relatively high black bear densities (and intra-specific competition for suitable habitats).

Although available data are inadequate to calculate rates of productivity for black bear in the Susitna basin, Miller and McAllister (1982) suggest that, on the basis of available productivity indices, that the Susitna populations are not as productive as black bear on the Kenai Peninsula. This was based primarily on the older age of reproductive maturity in the Susitna basin and the high rate of cub loss.

. <u>Dispersal</u>

Dispersal of black bears from the upper Susitna basin may contribute to bear populations in adjacent areas. Dispersal of bears into the Susitna basin appears less likely, however, because of the apparently saturated nature of black bear habitat along the Susitna River (Miller and McAllister 1982). Several instances of dispersal from the study area have been documented. One sub-adult male was captured at Clark Creek and was later shot near Hurricane on the Parks Highway. A 4-year old male was captured north of Susitna River and was later shot in an area 72 km to the south. Three adult black bears moved downstream from the upper Susitna valley to areas downstream of the Devil Canyon dam site. Two of these bears denned in the downstream areas.

. <u>Sport Harvest</u>

Based on Alaska Department of Fish and Game records for the 1973-1980 period, black bear harvests for GMU 13 averaged 66/year (ranges 45-85) during a 365 day season with a bag limit of 3 bears (cubs and females with cubs excluded from legal bag limit) (Table W50). Males have constituted 74% of spring harvests and 65% of fall harvests. Most of the harvest (74%), occurs in the fall season when bears are taken incidental to moose or caribou hunts.

The current harvest is well below the sustainable harvest level. At present it appears that few hunters sufficiently prize black bear meat or pelts from GMU 13 to charter an aircraft to hunt off the road system; only 35% of the hunters taking black bear during 1973-1980 recorded aircraft as their primary means of transportation (Table W50). However, it is probable that the increasingly restrictive seasons and conditions for moose and caribou hunting in GMU 13 will result in increased black bear hunting in this area, especially as more hunters become aware of the existence of substantial black bear populations in the unit.

Recorded black bear harvests in the Susitna study area during 1973-1980 average 8/year (a range of 1-15). In general, black bear harvests have been increasing in recent years with the largest recorded annual take occurring in 1980. The largest harvests have occurred in the downstream region of the Susitna River between the Talkeetna and Indian Rivers, the only portion of the study area currently accessible by river boat or highway vehicle. Improved access for highway vehicles and boats resulting from access routes open to the public will doubtless increase sport harvests in the study area. In downstream portions of the Susitna River, increased hunting is not anticipated to have significant impacts on black bear populations. However, upstream of Devil Creek, where acceptable black bear habitat is highly constricted along the main Susitna River corridor, increased hunting will likely reduce and could eliminate black bear populations.

(vi) Wolves

Wolves in GMU 13 have been the focus of many studies and a subject of controversy for over 30 years (Ballard 1981). The history of GMU 13 wolves between 1957-1968 is summarized by Rausch (1969). From 1948-1953, poisioning and aerial shooting by the federal government reduced wolf populations to low levels. By 1953, only 12 wolves were estimated to remain in the basin. The population expanded and peaked at 400-450 by 1965 when federal predator control efforts were curtailed (Rausch 1969). Moose populations declined to low levels in the area, stimulating a series of predator-prey interaction investigations beginning in 1975 (Stephenson 1978, Ballard and Spralcer 1979, Ballard and Taylor 1980, Ballard et al, 1980, Ballard et al. 1981a, b). Wolf control efforts were renewed in 1976-1978, but by 1980, the wolf population had returned to pre-control levels (Ballard 1980). Recent data on wolf distribution, habitat use, population characteristics, and detailed historics of individual wolves and their packs, are provided by Ballard et al. (1982c).

- Distribution

At least 19 wolf packs were known or suspected to be utilizing the Susitna basin in 1980 - 1981 (Figure W13). At least six and possibly seven of these packs would be directly affected by the Susitna impoundment and additional packs would likely be affected by borrow pits, access roads, campsites, and other facilities.

Individual wolf packs have established territories which, as indicated in Figure W13, overlap little with adjacent packs (Ballard et al. 1982c). However, due to the large harvest of wolves in this area, packs are periodically eliminated and areas with no wolves exist for varying periods of time until new packs are formed by animals dispersing from adjacent areas. Ballard et al. (1982c) provided detailed historics of pack formation, membership changes, and disintegration for 6 packs, beginning as early as 1977. This data indicates that pack territories appear to be more stable than membership (i.e., that a pack is defined by the area it defends rather than its size or individual members). This may be the direct result of the destabilizing influence of heavy and extended hunting and trapping and the removal of key individuals from pack structure.

During the summer, activities of packs containing breeding adults are centered on den and rendezvous sites, the latter being above-ground sites where the pups play and are fed from the time they are about 2 months old. Figure W14 shows the locations of known dens and rendezvous sites in the Susitna development area. Dens are generally but not always roughly centered within the packs's territory and are frequently used for more than one year. Average distance between 35 dens in the Susitna and adjacent areas was computed to be 45.3 km (Ballard et al. 1982c), a distance which compares well with 40.2 km observed in the Brooks Range of Alaska (Stephenson and Johnson 1973). None of the known den or rendezvous sites in the Susitna basin will be inundated by the impoundments, but both den and rendezvous sites that have not been located probably exist in the western portions of the Susitna basin.

- Habitat use

Habitats used by wolves vary widely (Paradiso and Nowak 1982) and in any particular area are probably determined largely by the habitat of their major prey. In the Susitna basin, detailed data on habitat use is available only for the Watana pack during the April to November period. This pack used a wide variety of habitats but was most frequently encountered in shrub and spruce habitat types (Ballard et al. 1982c).

Wolf dens in the Susitna area are mostly old red fox dens taken over and dug out by wolves. The majority are located on slightly elevated sandy areas providing good drainage. Entrance holes face predominantly south or east. Both dens and rendezvous sites have been found in a variety of habitats. Overstory trees or shrubs at den sites include spruce, aspen, balsam poplar, paper birch and willow in densities ranging from 90% cover to very sparse (Ballard et al. 1982c).

- Food Habitats

Food habits of wolves in the Susitna area were studied by both direct observation of kills and analysis of scats collected at den and rendezvous sites (Ballard et al. 1982c). The former method covers all seasons whereas the latter shows only summer food habits.

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

Table W51 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, Ballard et al. (1982c) suspected that the importance of calf moose was probably overemphasized by these data.

Predation rates in the Susitna area have been estimated to average one kill per pack every 5 days (Ballard et al. 1982c). Rates vary somewhat with pack size (Ballard et al. 1981b) but do not appear to vary seasonally (Ballard et al. 1982c) as has been suggested for some areas (Peterson 1980).

Studies of wolf food habits in the eastern Susitna basin and adjacent areas since 1975 have suggested that moose are the single most important food item (Ballard et al. 1981b). Adult moose are taken selectively from August through December while short and long yearling moose comprised a disproportionate number of January to July kills. Wolves take relatively healthy moose in winter. Ballard et al. (1981b) found that during severe winters adult moose were taken in proportion to their representation in the population but in average and mild winters disproportionate numbers of older adults were taken.

The annual percentage of observed wolf kills of caribou has varied from 4% to 30% from 1975 to 1981. Excluding 1978, when the main body of the Nelchina caribou herd wintered in the Wrangell Mountains and thus were largely unavailable during winter, the importance of caribou in the diet of Susitna basin 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 in relation to distribution of caribou. Caribou distribution, however, is probably related to their density (Skoog 1968). 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 the eastern Susitna basin and adjacent areas. If true, this pattern would suggest that if the herd grows even larger, caribou would also become more important as wolf prey. Assuming wolf poulations in this area 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 of some predation mortality.

- Home Range

Each of the six wolf packs in the Susitna basin studied by Ballard et al. (1982c) maintained a circumscribed home range during the period that the pack existed as a stable unit. Wolf packs in this area occasionally defend their territories against other wolves, although intrusions into a neighboring territory often occur when the home pack is not using that portion of the area. Observed pack home ranges varied in size from 943 km^2 to 2514 km^2 and averaged 1412 km^2.

- Population Characteristics

Wolves in the Susitna basin are heavily hunted and were also subject to an intensive harvest effort by Alaska Department of Fish and Game from 1975 to 1978. This harvest was an attempt to experimentally manipulate moose numbers by reducing predation. Whether the population was at a low level in 1980 - 1981, when detailed studies related to the Susitna project began, is unknown. The population in the Susitna basin in 1980-1981 was stable ranging from about 40 in spring after the hunting/trapping season to about 75 in fall when the pups join the hunting adults (Table W52).

Although there has been much speculation, there is little agreement on the factors that control wolf populations. Van Ballenberghe et al. (1975) believed that pack density, prey abundance and degree of exploitation varied so much among populations that the combination of factors controlling one population might be quite different from those controlling another. In the Susitna basin, however, human exploitation is quite clearly the most important factor. In 1981 and 1982, almost half the fall population was removed through legal and illegal winter hunting. Including wolves taken during the wolf control program from 1975 to 1978, the average yearly harvest from the Susitna basin and areas immediately adjacent (Game Management Units 13A, 13B and 13E) averaged 38 and ranged from 26 to 68. Additional wolves were probably taken illegally in each year (Ballard et al. 1982c).

Although there are few specific data, the maintenance of these high levels of harvest suggest high productivity in the population. Ballard et al. (1982c) do not report average litter size for the packs they studied, but their remarks suggest that 6 - 8 pups were produced yearly by each pack. High productivity, both in terms of proportion of adult females that whelp and litter size, have been demonstrated in other exploited populations in both Alaska and elsewhere (Rausch 1967, Van Ballenberghe et al. 1975).

The large numbers of pups produced each year results in a large population of young wolves likely to disperse to other areas. Ballard et al. (1982c) give numerous examples of radio-collared wolves that moved from one pack to another within the basin, wolves that established new packs in vacant areas, and wolves that left the basin entirely. Dispersal of individuals is often preceded by forays away from the pack home range and may be precipitated by death of most of the other pack members through sport hunting.

(vii) Wolverines

The wolverine remains one of the most poorly known of the larger carnivores, and few scientists have attempted to study wolverines in their natural habitat. Van Zyll de Jong (1975) states that the reason for this is due to the species being uncommon, highly mobile, and restricted to the more remote and inaccessible parts of the country. Most wolverine studies in North America have reported on the species' breeding biology and other information obtained from carcasses (reviewed by Rausch and Pearson 1972). Recent advances in radio-telemetry have resulted in studies of wolverine movements, habitat use, and home ranges in northwestern Montana (Hornocker and Hash 1981), northwestern Alaska (Magoun 1982), and in the upper Susitna basin (Gardner and Ballard 1982).

- <u>Distribution and Habitat Use</u>

Wolverines occur throughout the Susitna basin and appear to show little preference for specific habitat types (Figure W15). The lack of use of specific habitats is most likely related to the scavenging lifestyle of this species which dictates seasonally long movements, a relatively large home range, and a solitary existence (Hornocker and Hash 1981). Van Zyll de Jong (1975) stated that "the wolverine's niche explains the relative rareness of the species in the community compared to the efficient hunters among carnivores that act as providers [of carrion], and it implies a direct relationship between the biomass and turnover of large herbivore populations and the abundance and distribution of wolverines." The wolverine's propensity for wandering far and wide, which increases its chances of finding widely scattered and immobile food, as well as its well-developed food-catching behavior are probably also adaptations to the scavenger role (Hornocker and Hash 1981).

Food availability appears to be the primary factor determining movements and home range sizes of wolverines (Hornocker and Hash 1981, Gardner and Ballard 1982). Breeding activity also influences the sesonal movements of males, and to a lesser extent, of females (Hornocker and Hash 1982, Magoun 1982). Temperature may also influence movements; Hornocker and Hash (1981) reported that during the summer wolverines of both sexes moved to higher cooler elevations and traveled less during daylight hours. In the Susitna basin, Gardner and Ballard (1982) reported that changes in wolverine distribution occurred throughout the year, and that food availability probably influences these shifts. They noted a pronounced movement in spring, summer, and fall to higher elevations where arctic ground squirrels, marmots, and ground-nesting birds were abundant. Food is most available in the spring and summer, and wolverines consume a wide variety of food at that time (see Wilson 1982). Krott (1959) found carrion, small mammals, insects and insect larvae, eggs, and berries in the summer diet. Magoun (1982) found microtines, ground squirrels, marmots and caribou in the spring and summer diets of wolverine in northwestern Alaska.

Movements to lower elevations during winter are apparently associated with the increased importance of carrion in the diet during the winter months. During winters of moderate to deep snow depths, the lower elevations along the Susitna River support high densities of moose (Ballard et al. 1982a). Also, fewer birds and small mammals are available at higher elevations during the winter months (Kessel et al. 1982). Winter ground tracking indicated that wolverine were preying upon microtines, red squirrels, ground squirrels, and spruce grouse in addition to carrion (Gardner and Ballard 1982). Both red squirrels and spruce grouse are restricted to forested areas, and other small mammals are also most abundant in coniferous and deciduous forests.

The degree of territorialism exhibited by wolverines in an area appears to be related to the turnover rate of the wolverine population. Magoun (1982) found that female wolverines in an essentially unharvested population occupied exclusive home ranges that were overlapped by those of males. She did not have enough data to determine if adult male home ranges overlapped. Hornocker and Hash (1981) stated that wolverine home ranges in northwestern Montana overlapped between individuals of the same and opposite sex and claimed that territorial defense was essentially nonexistent. However, they were unable to establish the residency status of individuals in their population. Magoun (1982) reported that females with overlapping home ranges might be mother/daughter combinations, and that young males which have not yet dispersed might be overlapped by resident adult males. The data obtained on wolverines in the Susitna basin indicates that except for some overlap between adults and juveniles, individuals of the same sex occupy mutually-exclusive home ranges. The overlap of ranges shown in Figure W15 is due mostly to mortality of some of these animals during the studies. Hornocker and Hash (1981) suggested that trapping mortality in their study area, while not excessive enough to reduce population size, may have contributed to behavioral instability within the population causing a breakdown in the territoral system. They pointed out that unexploited mountain lion populations showed a highly refined system of territoriality, whereas exploited poulations were not territorial at all. Exclusive use of home ranges by same-sex adult wolverines in the Susitna basin and northwestern Alaska may therefore be a reflection of relatively low trapping mortality.

- <u>Population Characteristics</u>

The home range data obtained from the Susitna basin study and from other studies can be used to estimate the number of wolverine present in the upper basin. Home range sizes of male wolverine will be used in these calculations since more data is available for males than for females. The average home range size for 5 adult males located at least 5 times was 413 km^2, ranging from 141 km^2 to 628 km^2. These ranges were smaller than those reported for males by Magoun (1982) (mean = 700 km^2), but similar to the 422 km^2 value found by Hornocker and Hash (1981).

If we assume that wolverine in the 16,319 km^2 upper basin use all habitat types (including rivers, lakes, rock and ice), and further assume that adult male home ranges are mutually exclusive and contiguous, we arrive at an estimate of 40 adult males in the upper basin. Reported sex ratios of wolverine kits taken from dens and of fetuses do not differ from a 1:1 ratio (Pulliainen 1968, Rausch and Pearson 1972), and therefore an estimated 40 adult females also occur in the upper basin. According to Rausch and Pearson (1972), the effective reproduction of wolverine is 2 kits/litter. Hornocker and Hash (1981) believed that no more than half of the females on their study area were reproductively active in each of the five years of their study, and only 53% of mature females trapped in the Susitna basin were reproductively active (Gardner and Ballard 1982). About 40 kits are therefore added to the basin's population each year, resulting in a total estimate of 120 wolverines in the basin. The density of this population is therefore 1/136 km^2 (1/53 mi^2). This compares to other density estimates of 1/233 km^2 in northwestern Alaska (calculated from Magoun 1982), 1/65 km^2 in northwestern Montana (Hornocker and Hash 1981), 1/207 km^2 in British Columbia (Quick 1953), and 1/200 km^2 to 1/500 km^2 in Scandinavia (Krott 1959). There are probably fewer than 120 wolverines in the upper basin, since it is unlikely that wolverine use all areas, and emigration, immigration, and trapping and natural mortality probably result in smaller population size. Some juveniles also occupy home ranges that do not overlap completely with those of adults.

Trapping is probably the main cause of mortality among wolverines in the Susitna basin. A total of 27 wolverine were harvested from this area during 1979 - 1981; 20 during 1979 - 1980 and 7 during 1980 - 1981. The low take during 1980 - 1981 was probably due to poor weather and snow conditions. Most trapping occurs in the accessible periphery of the area and mortality from trapping is likely to increase with the construction of access roads into the upper Susitna basin.

(viii) Belukha Whales

The belukha whale is a widespread arctic and subarctic circumpolar species that inhabits coastal waters. In Alaskan waters, two discrete stocks, a Cook Inlet-northern Gulf of Alaska stock and a general Bering-Chukchi-Beaufort stock, have been identified based on migration patterns, summer concentration areas, and morphological differentiation (Sergeant and Brodie 1969, Murray and Fay 1979, Gurevich 1980). No evidence exists to indicate interchange between the Cook Inlet stock and the Bering Sea stock, and isolation has been suggested based on morphological differentiation.

It is speculated that the Cook Inlet population would experience some impact from the development of the Susitna project because of their annual concentration near the mouth of the Susitna River.

- Population Characteristics

  Population estimates of the Cook Inlet stock from the mid-1960's indicate 300-1,000 belukhas in Cook Inlet, with an estimate of 500 animals (Klinkhart 1966) most accepted. More recent surveys support this estimate (Calkins 1979, Calkins, unpub. data). Schneider (1982) reports 300 bulukhas from direct counts in upper Cook Inlet on June 11 and indicates that, due to turbidity, as many as 2 to 3 times that many may have been present.

- Distribution and Habitat Use

  In winter, belukhas may be found in some of the ice free bays in southern Cook Inlet. Some individuals apparently range across the northern Gulf of Alaska; sightings of belukhas have been reported from Shelikof Strait, Kodiak Island and Yakutat Bay (Fiscus, et al. 1976, Calkins and Pitcher 1978, Harrison and Hall 1978, Calkins 1979 and Calkins, unpub. data).

  Belukhas aggregate in groups from two to several hundred individuals in spring and summer seasons. These concentrations have been attributed to exploitation of locally concentrated foods, such as anadromous fish (Tarasevich 1960, Seargent 1962, Klinkhart 1966). They are also apparently associated with polygamous breeding in April and May, with calving (reported to occur in May through August in brackish lagoons), and with the subsequent nursing of neonates (Fay and McClung 1976, Seaman and Burns 1981, Fraker 1977).

  Most of the Cook Inlet population moves into upper Cook Inlet in spring and remains there through much of the summer. In spring and summer, concentrations develop near mouths of streams and rivers in the northern inlet. The largest concentrations occur annually between the mouths of the Susitna and Beluga Rivers, sometimes ascending the rivers for several miles. Various species of smelt and salmon, both outmigrating smelt and returning adults, are the most likely attractants in Cook Inlet rivers. There has also been speculation that the mouth of the Susitna River is a calving and nursing area.

Aerial surveys were flown by Schneider (1982) in upper Cook Inlet between May 17 and August 27, 1982 to identify the timing and magnitude of belukha concentrations. Belukhas were concentrated in the inlet south of the Susitna River mouth from the date of the first survey through late June or early July, with peak numbers of 300 animals counted on June 11. As previously mentioned, these counts may be one-third to one-half of the actual numbers present. By July 8, the concentrations appeared to have broken up and only 7 whales were sighted in the Susitna to Beluga River area.

Schneider (1982) indicates only that hooligan and king salmon were reported running in the rivers during the survey period. No estimate of the size of these runs is given.

No calves were sighted during these surveys, but Schneider (1982) attributes this to their low visibility in the turbid waters of the upper inlet and indicates that calves were likely present when surveys began on May 17.

Chickaloon Bay, to the southeast of the Susitna River mouth, was also identified as an intensive use area, with 20-25 belukhas sighted there on each survey through July 1. No data was presented on the number of calves seen in Chickaloon Bay.

(b) Furbearers

(i) Beavers

Beavers are common and widely distributed throughout much of North America. They occur throughout the Susitna River drainage, from Cook Inlet upstream along the river, its tributaries, and ponds to elevations above 1000 m (Gipson et al. 1982). They are herbivorous and eat herbaceous and aquatic vegetation as well as the bark, twigs, and stems of trees and shrubs.

The Susitna River, from Devil Canyon to the Delta Islands, was surveyed for beaver sign in summer 1980 by Gipson et al. (1982). Use of the river by beavers increased progressively downstream from Devil Canyon. An overflight of the river in the summer of 1981 and intensive surveys in 1982 confirmed this observation. No beaver lodges, food caches, or dens have been observed within the active floodplain between the Tyone River and Devil Canyon, but they do occur on some tributaries and lakes in the upper basin. In summer 1982, the river downstream of Devil Canyon was surveyed using a river boat, helicopter, and ground surveys to determine beaver habitat preferences, lodge construction materials, and forage plants. Preferred food sources were willow (particularly feltleaf willow), balsam poplar, and paper birch. Alder was the primary material for lodge construction but was rarely found eaten (peeled). Peeled birch, poplar and willow were also used for construction.

The Susitna River between the Deshka River and Portage Creek was divided into three sections on the basis of river morphology and vegetation characteristics: lower section from Deshka River to Goose Creek, middle section from Goose Creek to Talkeetna River, and upper section from Talkeetna to Portage Creek. Each section was divided into linear miles of floodplain parallel to the main channel, and each sample unit was one of the mile sections from the thalweg to the active floodplain boundary on one side. Beaver habitat was classified into four categories for analysis as described below. Although described in terms of water type, habitat also included bank characteristics, water sources, tree and shrub vegetation.

- Main Channel: consisted of the major river thalweg and associated land masses. Channels are characterized by rocky and eroding banks with high velocity, and high volume flows.

- Side Channel: consisted of channels which split off main thalweg yet which carry large volumes of water. Representative channels showed rocky banks, silty flow with generally high velocity. Substantial amounts of erosion were often associated with side channels.

- Sloughs: lower volume and slower flow characterize these channels. Silty banks with established vegetation are characteristic along with reduced erosion. The water source is predominantly Susitna with some clear water mixes. A number of sloughs may only exist at normal or high water levels.

- Clear water: this habitat consisted of creeks, river runoff, and seeps which were of non-Susitna or filtered clear water. Slow to moderate flow, silty banks, and established vegetation were characteristic.

In all sections of the river, beaver were found to prefer slow-moving side channels or sloughs, as well as mouths of tributaries (see Table W53.) Such sites increase progressively downstream as the river channel becomes more braided. Beaver in the middle and lower sections are reported by residents to use bank lodges which have an underwater entrance and an air vent under a large tree. If this is the case, the "high activity" values in Table W53 for these sections are low, since there is no detectable sign for these types of dens that would have been recorded.

Slough and Sadlier (1977) identified the major habitat variables for beaver as water depth, stability, and flow rate, and distance to suitable food species. They found that the variables which correlated best with beaver population densities were low flow, low gradient (low erosion potential), and banks containing a high percentage of food species. Results of the 1982 survey agree with their work as well as the findings of Boyce (1974) and Hakala (1952), who reported that beavers in Alaska favor lakes or slow moving streams bordered by subclimax stages of shrub and mixed conifer-deciduous forests. The results also confirm a study by Retzer (1955) who found that beavers avoid large rivers with narrow valleys and high velocity flows.

Aerial surveys of food caches in the fall have been shown to be an accurate method of determining the number of active beaver colonies in an area (Hay 1958, Machida 1982). An aerial cache survey conducted in 1982 revealed 14 beaver food caches in the active floodplain of the Susitna River between Portage Creek and Talkeetna (0.16 caches/km). Each cache is estimated to support five beaver (Boyce 1974), so the population of that stretch of the river is estimated at 70 beavers. This is a low population density compared to a range of 0.35-0.40 colonies/km found elsewhere in Alaska (Boyce 1974), but was expected due to the scarcity of side channels and sloughs with slow-moving water along this reach of the river. Beaver densities would be much higher if beaver in nearby ponds and tributaries were included, but these areas are unlikely to be affected by the project and therefore were not sampled. Population estimates were not possible for the river south of Talkeetna, because high water levels had obscured or destroyed many of the existing caches.

The 1982 survey also included Deadman Creek because of its proximity to the proposed access road. Densities of beavers were 0.53 active lodges/km along the middle portion of Deadman Creek and were even higher in a marshy section of upper Deadman Creek (Table W54). An estimated 65 beaver currently occupy this creek.

Beaver populations are productive and can withstand moderate trapping pressure. First breeding occurs at age 2 or 3, and annual litters average 3 to 4 young thereafter (Hill 1982). Young beavers disperse during the summer of their third year, sometimes travelling as far as 200 km to set up new lodges (Hill 1982). Trapping for beaver has historically been common along the Susitna River below Devil Canyon, along major tributaries, and around larger lakes like Stephan Lake (Gipson et al. 1982). Beavers in alpine areas have seldom been trapped because of the effort involved. These populations are vulnerable to environmental alteration and/or overtrapping because of their dependence on small, isolated riparian habitats (Gipson et al. 1982).

(ii) Muskrat

Muskrats are common and widely distributed throughout most of North America. They occur throughout the Susitna River drainage from Cook Inlet upstream along the river, its tributaries, and ponds to elevations above 1000 m. Muskrats are primarily herbivorous, with a diet that includes pondweed and swamp horsetail (Perry 1982).

The upper Susitna basin was surveyed for muskrat signs in the early spring of 1980 by Gipson et al. (1982). Lakes within 4.8 km of the Susitna River were surveyed by helicopter, from the confluence with the Oshetna River to Gold Creek. Muskrat pushups were observed on 27 (26%) of the 102 lakes surveyed (Table W55). Most of the lakes and ponds with muskrat sign were above the river valley, between 265 m and 865 m in elevation. Populations of muskrats were also noted along slow flowing sections of larger creeks, particularly where lakes drain into streams (Gipson et al. 1982).

A downstream survey conducted by riverboat in the summer of 1980 indicated that muskrat numbers increase with distance from Devil Canyon. No sign of muskrat was noted on the river between Devil Canyon and Talkeetna. Between Talkeetna and Montana Creek, sign of muskrat was limited to sloughs and marshy areas near the mouths of feeder streams. Muskrat sign was more commonly observed downstream of Montana Creek where numerous side channels and sloughs occur (Gipson et al. 1982).

Trapping for 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. Muskrats in alpine streams and lakes have seldom been trapped because of the effort involved.

(iii) River Otters

Information concerning the distribution and abundance of river otters in the upper Susitna basin was obtained during winter aerial and ground surveys (see Tables W56 and W57, and Figure W16). These data indicate that otters are common along the Susitna, its tributaries to 1200 m elevation, and around large lakes (Gipson et al. 1982). This distribution is probably related to the distribution of prey of otters, which include primarily fish and crustaceans (Ryder 1955, Knudson and Hale 1968, Toweill 1974, Gilbert and Nancekivell 1982).

In November 1980, an unusual concentration of otter tracks was found on the river ice within the proposed impoundment areas (Gipson et al. 1982). The significance of this track concentration is unclear, but it may represent upriver or downriver movements of otters prior to freeze-up. It is also possible that the otters were concentrating along the river to feed on grayling, which were migrating out of the tributaries to overwinter in the Susitna.

Some otter trails were also observed in cross-country travel, away from bodies of water. Such tracks have been noted in other areas of southcentral Alaska and may represent dispersing sub-adults (Gipson et al. 1982). Local trappers seldom take river otters because they are relatively difficult to trap, and the pelt values have usually not been high enough to justify the effort.

(iv) Mink

Mink are locally abundant in the upper basin along the river, its major tributaries to 1200 m elevation, and along lakeshores. Track counts from both air and ground in fall 1980 (Tables W56 and W57) suggest that mink are more abundant in the upper reaches (east of Kosina Creek) of the impoundment area than they are elsewhere (Gipson et al. 1982). Two mink were radio-collared in 1980, but no valuable data were obtained because one animal slipped its collar and the other radio failed. Food habits of mink vary among areas, depending on prey availability. Small mammals and fish usually form the majority of the diet, but crustaceans and birds may also be eaten (e.g. Errington 1954, Wilson 1954, Korschgen 1958). Muskrats may form a major portion of the diet where they are available (Hamilton 1940, Sealander 1943).

(v) Marten

- Distribution

Pine marten are common nocturnal mustelids found in spruce forests throughout interior Alaska. They are locally abundant in the vicinity of the proposed Devil

Canyon and Watana impoundments. Data from aerial transects flown in November 1980 (Gipson et al. 1982) indiate that marten are present along the Susitna River at least as far downstream as Portage Creek and as far upstream as the Tyone River.

- Home Range

Gipson et al. (1982) found that home ranges of adult male marten were mutually exclusive and overlapped those of other sex/age classes. Average home ranges of 10 adult males were 7.02 km^2. Female home ranges averaged 3.71 (n=3), excluding one animal with an unusually shaped home range. Between spring and autumn 1981, some marten home ranges appeared to shift location and vary in size periodically. Marten rarely swim across rivers or large creeks and these often formed partial home range boundaries in the study area.

Home range sizes in the Susitna area are midway between the figure of 12.8 km^2 for 4 marten in Minnesota (Mech and Rogers 1977) and 4.1 km^2 for 5 marten in the Yukon Territory (Archibald 1980). Differences in home range sizes in different areas and seasons is attributable to variability of food resources (Soutiere 1978, Lensink et al. 1955).

- Population Characteristics

An estimated density of 0.147 marten per km^2 was calculated from radiotelemetry data on 10 adult male marten in the drainages of Deadman and Watana Creeks along the Susitna River between the creeks (Buskirk, pers. comm.). This estimate assumes a 1:1 sex ratio with male and female territories overlapping, and 65% juveniles in the population (a figure derived from trapper harvest data in the Yukon Territory by Archibald 1980).

Information from former and present trappers indicates that marten continue to be economically the most important furbearer in the vicinity of the impoundment zones.

- Habitat Use

Track counts from a November 1980 aerial survey indicate that marten are most numerous in coniferous and mixed forest and woodland habitats below 1000 m elevation (Gipson et al. 1982). The highest track counts occurred between Devil Creek and Vee Canyon.

Marten resting sites were located below ground in late autumn, winter, and early spring. In summer, when soil temperatures are lower than air temperatures, marten rest above ground. Summer resting sites could not be characterized due to the escape response of marten above ground. Thirty-one of 37 winter resting sites (83%) were in red squirrel middens or nests. All were in forest or woodland vegetation types.

- Food Habits

The diet of marten shows some seasonal variation but microtine rodents are the primary prey at all times of the year in interior Alaska (lensink et al. 1955). Microtines had an 88.8% frequency of occurrence in scats from the upper Susitna basin (Buskirk, pers. comm) (Table W58). Plant foods, such as bog blueberries, crowberries, mountain cranberries, and rose hips, are consumed most frequently in autumn, and attain an average frequency of occurrence of 23.3%. Bird remains were present in 9.6% of scats, most frequently in winter, and squirrels occurred in 6.8%, most frequently in spring.

(vi) Red Foxes

Red foxes and their sign have been observed throughout the upper Susitna basin including the proposed Devil Canyon and Watana impoundments. During 1980 and 1981, Gipson et al. (1982) employed radio-tracking, snow tracking, and aerial snow tracking to determine fox distribution, abundance, and habitat use. Food habits were studied from scat analysis, stomach content analysis, and examination of food remains at dens and on fox trails. Aerial surveys were conducted to locate fox dens and dens were surveys periodically throughout summer to determine use.

- Habitat Use

. Denning Habitats

Nineteen fox dens were located in the upper basin during baseline studies in 1981 (Figure W17) (Gipson et al. 1982). Sixteen dens were located north of the Susitna River with several dens concentrated in the upper Watana Creek and upper Deadman Creek drainages. Gipson et al. (1982) report that more dens are likely to exist on the south side of the river, but the aspect, physiography, and vegetation appear more favorable for denning and hunting on the north side.

Dens are typically situated on an aspect facing south and/or west, and on well-drained prominences up to 5 m above surrounding areas. Dens are also characterized by proximity to a lake of over 4 ha or a creek. Dens were found between 1000 m and 1200 m elevation in areas of rolling hills adjacent to mountains. All active dens located were in or near areas of medium to high ground squirrel density.

Foxes in this study area remained at den sites into October, much later than in other areas of Alaska (see Gipson et al. 1982) or elsewhere (Storm 1972, Sheldon 1950). Foxes in the Susitna project area appear to use den sites throughout the winter, as evidenced by clearing of snow from at least one entrance of most dens visited during winter months.

Foxes in the upper Susitna basin appear to prefer relatively high elevation areas, near or above timberline. Black spruce flats upstream from Vee Canyon are also commonly used. Some foxes use low elevation tributary deltas during autumn, then shift to alpine zones as snow depth and volume of water flowing over the ice increase. Other foxes remain above timberline year round. Trails in snow indicated that foxes commonly foraged in winter in areas above timberline frequented by large flocks of ptarmigan.

Almost twice as many tracks (151 vs. 79) were located south of the river as on the north (Table W59). This is in contrast to the greater number of active dens found on the north side. At the upper reaches of the proposed impoundment fox density was observed to increase markedly. The south side of the river above Vee Canyon changes from mountainous terrain to open, marshy flats which Gipson et al. (1982) say characterize good fox habitat.

Gipson et al. (1982) report that searches along the Susitna River and lower elevations of tributaries in late winter and early spring 1980 produced no evidence of foxes in these areas. Tracks and other sign were noted on river banks in the following late fall and early winter.

- Food Habits

Principal foods of foxes in the upper Susitna basin were determined by Gipson et al. (1982) through direct observation, identification of remains at dens and on trails, scat analysis, and stomach analysis of foxes taken by trappers. In spring and summer, diets included Arctic ground squirrels, red-backed voles and singing voles. Ptarmigan were taken throughout the year and were major components of the diet in winter. Muskrats are taken where available and may be relatively important to foxes in the vicinity of large lakes such as Stephan Lake, Clarence Lake, and Deadman Lake. Dispersing young muskrats and muskrats at pushups are especially vulnerable to predation by foxes.

Carrion is also identified as important by Gipson et al. (1982). Foxes were observed feeding on a carcass of moose and another of caribou near Watana Camp, and on a sheep carcass on the east fork of Watana Creek.

Snowshoe hare are presently scarce in the Susitna study area and are therefore unimportant in the diet of foxes there. The scarcity of hares may be responsible in part for the relatively low number of foxes in the area as well as the seasonal shifts to higher elevations where ptarmigan are available.

- Home Range

Summer home ranges varied from 18.3 to 32.7 km^2 in the Susitna study area with little difference in home range size between males and females. The larger size of home ranges in the Susitna study area compared with studies in midwestern states was attributed by Gipson et al. (1982) to the greater availability of food in that region.

- Population Characteristics

Six of 19 dens found in a 1751 km^2 area in the upper basin in summer 1981 were active (Gipson et al. 1982). Dens were classified according to size and use as described in Table W60; locations are mapped on Figure W17. A seventh den was probably also active, giving a density of one family per 250-292 km^2. Gipson et al. (1982) report that the most reasonable estimate of density is one family per 83 km^2 based on the assumption that at least one-third of active dens were found in 1981.

Transect data demonstrate a marked increased in number of fox tracks encountered progressing upstream from Devil Canyon to the Tyone River. Dean Wilson (pers. comm. cited by Gipson et al. 1982) indicated that most of the furs he buys are taken in open, marshy country and that prime fox habitat decreases from the MacLaren River to the Tyone-Oshetna-Susitna areas as flat open plains rise to mountainous alpine terrain. Gipson et al. (1982) conclude that the Susitna project study area supports a low density fox population relative to other areas in Alaska.

(vii) Lynx

The distribution of lynx in the upper basin is very limited at present. Tracks and scats have been found in several areas including the mouth of Goose Creek (probable lynx tracks seen from the air on November 19, 1980, and a dense concentration of scats and tracks found on October 22, 1981), the mouth of Jay Creek (tracks seen on October 30, 1981), and along Goose Creek, 1.6 km from the mouth (tracks seen on November 3, 1981)(Gipson et al. 1982).

In the past, lynx were apparently fairly numerous in the canyon country of the Susitna River, being found primarily in the forests along the river (H. McMahan, pers. comm. cited by Gipson et al. 1982). Trappers in the vicinity of the impoundments reported no sightings of lynx or their tracks, and reports from trappers in the Gold Creek area suggest that lynx have been uncommon there in recent years as well (Gipson et al. 1982).

Lynx population levels fluctuate in response to availability of snowshoe hares (Keith 1963) which were uncommon in the Susitna basin in 1981 (Kessel et al. 1982). Gipson et al. (1982) reported that historically, the frequency of natural forest fires increased from Portage Creek to the Tyone River, and speculated that snowshoe hares (and lynx) numbers may have been higher in the past. However, Kessel et al. (1982) note that no fires have occurred in the Susitna basin in the recent past, and they report that hare numbers appear to be chronically low in the Susitna area. If fire or other habitat change leading to an increase in snowshoe hares occurs, lynx populations will likely also increase. However, for the present, lynx are uncommon in the area.

(viii) Coyote

The distribution of the few coyotes occurring in the upper basin is generally limited to those areas downstream of Devil Creek. No coyotes or their tracks were observed by Gipson et al. (1982) during baseline studies in the Susitna area, although several sightings of coyotes in fall 1980 were reported to them. Other sightings of coyote, or their tracks, have also been reported in the Gold Creek and Canyon areas (H. Larsen, pers. comm., R. Roullier, pers. comm. cited by Gipson et al. 1982). Coyotes have not been seen or taken by trappers upstream of Devil Creek. The distribution and abundance of coyotes in the Susitna area is probably limited by wolves rather than by habitat, food availability, or trapping pressure. Wolves are usually aggressive toward coyotes within their home range (Rolf Peterson and Jim Woolington, pers. comm).

(ix) Short-Tailed Weasel

Short-tailed weasels are locally abundant in the upper basin, and their tracks have been observed in a variety of habitat types at elevations ranging from the banks of the Susitna River to over 1500 m. Transect surveys conducted in November 1980 yielded 746 short-tailed weasel tracks, 328 (44%) of which were counted on a single transect near the Tyone River (Table Furbearer-1). Most of the tracks (489 or 66%) were observed in woodland white or black spruce vegetation types; an additional 190 (25%) were counted in medium shrub types (Gipson et al. 1982). It appears that short-tailed weasels can meet their food and cover needs in a variety of habitat types. Short-tailed weasels have been taken both deliberately and incidentally by trappers on upper Tsusena Creek, in the Fog Lakes area, and elsewhere in the study area, but they are not a species of major economic importance.

(x) Least Weasel

Least weasels occur at least sparsely throughout the upper basin and may be locally abundant. However, their small size and secretive behavior makes confirmation of their presence difficult. Several sets of tracks believed to be those of least weasels were seen in March 1980 along lower Watana Creek. The carcass of one 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 Site A on October 25, 1981 (Gipson et al. 1982). The pelts of least weasels have practically no commercial value (Svendsen 1982), and thus information from trapping returns is rarely available to supplement direct observations.

(c) Birds

Few data on bird populations in the upper Susitna basin were available prior to the initiation of baseline studies for the Susitna Hydroelectric Prject. Baseline data on breeding birds were collected by the University of Alaska Museum (Kessel et al. 1982) in 1981 and 1982, and surveys for migratory waterbirds were conducted during spring 1981 and fall 1980 and 1981. Surveys for cliff-nesting raptors and tree-nesting bald eagles were conducted in summer 1980 and spring 1981.

Bird populations in the lower Susitna floodplain were also poorly known prior to the project. To obtain an overview of the distribution, abundance, and habitat use of birds in that area, three types of avifaunal surveys were conducted between Devil Canyon and Cook Inlet: (1) spring aerial surveys of waterbirds in 1981 and 1982; (2) a ground survey of all bird species in early summer 1982; and (3) an aerial survey for bald eagle nests in summer 1982.

A total of 135 species of birds have been recorded in the upper basin. Their relative abundances (see Appendix EE) are largely a function of habitat availability. The most abundant species in the project area are common redpoll, savannah sparrow, white-crowned sparrow, Lapland longspur, and tree sparrow. Redpolls are habitat generalists, whereas the four other species are birds associated with shrublands, which cover 60% of the region (Section 3).

Of the 135 species known to occur in the upper basin, 15 are ranked as regionally rare on the basis of current information: 4 raptors (osprey, American kestrel, snowy owl, boreal owl), 3 species of ducks (gadwall, blue-winged teal, ring-necked duck), 4 shorebirds (upland sandpiper, turnstone sp., surfbird, sanderling), 3 small land birds (black-backed three-toed woodpecker, western wood pewee, yellow warbler), and ruffed grouse. Most of these bird species are either at the periphery of their geographic ranges or are limited by a lack of appropriate habitat. All 15 species are represented by larger populations in other portions of Alaska.

At least 82 bird species have been recorded along the lower Susitna floodplain (see Appendix EF). The highest relative abundance and species diversity of birds occurred in the mid- and late-successional vegetation types.

(i) Raptors and Raven

Surveys specific for nesting raptors in the upper Susitna basin were made only during summer 1980 and spring 1981, and in October 1982. A total of 10 raptor species were recorded upstream of Devil Canyon. Five species (6 including common raven, a functional raptor that often provides nests for some raptor species) are known to nest in the area, and two additional species probably breed there (Appendix EF). In total, 53 raptor/raven nest sites have been reported from the upper basin (White 1974, Kessel et al. 1982, Kessel, pers. comm.; see Table W61). At least two of these locations (GE-6 and GE-12) do not appear to exist and probably represent two of the remaining 51 locations (see Table W61). Active nesting locations in 1980 included 6 golden eagle, 4 bald eagle, 1 common raven and 1 nest of an unidentified species (probably gyrfalcon). Active nest sites in 1981 included 6 golden eagle, 5 bald eagle, 1 gyrfalcon, 2 northern goshawk, and 4 common raven. One additional active golden eagle nest was discovered during the course of other work in 1982. Nesting locations that were not active in 1980 and 1981 presumably function either as alternative sites or, in some cases, may be used by additional pairs in years when population levels may be higher. Table W62 shows the general breeding phenology of golden eagles, gyrfalcons, and ravens in Alaska. These schedules are applicable to the upper basin.

In 1974, White (1974) found 14 active nests within the same area of the upper Susitna basin: 2 gyrfalcon, 3 bald eagle, 9 common raven, and an additional location that was probably occupied by gyrfalcons that year (GYR-1; see Table W61). White also reported an additional 13 inactive nests, ascribing 7 to ravens, 3 to golden eagles, 2 to bald eagles, and one to goshawks. The reason for the substantially different species composition between 1974 and 1980-81 (more ravens and fewer eagles in 1974) may be related to differences in survey intensity and possibly to natural variations in the prey base.

The density of active golden eagle nests present in the upper basin in 1980 and 1981 (one pair per 14.8 km of river) (Kessel et al. 1982) was similar to that found along the Brooks Range portion of the Dalton Highway in 1979 (one active nest per 15.7 km) (Roseneau and Bente 1979). The latter density appears to be one of the highest reported for Alaska. Murie (1944) found golden eagles nesting as close as 1.6 and 2.4 km to each other in Denali National Park in 1941 and 1939, respectively. Golden eagles regularly build and maintain a number of simultaneous nests, sometimes several kilometers apart (D.G. Roseneau, pers. comm.), which are used as alternative sites in different years (Brown and Amadon 1968). White et al. (1977) suggested that local populations of golden eagles may increase during years of high snowshoe hare populations; however, hares were relatively scarce in the upper basin in 1980 and 1981 (Kessel et al. 1982). Murie (1944) noted that artic ground squirrels were a major prey of golden eagles in Denali National Park in 1939-1941, and these rodents were abundant in the upper basin area during the study.

Surveys for nesting bald eagles were conducted in the lower Susitna River floodplain in April 1980 by the U.S. Fish and Wildlife Service, in late June 1981 by TES, and in early July 1982 by the University of Alaska Museum. In total, these surveys located 38 nests (see Table W63). In 1982, the year for which data are the most complete, only 14 of the 24 nests found in 1980-81 could be located, but 14 new nest sites were discovered. Of these 28 total known nests, 17 were active and 11 were inactive. The amount and suitability of bald eagle nesting habitat and the number of nesting bald eagles increases markedly downstream of the Indian River (see Table W63.) Most of the bald eagle nests were concentrated in three sections of the river: (1) between Talkeetna and the Parks Highway Bridge; (2) between Kashwitna Lake and the mouth of the Yentna River; and (3) from Bell Island to the mouth of the Susitna River.

The density of bald eagles nesting in the lower Susitna River floodplain is slightly higher than that calculated for the Tanana River (Roseneau, pers. comm.).

Gyrfalcons are less common than eagles in southcentral and central Alaska, but some regularly nest throughout the Alaska Range. Cade (1960) estimated the total Alaska population at only about 200-300 pairs. Roseneau et al. (1981) considered that an underestimate but doubted that the population exceeded 500 pairs. Gyrfalcon densities vary considerably between years (Cade 1960, Roseneau 1972, Swartz et al. 1975), but variation is probably less over large geographic regions (Roseneau 1972). The majority of the Alaskan population is found in northern and western Alaska (Roseneau et al. 1981), and gyrfalcons there tend to exhibit relatively low site fidelity from year to year (Cade 1960, Roseneau 1972). However, in the Alaska Range, where suitable nesting cliffs are more widely dispersed, most sites appear to be used every year (Bente 1981).

There were no confirmed sightings of peregrine falcons in the upper Susitna basin during 1980, 1981 or 1982 in spite of the number of manhours spent on ornithological field work and on raptor surveys (Kessel et al. 1982,Kessel, pers. comm.). White (1974) saw two individual peregrines during a 10-15 June 1974 survey; however, he found no sign of nesting. One of the birds 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 up river from the Devil Canyon Dam axis." White (1974) stated that the Yenta-Chulitna-Susitna-Matanuska drainage basin "seemingly represents a 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."

Suitable nesting habitat for goshawks and great-horned owls consists primarily of occasional stands of mature paper birch and paper birch-white spruce stands, which are most commonly found downstream of Devil Canyon (Roseneau, pers. comm.). Some nesting habitat for other tree-nesting species (i.e., red-tailed hawks, American kestrels, sharp-shinned hawks, boreal owl, and hawk owls) and ground-nesting species (i.e., merlins, northern harriers, and short-eared owls) also occurs in the Susitna basin, but no concentration areas of nesting habitat are known or expected to occur.

(ii) Waterfowl and Other Large Waterbirds

The upper basin and the Lower Susitna River floodplain do not support large concentrations of waterfowl or other waterbirds during either migration or the breeding season (Kessel et al. 1982).

The species composition of waterfowl in the upper basin 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 W64). 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, (one of the most numerous ducks in central Alaska) occurred in relatively small numbers in the study area, in spite of the fact that both 1980 and 1981 were high population years for pintails in Alaska due to severe drought in the Canadian prairie provinces (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 to at least the MacLaren River. On a random flight over ponds in this area on 4 August 1981, Kessel et al. (1982) recorded 19 groups of trumpeter swans. Forty adult birds, including 9 pairs with broods (28 cygnets) were seen. This area is on the western edge of the habitat used by the Gulkana Basin trumpeter swan population which has more than doubled during the past five years (King and Conant 1981).

The lower Susitna River itself appears to be little used by waterbirds. Few birds were seen during spring aerial surveys in either 1981 or 1982 (Table W64) or during the June 1982 ground surveys (see Appendix EE).

Overall, swans, greater white-fronted goose, scaup sp., common merganser and merganser spp. were the most abundant species seen. Numbers were highest in the last 37 km of the river between the mouth of the Yentna River and Cook Inlet.

Ice on the lower river apparently broke a week or more later in 1982 than in 1981. During the May 7, 1981 survey, the river above Talkeetna was breaking up and carrying a heavy load of ice chunks, whereas on May 10, 1982, this section of river was still almost entirely frozen. Since spring migration of dabbling ducks in central Alaska was only 2 to 3 days later in 1982 than 1981 (Kessel, unpubl. data), the main spring movement had passed through the Susitna region in 1982 before water became available in the river above Talkeetna.

In addition to early season ice above Talkeetna, the main reasons for the low use of the lower river appear to be its rapid flow and heavy silt load. These factors discourage the development of aquatic plants and associated invertebrates, the main diet of most waterbirds, and make food invisible, except at shallow edges or in sloughs. Corroborating this assumption is the fact that the most numerous ducks on the river were fish-eating mergansers.

- Migration

The upper Susitna 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. Corps of Engineers 1977). A relatively small number of individuals were seen during three surveys in Spring 1981 and six and five surveys in fall 1980 and 1981, respectively (Table W64).

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. Pintails were common during spring migration but uncommon in fall. Few geese or cranes were seen at either season (Kessel et al. 1982).

The upper Susitna basin was less important to migratory waterfowl in spring than fall. Ice breakup does not occur until mid-May on many lakes in the upper basin with the result that little open water is available to early-migrating waterbirds, such as the dabbling ducks and common goldeneye. Early migrants used the Susitna River itself and the thawed edges of lakes. Use of the upper basin's water bodies increased toward the end of May, concurrent with the availability of more open water and the influx of the later-arriving loons, grebes, scaup, oldsquaw, scoters, and mergansers.

The pattern of fall movement in the upper basin is similar to that known for the rest of central Alaska. That is, peak numbers of American wigeon, pintail, and green-winged teal occur during the first half of September; of loons, grebes, and scaup during the second and third weeks of September; and of mallards, scoters, buffleheads and goldeneyes from the last third of September to mid-October. Swan migration, which includes both trumpeter and whistling swans, occurs between the last week of September and the end of October.

- Relative Importance of Water Bodies

The wetlands of the upper basin supported relatively few waterbirds during the summer. An average density of only 22.5 adult waterfowl and gulls/km^2 and 2.9 broods/km^2 were found on 28 intensively surveyed waterbodies in summer 1981 (Table W64). By comparison, a census of 13 waterbodies in the upper Tanana River valley, similar in size class distribution to those surveyed in the upper basin, had average densities of 183.8 adults/km^2 in 1977 and 110.9 adults/km^2 in 1979 (Spindler et al. 1981). Broods averaged 6.2/km^2 in the upper Tanana River valley (Spindler et al. 1981). Productivity in the eastern portion of the Upper Tanana River valley study area in 1979 was 30-40 percent lower than historical levels typical of Minto Lakes and the Yukon flats (Kessel et al. 1980). Minto Lakes, Tetlin Lakes, and portions of the Yukon Flats are considered among the most productive wetlands in Alaska (J. G. King, U. S. Fish and Wildlife Service, pers. comm. cited in Kessel et al. 1982). Thus, the waterbodies of the upper basin appear to support a relatively impoverished population of waterfowl during the summer.

The average density of waterbirds observed on lakes and groups of lakes in the upper basin are shown in Table W65. Densities were generally quite low with the highest fall densities occurring at Murder Lake, Watana Lake, and the MacLaren River-Tyone River group (see Figure W18). Murder Lake had by far the highest density of waterbirds in spring; the density for lakes near lower Deadman Creek was also fairly high.

Kessel et al. (1982) calculated Importance Values (I.V.) for each lake surveyed based on the number and density of birds and number of species observed on each lake compared to all other surveyed lakes. Seasonal population statistics are listed in Tables W66 for the lakes having the highest scores. Of these more important water bodies, Stephan and Murder Lakes were among the top three in Importance Values for all seasons. Stephan Lake received twice as much use in fall as in spring, but both water bodies consistently had relatively high levels of species richness. These lakes assumed additional importance in early spring and late fall because of ice conditions. Murder Lake, which reportedly has some open water all winter, provided some of the first open water for early spring migrants, as did the inlet of Stephan Lake; green-winged teal, mallard, and pintail were using this open water on 3 May 1981. Likewise, these lakes provided the last open water in fall and were used by the late migrants. Swans used these lakes during October as other lakes in the region became ice-covered. Between 9 and 11 trumpeter swans frequented Murder Lake between October 10-18, 1981 (J. Ireland, pers. comm. cited in Kessel et al. 1982); 11 to 22 unidentified swans were on Stephan Lake from October 9-23, 1981, and 120 swans were there on October 10, 1980.

WB 131, near the mouth of the MacLaren River, was another lake consistently supporting high levels of waterfowl abundance, density, and species richness. Its I.V. in spring was lessened by the fact that it was still frozen during the first two spring surveys. Because it was far from the proposed construction sites, it was not censused for breeding birds, but a flight over the lake on 4 August 1981 revealed a flock of some 100 molting ducks, mostly scaup, as well as a pair of trumpeter swans. This and WB134 were the only duck-molting lakes found in the basin. A flock of 22 to 42 trumpeter swans congregated to feed on this lake throughout the first half of September 1980.

WB 140, east of the Oshetna River, had the highest I.V. of 28 water bodies censused during the breeding season. Not only did it have a high species richness (11 species), but it also supported a large number of birds and an above average density. It was also of above average importance during migration, even though it thawed later and froze earlier than most other lakes.

Clarence Lake had the fourth highest I.V. during spring and fall migration, but was less important during the summer. It had a relatively high species richness at all seasons, being used by both diving and dabbling ducks during migration, but primarily by divers in summer.

Watana Lake was used in fall, especially in 1980, by migrant scaup, goldeneyes, and mergansers during the last half of September. Otherwise it was of little importance to birds.

Pistol Lake in the lower Deadman Creek area had a relatively high I.V. in spring because of the number and diversity of birds it contained after it began to thaw toward the end of the first week of May. However, this relatively large lake was only of average importance during summer, and was little used in fall.

The southernmost Fog Lake supported high levels of abundance and species richness at all seasons. It received less use in spring than at other seasons, probably because ice cover was still extensive as late as May 17, 1981. On this date, ducks were heavily concentrated in the open water at the inlet end of the lake. This lake and WB 140 had the highest species richness (11 species) during summer.

WB 032, a small lake at the west end of the Fog Lakes, supported a high density of birds in summer and showed high productivity (at least four broods of horned grebe and two of American wigeon seen on July 28, 1981). It was not monitored during migration.

Swimming Bear Lake, an alpine lake, received its primary use during summer. After it thawed in late May, it was occupied by at least five species of waterbirds (scaup, oldsquaw, scoter, mew gull, and arctic tern), three of which were observed with broods on July 29, 1981. Flocks of scaup and white-winged scoters were seen on the lake during the last half of September 1981.

None of the water bodies in the upper basin had importance values as high as those calculated for some of the better wetland sites of eastern interior Alaska from data obtained during fall 1980 by Ritchie and Hawkings (1981) (Figure W19) and during spring 1980 by Ritchie (1980) (Figure W20).

(iii) Other Birds

- Shorebirds

Seven of the 19 species of shorebirds that occur in the upper basin are transients that occur only during migration (Appendix EF). An additional six species nest in alpine tundra habitats that will be little affected by the Susitna development. Ths six species that will be most affected (semi-palmated plover, common snipe, upland sandpiper, spotted sandpiper, solitary sandpiper, and greater yellowlegs) nest on alluvial bars along the river edge or in lower elevation woodlands and meadows. No shorebirds overwinter in the Susitna region.

Seven species of shorebirds were seen along the lower Susitna River during spring air and ground surveys (Appendix EF). Spotted sandpipers were common breeders along shores of the main river as well as along its sloughs and feeder creeks; solitary sandpipers were also fairly common along the river. Semi-palmated plovers were uncommon breeders on alluvia, and greater yellowlegs were uncommon probable breeders along the river. Winnowing common snipe were recorded at various locations. Only one migrant whimbrel was seen on an alluvial island below Talkeetna, and two female red-necked phalaropes were also seen on the river.

- Grouse and Ptarmigan

The spruce grouse and three species of ptarmigan breed and winter in the upper Susitna basin (Appendix EF). All species of ptarmigan breed at higher elevations, and thus little of their breeding habitat will be affected by the impoundments. Spruce grouse nest and winter in coniferous and mixed forests and willow and rock ptarmigan probably move to the lower elevation conifer forests in winter. Spruce grouse were not observed along the lower Susitna River during the spring air and ground surveys, although some probably occur in the area. Small numbers of willow ptarmigan may occur along the lower river in some winters, but ptarmigan are not normally found near the downstream floodplain.

- Owls

Three (great horned owl, hawk owl, boreal owl) of the five species of owls that have been recorded in the upper basin are year-round residents in mixed and coniferous forests (Appendix EF). The short-eared owl, a migrant, occupies open habitats in small numbers in summer and a few may breed in the region. Snowy owls, occasional migrants or winter visitors, are rare in the upper basin and tend to occur only in tundra areas.

Only single records of two species of owls (great horned owl, short-eared owl) were obtained along the lower Susitna River during the spring surveys (Appendix EF). Great horned owls are likely residents and breeders, especially in mature cottonwood stands along the river and sloughs.

- Woodpeckers and Passerines

In terms of numbers, woodpeckers and passerines comprise by far the greatest proportion of the birds inhabiting the upper Susitna basin. Fifty-seven species have been recorded and nine (possibly 10) of these are year-round residents (Appendix EF). All of the woodpeckers and a large proportion of the passerines are forest species, but passerines are abundant in all vegetated habitats from closed forest through shrublands to alpine tundra. Breeding densities of these terrestrial species are discussed in more detail below.

A few passerines occur primarily in (or over) aquatic habitats and they are not adequately represented in censuses of terrestrial habitats. These include four species of swallows and the dipper. Bank swallows and cliff swallows nest colonially, the former in cutbanks and the latter in areas of cliffs, and both forage largely over water. Tree swallows and violet-green swallows are not colonial and nest in a variety of habitats; they also forage primarily over rivers and lakes. The dipper is a bird of mountain streams. It forages in the streams and nests along stream banks. Dippers are uncommon in the upper basin, but there are no quantitative estimates of numbers.

Thirty-nine species of woodpeckers and passerines were recorded along the lower Susitna River during the spring surveys. Six, possibly seven, are year-round residents (Appendix EF). Relative abundance of some species are discussed below.

- Upper Basin Bird Communities

Breeding populations of terrestrial birds in the upper basin were studied in 1981 and 1982 by means of plot censuses (Kessel et al. 1982, Kessel, pers. comm.). The average number of territories of each species on the census plots in the two years is shown in Table W67. The data for all species are summarized in Table W68.

Generally, the forest and woodland habitats support higher densities and/or biomasses of birds than the shrub communities. Highest densities found in forests were at a cottonwood forest plot near Sherman, which supported an average of 43.0 bird territories/10 ha. The lowest densities in forest habitats were in the white spruce forest plot at the mouth of Kosina Creek (16.9 territories/10 ha). Of the shrub habitats, low-mixed shrub had the highest densities (35.4 territories/10 ha) and mat and cushion tundra the lowest (11.5 territories/10 ha). Although alpine tundra areas including upland cliffs and block-fields and mat and cushion tundra had the lowest bird usage, these types supported some bird species generally not found in other habitats, such as white-tailed ptarmigan, horned lark, wheatear, water pipit, gray-crowned rosy finch, and snow bunting.

The pattern of habitat occupancy in the upper basin shows many similarities to patterns found in other areas of interior Alaska and in taiga areas in general. Spruce stands with little or no understory generally support low densities of breeding birds whereas mixed forest, scattered woodlands and deciduous forests generally support intermediate to high densities of birds (Gillespie 1960, Carbyn 1971, Spindler and Kessel 1980, McLaren and McLaren 1981).

In many areas tall shrub habitats support very high densities of breeding birds (Ward 1975, Spindler and Kessel 1980, McLaren and McLaren 1981) and the very low density in the Susitna tall alder shrub plot is anomalous. Kessel et al. (1982) believed that the low density was related to the plant species composition. Alder thickets in the Tanana Valley, which support high avian densities, are dominated by willow, thinleaf alder and balsam poplar, which have average to above average levels of primary productivity. The tall shrub thickets of the upper Susitna basin study area were composed almost entirely of _Alnus crispa_, which has relatively low levels of primary productivity (Spindler and Kessel 1980).

Density of breeding birds in most habitats declined substantially between 1981 and 1982 (Table W69). The reasons for this are unknown but could be due to differing weather conditions or differences in availability of insect food. Boreal forest bird populations are known to increase and decrease with spruce budworm cycles (Kendeigh 1947, Erskine 1977) and availability of other insects may also affect population levels.

Bird species diversity can be expressed either in terms of simple species richness or in terms of an index which includes other aspects of the bird community. Table W68 shows both number of species and the Shanon-Weaver diversity index. The latter takes into account both the number of species present and the proportion of the total community represented by each species (evenness).

Species diversity may be quite heterogeneous even in different samples within the same overall habitat type (see, for example, white spruce-paper birch forest plots I and II and also Spindler and Kessel 1980). This variability is presumably due to variation in the structure, density and possibly species composition of plants forming the habitat.

Despite the variability in diversity estimates based on relatively small plots, some patterns are apparent. Forest habitats generally have higher diversities than shrub or tundra habitats, whereas shrub habitats generally have higher diversities than tundra habitat. This agrees with the general observation that species diversity increases with the number of layers in the vegetation (MacArthur and MacArthur 1961, Karr and Roth 1971, Willson 1974). There are, however, two anomalies--the relatively high diversities in dwarf black spruce forest (woodland black spruce), which lacks a tree overstory, and high diversities in tall alder shrub stands. Despite the lack of a tree overstory in dwarf black spruce forest, the same general characteristics of a coniferous tree habitat with deciduous shrub understory are present, but side-by-side rather than layered. McLaren and McLaren (1978), working in the eastern Canadian boreal forest, found that dwarf spruce forests with a substantial deciduous shrub component had a high density and a very similar diversity to taller spruce forests with deciduous understory.

The high diversity in tall deciduous shrub habitat also seems to be a general characteristic of boreal shrub communities (cf. McLaren and McLaren 1978, Spindler and Kessel 1980). The reasons for this high diversity are not known, but may be related to the tendency for deciduous shrub communities to occur near water. MacArthur (1964) found that presence of water tended to increase bird species diversity over what would have been expected on the basis of habitat structure alone.

Each habitat type that has been studied in the upper basin supports a moderately distinct bird species association, as indicated by the following list of the four or five most abundant species in each habitat:

- 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; and

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

- Lower Susitna River Floodplain Bird Communities

Information on the relative abundance and habitat use of terrestrial birds in the lower Susitna River floodplain was obtained during a ground survey conducted in June 1982 by the University of Alaska Museum. Abundance was determined by counts of singing birds in each habitat type.

Generally, following ecological tenets, both abundance and species richness increased progressively from the early to late vegetation successional stages (Table W68).

Species composition of the early successional stages was dominated by waterbirds, such as plovers, sandpipers, gulls, and terns. The only regular land bird was the white-crowned sparrow, which was common in the medium-height shrub of the late stages of early succession.

Species composition and abundance in the tall shrub and forest habitats of the lower Susitna River floodplain followed known patterns of habitat selection in central Alaska, except in the cottonwood forests. Several bird species normally associated with tall shrub communities (i.e., gray-cheeked thrush, blackpoll warbler, northern water-thrush and fox sparrow) were found to select nesting territories within riparian cottonwood forests, probably because these forests have a well-developed, tall shrub understory.

A profound effect of silt ground cover on avian abundance was also noted along the lower floodplain. Forest and tall shrub stands with a heavy ground cover of recently-deposited silt were essentially devoid of birdlife. Earlier studies (Spindler and Kessel 1981, Kessel et al. unpubl. data) have suggested that there is little preference by most terrestrial birds for specific taxa of plant ground cover, but apparently some kind of vegetative cover is necessary--undoubtedly because of its role in providing food resources.

(d) Non-Game (small) Mammals

Non-game (small) mammals include shrews, voles, lemmings, deer mice, tree squirrels, ground squirrels, marmots, pikas, snowshoe hares, and porcupines. Small mammals, by the nature of their size and visibility, are not high profile species such as many other groups of wildlife and birds. However, they are important ecological components of most northern ecosystems. Small rodents have been shown to be important in nutrient cycling; soil aeration; dispersal of seeds, mycorhizzae and spores; control of insect pests; and as the primary or secondary prey of many carnivores (Grodzinski and Wunder 1975).

Because most species of small mammals that occur in Alaska are distributed throughout a diverse array of habitats, none of the small mammal species in the Susitna basin will be seriously affected by the project. However, the loss of small mammals in the impoundment and development areas could have an effect on some carnivores (through a reduction in prey availability) and on some plant communities. Consequently, the small mammal studies conducted in the Susitna basin (Kessel et al. 1982) have primarily addressed habitat use and estimation of relative population numbers in different habitats.

Studies of small mammals were restricted to an area ranging 15 km to either side of the Susitna River, extending from near Sherman on the west (approximately 10 km south of Gold Creek) to the Maclaren River on the east. Within this area, 49 trapline transects were established. Sites for the transects were selected to represent as broad a spectrum as possible of the various vegetation types in the region. Details on sampling techniques are provided in Kessel et al. (1982). Information on small mammals was also obtained by opportunistic observations.

(i) Species Composition and Relative Abundance

During the study period, 16 species of small mammals were trapped and/or observed in the upper basin. In addition, there was evidence of two other species occurring in the region: bats (two separate sightings of what were probably the little brown bat), and water shrews (tracks of a small mammal between ice openings on Watana Creek). The diversity of small mammals documented in the upper basin is similar to known distributions in the literature. However, the occurrence of arctic shrews in the study area constitutes a minor range extension; the closest previous record was from Denali National Park (Murie 1962).

The one spring and three fall trapline surveys involved a total of 23,061 trap nights of effort. A total of 950, 2328, and 447 small mammal specimens were captured during 1980, 1981, and 1982, respectively. A total of 1977 microtine rodents (6 species) and 1748 shrews (4 species) were captured. Northern red-backed voles and masked shrews were the two most abundant species of small mammals, together constituting 74 percent of the total captures. A total of 1458 northern red-backed voles and 1289 masked shrews were captured during the 1980-82 studies. Other shrews captured were arctic shrews (303 specimens), dusky shrews (146), and pygmy shrews (10). Captures of microtines included 224 tundra voles, 103 meadow voles, 148 singing voles, 29 brown lemmings, and 15 northern bog lemmings (Table W70).

Capture results illustrate the large population fluctuations that can be observed in small mammals among and within years (Table W70). Number of captures during the spring were consistently lower than the preceding or succeeding fall periods. Fall 1982 capture levels were low for all species except singing voles, brown lemmings, and bog lemmings. Number of captures for these latter three species increased gradually during the study period. Masked shrew captures were particularly low during fall 1982 as compared to the numbers captured during fall 1980 and 1981. The northern red-backed vole was the only species to maintain its relative abundance, and in all sampling periods was the most abundant species.

Six other species of small mammals were not trapped but were observed in the study area: arctic ground squirrel, hoary marmot, collared pika, red squirrel, porcupine, and snowshoe hare. Although no quantitative estimates of abundance were obtained for these species, limited information on distribution was collected and is described below.

The arctic ground squirrel is a numerous and ecologically important mammal of the region. The largest numbers were observed on the drier slopes, knolls, and ridges above treeline; only small numbers were observed at lower elevations. General observations indicate that the Susitna study area supports a relatively high and stable population of ground squirrels, probably comparable to densities reported elsewhere in the state. For example, in the Talkeetna Mountains to the south, Hock and Cottini (1966) removed 27 squirrels in one day from .05 ha (54 squirrels/ha) with little apparent decrease in numbers; the squirrel population in this area remained high throughout four years of study. In the eastern Brooks Range, Bee and Hall (1956) counted 175 ground squirrels along a 1-km ridge, and 70 squirrels on approximately 1.5 ha of hillside nearly (47 squirrels/ha).

Hoary marmots were common residents of the alpine zone. Scattered colonies were found above treeline. None were seen within the proposed impoundment areas. Collared pika are another alpine species, found commonly on talus slopes at higher elevations. No pikas were seen below treeline. Densities of pikas in Denali National Park during 1962 varied from 5/ha in large rock slides, to 25/ha on small, isolated rock piles.

Red squirrels, porcupines, and snowshoe hares were generally confined to the forested areas of the basin. Red squirrels were present in coniferous forests throughout the area, but were most numerous in the mature spruce stands that occur along the larger creeks such as Watana and Tsusena Creeks. Porcupines are uncommon in the study area; a few individuals were sighted during the summer of 1980, and 3 to 4 sets of tracks were seen during the winter of 1980.

Snowshoe hares, a major source of food for predators over much of central Alaska, were generally restricted to areas east of Watana Creek. Localized "pockets" occurred primarily in the vicinities of Jay Creek, Goose Creek, and the lower Oshetna River. Snowshoe hare populations undergo 8 to 12 year cycles of abundance (Keith and Windberg 1978); peak densities may be as high as 38.6 hares/ha whereas densities may drop to as low as 0.12 hares/ha during population lows (Green and Evans 1940). Long-term information on overall hare abundance, provided by several local residents, indicated that the recent low number of hares is a chronic situation and not just a low phase of the population cycle.

(ii) Habitat Use

- Shrews and Voles

Forty-two trapping sites were organized into floristically similar groups using a cluster analysis of frequency counts of 81 plant taxa from the vicinity of the sample sites (Figure W21). The clustered subgroups roughly correspond to the following vegetation types from Viereck and Dyrness (1980): sedge-grass and shrub tundra, sedge-grass and low willow shrub, herbaceous-mixed low shrub meadow, open white spruce forest, woodland spruce, black spruce bog (some low birch shrub sites were included in this group), paper birch-white spruce forest, cottonwood forest, tall alder shrub, and tall grass meadow. The number of captures of each small mammal species relative to these vegetation types is shown in Figure W22.

Shrews and red-backed voles in the upper basin displayed a relatively broad and uniform distribution pattern across the habitat landscape (Figure W22). Masked shrews, the numerically dominant shrew species, occurred at all trapping sites. They were most numerous in deciduous forest (particularly cottonwood), grassland, and tall shrub sites. Arctic shrews occurred at 29 trapline sites, with peaks of abundance on the drier non-forested sites, particularly grassland (at low elevations) and low shrub (above treeline). Dusky shrews were thinly distributed across the vegetation types of the study area. Although dusky shrews were captured at 23 sites, no particular preferences were apparent; however, none were captured in the wettest sites. The few captures of pygmy shrews in cottonwood forest (3 specimens), white spruce forest (1), and grassland (1) during fall 1981 and open spruce forests (5) and cottonwood forest (1) during fall 1980, suggest a restriction of this species to forest habitats. Northern red-backed voles, the dominant microtine of the region, occurred on all but five trapline sites. Northern red-backed voles were moderate to very abundant in most forest and shrub types. The greatest numbers were recorded in open and woodland spruce and cottonwood forest sites. In contrast, herbaceous meadows, particularly wet meadows and paper birch forest, supported low numbers of this species.

In contrast to the more general habitat occupancy patterns of most shrews and red-backed voles, the three Microtus species displayed stronger habitat specificity, as evidenced by their general restriction to open, non-forested sites (Figure W22). Singing voles were captured on only 10 trapline transects. They were most abundant in open low willow-birch shrub on relatively dry soils but were also found in herbaceous tundra, and mat and cushion tundra above treeline. Tundra voles and meadow voles occurred primarily in sedge and grass-forb meadows and bogs. Tundra voles were captured on 22 sites (primarily grass-forb, but also sedge-grass), compared to 10 sites for meadow voles (primarily wet sedge-grass). Small numbers of brown lemmings were captured on 11 sites at or above treeline, usually in wet herbaceous and low shrub situations. Bog lemmings were taken at lower elevations in mesic sedge-grass/low shrub meadow (2 captures), grass meadow (1), and near a seepage in white spruce forest (1).

To summarize the differences in habitat use among the various species of small mammals, a standardized habitat niche breadth measure was calculated for each species captured during fall 1981 (Table W71). The ubiquitous masked shrews and red-backed voles had the broadest habitat niche breadth, followed closely by dusky shews and arctic shrews. Microtus species, particularly singing voles, had the narrowest habitat niche breadths, along with the rare or uncommon pygmy shrews, bog lemmings, and brown lemmings.

Small mammal community structures, especially as they relate to species dominance and habitat breadth, are highly correlated with population levels and species interactions. Because most northern microtine populations undergo extreme fluctuations in density (Krebs and Myers 1974), strict ecological boundaries are difficult to delineate. A small mammal population sampled during the peak phase of a population cycle may occupy a greater range of habitats than during a population low. Interspecific competition for space may also vary with density. For example, Guthrie (1965) found that open herbaceous-dominant habitats left vacant by declining Microtus populations, were quickly colonized and dominated by the northern red-backed vole suggesting that Microtus species were able to exclude northern red-backed voles from some habitats.

Northern bog lemmings and brown lemmings were uncommon members of the small mammal community in the Susitna basin. Bog lemmings are generally uncommon throughout their range, and little is known of their ecological requirements (Banfield 1974, West 1979, MacDonald 1980). In other areas of the state, small numbers have been taken primarily in shrub bogs and marshes (Osgood 1900, Dice 1921, West 1979, MacDonald 1980)--not unlike the few sites where they occurred during this study. Their diet is apparently restricted to sedges, grasses, some forbs (Cowan and Guiguet 1956) and mosses (West 1979).

Although the high country of the upper basin has an apparent abundance of suitable brown lemming habitat, only small, scattered numbers were captured during the 1980-81 study. However, they have been found in fairly large numbers in other montane areas of central Alaska (R. L. Rausch pers. comm.). The low numbers in the Susitna area may be due to a failure to sample the right habitats, or, more likely, to sampling during a period of low population levels. Brown lemmings are usually associated with wet sedge-grass tundra above treeline, but also are found locally at lower elevations in spruce bogs and wet meadows (Buckley and Libby 1957, Banfield 1974). This species is almost completely dependent on a diet of sedges and grasses (Guthrie 1968), although mosses may be important at times (West 1979).

- Other Species

Arctic ground squirrels inhabit herbaceous tundra and open shrub habitats above treeline. At lower elevations they also colonize riverbanks, lakeshores, moraines, eskers, road sidings, and other disturbed sites with subclimax vegetation (Banfield 1974, Kessel et al. 1982). Our observations corroborate Bee and Hall's (1956) conclusion for the Brooks Range that the optimum conditions for ground squirrel colonies are:

. Loose permafrost-free soils on well-drained slopes;
. Vantage points from which the surrounding terrain can be observed; and
. Bare soils surrounded by vegetation that is in an early xerosere stage of succession.

Carl (1962) found that ground squirrels avoided sites where tall vegetation (greater than 20 cm) impaired vision. The effects of squirrel activity--e.g., burrowing, mound building, feeding, feces deposition--within areas of established colonies tends to maintain vegetation at an early successional stage (Carl 1962, Youngman 1975).

During the snow-free months ground squirrels provide an abundant, reliable food source for a number of mammalian and avian predators (Carl 1962, Murie 1962, Bente 1981, Olendorff 1976). At High Lake in 1981 the first ground squirrel emerged from hibernation the third week of April; the latest date in 1981 on which ground squirrels were seen was 4 October (E. Powell, pers. comm.). These emergence and entrance dates are essentially the same as those reported by Hock (1960) and Hock and Cottini (1966) in the Talkeetna Mountains near Anchorage, and by Carl (1962) at Ogotoruk Creek, northwestern Alaska.

Hoary marmots and pikas are generally restricted to tundra/talus habitats at high elevations (Hoffman et al. 1979, Kessel et al. 1982). Both are ecotone species: their homes and shelters are in one habitat (rocks of various size and shape) and their food in another (herbaceous tundra types) (Broadbrooks 1965). Hock and Cottini (1966) suggested that a portion of their marmot population underwent seasonal shifts in altitude, moving down from high rocky slopes in fall to sites having better conditions for winter denning and having an available food supply in early spring. An opposite seasonal movement apparently occurs in some Montana hoary marmot colonies (Barash 1974). The only suggestion of fall movement in the upper basin was the observation of several marmot trails and a single marmot traversing the 1067 m-high valley near Swimming Bear Lake (WB 150) in about 8 cm of snow on 10 October 1980 (T. Hobgood, pers. comm.). Marmots hibernate longer than ground squirrels; in the Talkeetna Mountains near Anchorage, marmots emerge from hibernation during the first third of May and begin entering hibernacula in early September (Hock and Cottini 1966). Pikas are active throughout the year (Sheldon 1930, Broadbooks 1965, Hock and Cottini 1966), and store large quantities of dried plant material in late summer for use during the winter months.

The arboreal red squirrel occupies a variety of forest habitats, but prefers mature coniferous forest (Cowan and Guiguet 1956). White spruce forest is generally considered the optimal habitat in interior Alaska (e.g., Nodler 1973). Red squirrels feed primarily on the seeds of spruce, particularly white spruce, but supplement their diet with fungi, fruits, and even the buds of spruce and aspen (Smith 1967, Nodler 1973). They store large quantities of spruce cones and mushrooms in middens for winter use (Murie 1927, Streubel 1968). Buskirk (pers. comm.) noted that red squirrel middens in the upper basin in fall 1981 appeared to be composed only of mushrooms and spruce buds. A massive cone crop failure caused by an area-wide epidemic of white spruce needle rust (Chrysomyxa ledicola) during 1980 (J. H. McBeath, University of Alaska, Agric. Expt. Station, pers. comm.) may explain why squirrels were storing such low quality food as spruce buds (Smith 1967). Smith (1967) reported a 67 percent drop in a red squirrel population following the second year of a two-year cone crop failure in white spruce forest and suggested that the squirrels had emigrated into surrounding black spruce stands. Repeated cone crop failures could have similar effects on red squirrels in the upper basin.

Porcupines occupy a broad range of forest and shrub habitats (Woods 1973). In mountainous regions they prefer heavily wooded forests during the winter (Hock and Cottini 1966, Harder 1979), but may occasionally be found above treeline, even during the coldest months (Irving and Krog 1955). Porcupines were only occasionally found in forested areas of the upper basin.

In interior Alaska, Wolff (1977) found that snowshoe hare habitat preference depended on population density; during population lows, hares were restricted to dense black spruce forest and willow-alder thickets, but during highs they used a wider variety of vegetation types, including recently burned areas with minimal cover. He concluded that a patchy environment of recently burned sites with inclusions of unburned spruce was the preferred hare habitat. The chronic scarcity of snowshoe hares in the upper basin is probably related to a scarcity of suitable habitat. Recent burns and riparian shrub thickets are noticeably absent from this area.

4.3 Impacts

(a) Watana Development

(i) Moose

Moose are common in the Susitna River valley and are one of the most important wildlife species that will be affected by the Watana project. Activities associated with the construction of the Watana project will affect moose mostly in areas adjacent to and within the dam and impoundment area. Activities associated with the filling and operational phases will affect moose in both the upper and lower Susitna basins. The construction and operation of the Devil Canyon dam, access routes to the development sites, and transmission lines also will affect moose in the Sustina basin; impacts resulting from these activities are discussed later. Although the Watana project may benefit moose in some areas of the Susitna basin, detrimental effects of the project will likely result in a decline in the number of moose and altered distributions of this species throughout the basin. Because both migratory and resident populations of moose utilize areas in the immediate vicinity of the proposed impoundment area (Ballard et al. 1982.), impacts associated with each phase of the project could influence moose populations in other drainages removed from the Susitna basin.

In this discussion, impacts of the Susitna project on moose will be assessed by determining the extent (temporal and spatial) to which carrying capacity for moose is reduced within the basin, and by the effect on population regulatory mechanisms (Figures ______). The effects of developments that reduce carrying capacity or productivity of moose populations for a long period (i.e., more than 10 years) will be considered as severe impacts. Moderate impacts may either affect a large proportion of the moose population for a short period (less than 5 years) or a smaller proportion of the population for long periods. Minor impacts will include very short term (less than 1 year) effects.

The direct impacts that will most severely affect moose population in the Susitna basin are, in order of decreasing severity, permanent loss of habitat, blockage of traditional migration routes, disturbance by machines and humans, hazards associated with the drawdown zone and alteration of habitat. The major secondary impact of the Watana development will be the provision of access to a previously remote area, and a substantial increase in hunting pressure with subsequent increases in moose mortality.

It is not possible, with currently available information, to reliably estimate the total numbers of moose that will be directly or indirectly affected by the Watana project. Ballard et al. (1982a) estimated that about 2400 moose would have home ranges that overlap an 8 km zone surrounding the impoundment area. This estimate was based on 162 radio- collared moose from an estimated regional population of 4500 (total estimate for the Upper Susitna River Basin). Although this estimate is biased (see Ballard et al. 1982a for a discussion), it does provide a rough estimate of the number of moose that may be affected by the project in the upper basin.

The eventual fate of the estimated 2400 moose having home ranges that overlap the 8 km zone around the Watana and Devil Canyon projects is unknown; some will successfully disperse to other parts of the Susitna basin or to adjacent drainages, some may adapt to disturbances and will remain in the immediate vicinity of the impoundment, and some will die as an indirect or direct result of the development. Current studies will greatly refine this assessment.

- Construction

  Construction of the Watana dam will involve intense construction activities at the actual damsite, establishment of temporary camps and a permanent townsite, removal of forest cover in most parts of the impoundment, and the excavation and transportation of borrow material. The major impacts on moose during construction will be habitat loss or alteration, disturbance, interference with seasonal movements, and mortality associated with construction activities and hunting.

  . Habitat Loss

  Clearing of the impoundment area, townsite, local transportation corridors, and operational areas will result in the permanent loss of some high quality habitat for moose in the upper Susitna basin. Campsites, borrow pits, and construction access roads will temporarily alienate smaller areas of habitat from moose use. There is no question that moose will be affected by this loss of habitat; browse availability will be reduced, wintering range, calving areas and breeding areas will be lost, movements may be altered as a result of behavioral or physical barriers, animals will be more vulnerable to predation and hunting (as a result of the loss of cover), and repeated human and mechanical disturbances may preclude use of some areas by moose. Accidental fires may also temporarily eliminate moose habitat, although in the long term would provide additional areas of high quality browse to moose.

Clearing of the impoundment area will remove a wide range of riparian, deciduous forest, coniferous forest, and muskeg communities which are important to moose during all or part of the year. Although some areas may develop sparse successional growth prior to flooding, inundation will eventually permanently destroy these habitats. The distribution and occurrence of major plant communities in the Watana development area are discussed in Section 3.2(a).

As discussed earlier (Section 4.2(a), (i)), current maps of forest cover types are poor measures of moose habitat quality. Forest cover types are based on the dominant tree species in the forest canopy and do not adequately assess shrub distributions and abundance. As a result, most browse components of moose habitat are not accurately characterized by forest canopy units at this time. Vegetation studies to determine forage quality are planned, but until that information is available, assessments must be based upon the existing information. Moose habitat use (Ballard et al. 1982a) and plant community distributions (McKendrick et al. 1982) were assessed on the basis of forest cover units, and therefore the following assessment utilizes forest cover units to determine the potential effects of habitat loss on moose.

To obtain a crude estimate of the importance of habitat loss to moose in the upper basin, we examined the proportionate losses of forest cover types in relation to their regional availability and the proportionate use of these forest cover types by moose during the spring, summer-fall, and winter periods (Table E.3.W72). Because summaries of moose relocations were provided for all of the upper Susitna basin (i.e., the Watana and Devil Canyon development areas), it was not possible to separately examine the proportionate use of cover types by moose in each of the two areas.

Proportionate losses of major cover types in relation to their availability in the Watana watershed indicate that 62% of the birch forests and 33% of the mixed forest communities will be removed by inundation. About _____% of spruce forest and 5% of birch shrub cover types also will be lost. All of the plant communities lost will be lower elevation areas.

Winter Use - There is a general consensus that moose populations in North America are ultimately limited by the availability and quality of winter range (Coady 1982). High quality winter range of moose is characterized by (1) abundant trees and shrubs that are most preferred by moose as winter browse, (2) consistently low snow depths in relation to surrounding areas, and (3) good interspersion of young seral growth (for foraging) and older aged forest stands (for cover) (LeResche et al. 1974, Peek 1974). The nutritional quality of browse (e.g., amounts of crude protein, fats, and carbohydrates, digestibility, total calories), also is important in determining the quality of winter range (Oldenmeyer 1974). Other factors such as predation, hunting mortality, disease, and weather may reduce moose populations below the carrying capacity of the range (Figure 3.____).

Although the quality and quantity of winter range is likely the limiting determinant for carrying capacity of moose, it is critical to moose survival only during severe winters and may not be a preferred habitat or forage. Winter severity, particularly snow depth, strongly influences the use of winter browse by moose (Coady 1974; LeResche et al. 1974). During mild winters when snow depths are low throughout much of the range, few moose may utilize critical winter ranges. During severe winters, however, deep snows may force high numbers of moose to overwinter in limited areas. The limiting effect of critical winter range may thus only be evident during periods of severe winter conditions.

Although not observed during current moose studies in the upper Susitna basin (Ballard et al. 1982a), earlier studies of moose in the basin (U.S. Fish and wildlife Service 1975, Ballard and Taylor 1980) suggest that during severe winters with heavy snowfall, moose move from upland shrublands to mixed spruce deciduous woodlands at lower elevation. Mild winters with limited snow cover during 1980 and 1981 are thought to have resulted in the use of upland areas by moose in the Susitna Basin and their absence from lower elevation sites. A census of the Watana impoundment on March 25, 1982 (a time when most moose that used the impoundment area in that year would be found there) determined that 260 moose occurred in the Watana impoundment area. The Watana impoundment area includes several large areas of river valley bottomland that are probably critical to moose survival during severe winters. Observations of intense browsing of bottomland shrubs by ungulates (McKendrick et al. 1982) support this suggestion and indicate that browse resources in bottomland areas may presently be at, or near, their carrying capacity.

Because low elevation riparian shrub, deciduous forest, coniferous forest, and muskeg habitats will not be available in areas adjacent to the impoundment, the removal of these habitats by initial clearing activities and later flooding will deprive moose of a large area of high quality winter range. Assuming that bottomland browse resources throughout the upper Susitna basin are presently fully utilized by moose, clearing and flooding of the impoundment will force moose to depend on and likely over-utilize the remaining winter range. Increased mortality can be expected due to starvation and increased predation.

Spring Use - During recent moose studies, many of the radio-tagged animals moved to lower elevation habitats adjacent to the Susitna River during late spring. It is believed that these movements are related to the earlier snowmelt and emergence of new plant growth in low elevation sites (Ballard et al. 1982). Because moose typically have a negative energy balance during winter and are in poor physiological condition by late spring (Gasaway and Coady 1974), the availability of new plant growth may be critical to survival. During the spring, parturient cow moose commonly used low elevation sites along the upper Susitna valley, presumably to calve. The availability of new plant growth and suitable shrub cover in these low elevation sites is thought to be important to the survival of both the cow and her calf. Bull moose and cow moose without calves also utilize the low elevation habitats during the spring.

Clearing and flooding of bottomland areas would reduce the available area of these lower elevation sites where spring snow melt and plant emergence appears to be more rapid. Because micro-climatic changes resulting from the impoundment are suggested to delay spring greenup by 5-15 days (McKendrick et al. 1982) and because remaining habitats around the impoundment area will be at higher elevations, moose may be deprived of a large area of early spring habitat. This impact would be most severe following winters with deep snowfalls when moose may be highly dependent on the availability of these spring foraging areas.

Clearing of the impoundment also will result in the loss of several areas, which on the basis of concentrations of calving moose, may be traditional calving sites. Although it has not been shown that moose use traditional calving areas, as do several other species of ungulate, studies by Markgren (1969) and Stringham (1974) suggest that calving areas may be used repeatedly by individual cows. Predation upon moose calves by brown bears is a major mortality factor of moose during the spring and summer (Ballard et al. 1980), and displacement of parturient cow moose from calving areas may increase the vulnerability of their calves to predation.

Summer and Fall Use - Because most moose in the upper Susitna basin commonly move to upland shrub habitats during summer and fall, loss of bottomland communities will not have serious effects on summer and fall habitat use. However, some moose remain in the valley bottoms throughout the year and would be displaced from their summer and fall range.

Although repeated human and mechanical disturbances could result in an alteration of activity budgets and so reduce the amount of time that is available for growth, survival, and production, a more serious immediate impact is the alienation of some portions of the range as a result of possible avoidance of human activity areas. Prolonged avoidance may result in an effective loss of habitat and animals may concentrate in limited areas of prime range or subsist on marginal range. Either scenario could result in a reduction in carrying capacity and eventual population declines (Sopuck et al. 1979).

Moose appear to be more tolerant of disturbances than most ungulates (Tracy 1977), particularly if disturbances are predictable, neutral stimuli such as moving vehicles (Kucera 1976; Schultz and Bailey 1978). Cow-calf pairs generally respond more strongly than bulls and cows without calves (Tracy 1977). If moose are not directly approached by humans or machines, they appear to tolerate even moderate and high activity levels. For example, repeated aerial surveys of moose in the vicinity of the Revelstoke hydroeletric project in British Columbia over a five-year period that spanned pre-construction and construction phases, indicated that moose numbers had not changed despite frequent blasting and heavy industrial activity (R. Bonar, pers. comm.). Observations of moose, including cows and calves, in close proximity to active oil sands extraction plants in northern Alberta despite frequent mechanical disturbances and blasting, support this observation (J. Green, pers. comm.). However, toleration of such activities by moose appears to occur only in the absence of high levels of human harassment and hunting. Moose can be expected to strongly avoid human activity areas if harassment and hunting commonly occur.

Assuming that the Watana dam construction site and associated facilities are restricted to as small an area as possible and that hunting and harassment is prohibited, moose will probably continue to utilize forested areas near these sites. If hunting is permitted, moose will avoid the major activity centers, resulting in an additional loss of habitat beyond that associated with only the impoundment and construction areas.

Because the clearing of the impoundment will involve noisy and unpredictable disturbances, moose will probably avoid the areas of active clearing. As a result of avoiding these disturbances as well as a lack of cover in cleared sites, moose will gradually concentrate in areas adjacent to the impoundment during the three to four year clearing program. The concentration of moose in these areas will increase intraspecific competition for food and space. In turn, mortality of moose as a result of starvation and predation may increase, natality may decrease, and carrying capacity and population productivity will gradually decline.

Aircraft enroute to or from the Watana airstrip may cause minor disturbances to moose. In general, most aircraft are expected to maintain high altitudes except during landing and take-off, and will not be a major disturbance stimuli. Frequent, low-altitude flights by fixed-wing aircraft or helicopters may elicit panic responses in moose. Because the intensity of reactions to aircraft by ungulates is influenced by such factors as the time of year, distance of the aircraft from the animals, group size, sex and age composition, type of aircraft, activity of the animals, and the type of terrain (Sopuck et al. 1979), it is difficult to generalize potential impacts on moose of repeated aircraft disturbance. The use of wooded areas on or in the immediate vicinity of several international airports in Canada, suggests that if moose are not harassed, they do habituate to even low altitude and frequent overflights of aircraft (Green 1981).

. Interference With Seasonal Movements

Watana impoundment may interfere with river crossings and seasonal movements of moose in the upper basin. Clearing of the impoundment area will not physically obstruct movements but may interfere with these movements as a result of moose avoiding active clearing operations or the expansive clear-cut areas. Increased visual exposure to predators and hunters may inhibit moose from crossing these cleared areas. Several studies have documented avoidance of large clear-cut areas by moose (Hamilton and Drysdale 1975; Parker and Morton 1978; Tomm 1978); in general, moose appear reluctant to enter areas where they would be far (i.e., more than 150-200 m) from forest cover. Following filling, the Watana impoundment will constitute a greater obstacle to seasonal movements of moose than did the river. A more detailed discussion of the effects of the Watana development on seasonal movements is discussed below under Filling and Operation.

. Mortality

Although a few moose may be killed as a result of collisions with vehicles or other accidents associated with construction activities, the effect of these mortalities on moose populations will be negligible. The most serious mortality factor associated with the construction of the Watana Dam probably would be the increase in hunting associated with the influx of people into a previously remote area. Effects of increased hunting on moose are described more fully in Section 4.3 (c), (i).

. Alteration of Habitat

Alteration of habitat arising from construction activities will be minimal. Some alterations may actually benefit moose but the size of these areas will be insignificant in relation to the overall size of the project. Successional growth of herbs and shrubs in temporarily cleared areas such as borrow pits, construction roads, and campsites will provide some additional new forage for moose, assuming that moose return to these areas. More forage may be available for a short period in the cleared impoundment area following clearing and before filling.

- Filling and Operation

During the filling and operations phases of the Watana development, the major impacts to moose will be permanent loss of habitat, alteration of habitats upstream and downstream of the damsite, blockage of movements, disturbance, and increased accidents and hunting mortality.

. Permanent Loss of Habitat

As flooding of the impoundment area proceeds, a variety of bottomland and low elevation habitats along the Susitna River will be permanently lost. As already discussed for the construction phase of the project, clearing of the impoundment area will result in a substantial reduction of the value of these areas to moose. By the time these areas are flooded, few or no moose may be utilizing these areas. However, the impoundment will prevent any successional growth from becoming established and will permanently alienate the area from moose use. The consequences of the loss of these low elevation areas has already been discussed.

As a result of the habitat loss, moose will be forced into adjacent areas. Although it has not been possible to determine the distance moose will disperse from the impoundment area, it is clear that densities in adjacent ares will increase rapidly during the clearing and filling of the impoundment. Hunting guides in the vicinity of the W.A.C. Bennett dam in northern British Columbia reported an increase harvest of moose in areas near the impoundment for a few years following flooding (K. Child, pers. comm.). Increased moose densities could result in a decline in habitat quality in adjacent areas. Information on browse utilization and availability is now being analyzed for the upper Susitna study area. If over-utilization of food resources, particularly winter browse (generally conceded to be a major limiting factor in moose populations) occurs, increased mortality and decreased productivity can be anticipated.

During the operation of the Watana dam, a maximum drawdown of 29 m will create an unvegetated shoreline zone that in the Watana Creek area may be over 1 km wide. The area will be covered during the late spring to early summer, and will be exposed gradually during the late summer, fall, and winter periods. Although a few herbs and forbs may become established during early summer, most of the area will remain a bare mud slope.

Fine material will gradually move downslope so that much of the upper drawdown zone will eventually be composed of coarser material. Except during crossings of the reservoir, it is unlikely that moose will utilize the drawdown area. Hazards of the drawdown area to moose movements are discussed below.

- Alteration of Habitats

The Watana Project will result in the alteration of plant communities in both the upstream and downstream Susitna basins (Section 3.3 (a)). These alterations will affect moose use of existing habitats and may have some effects on the long-term productivity of populations.

Upper Susitna Basin - Based on analyses of home ranges and seasonal movements (Ballard et al. 1982a), moose commonly utilize lower elevation habitats in close proximity to the future impoundments. Vegetation in the areas immediately adjacent to the impoundment may be altered as a result of several mechanisms such as minor changes in seasonal temperatures, wind direction and speed, and ice fog preventing direct sunlight from reaching the ground (see Section 3.3 (a)).

If the proposed reservoirs decrease either spring daytime temperatures (Baxter and Glaude 1980) or insolation, the spring green-up period may be delayed. This phenomenon is complicated by the fact that some plants use photoperiod rather than temperature to trigger early spring growth (see Section 3.3). Parturient cow moose, as well as male and young moose, were observed to move down to lower elevation areas of the Susitna River during the early spring, presumably to utilize the early emerging vegetation. Assuming that the timing of the spring green-up is important to the condition of parturient cows and the survival of their calves, any delay in green-up may reduce the survival of calves. If moose are forced to utilize higher elevation areas where green-up is later (in comparison to low elevation sites), a reservoir-mediated delay in green-up would further aggravate problems of nutritional stress during the spring period.

Erosion of the impoundment shore will likely occur during the period of maximum fill until the new banks become stabilized. In particular, permafrost slumping along the south shore of the impoundment may eliminate large areas of habitat along the shore. Areas of successional vegetation, favorable to moose, may develop on these areas along the shores of the reservoir.

Lower Susitna Basin - Changes in the flow regime will alter the availability and local distribution of important moose habitat in the lower Susitna basin. The hydrological changes will vary considerably along the lower reaches of the Susitna River due to the diluting effect of tributaries as well as changing channel morphology (see Section 3.3 (a)). Differences between pre- and post-project flow regimes will be greatest upstream of Talkeetna, whereas downstream of the Yentna River confluence, few changes are expected in channel morphology, frequency of flooding, or vegetational succession. Post-project river stage downstream of Talkeetna will be less than lower than natural conditions (see Section 3.2).

Any changes in vegetation resulting from the project are expected to have either a positive effect, or no effect, on the moose population between Devil Canyon and Talkeetna during the license period. Much of this river reach is bordered by steep side slopes with only small quantities of moose browse. Newly-exposed areas immediately adjacent to the river channel will usually have a gravel or cobble substrate. Vegetation development will still be in the mid-successional stages favored by moose by the end of the license period.

The extent of early successional areas created by ice scouring in the Devil Canyon-Talkeetna reaches of the river may be reduced slightly as a result of reduced spring flows, but because ice production in Devil Canyon is expected to continue near existing levels until the Devil Canyon dam is constructed, ice-scouring of the river banks will continue.

Female moose in the area north of Talkeetna appeared to move to and use riparian habitats and river islands during the calving period (Modafferi 1982). Islands appeared to be particularly good calving areas, perhaps as a result of lower numbers of predators (Stringham 1974). Lower flows in the Susitna River resulting from the Watana project likely will result in a redistribution of riparian and island habitats, rather than substantially altering their composition or abundance. Lowered river flows will probably result in early successional vegetation becoming established on the newly-exposed portions of the bank and a gradual succession to climax vegetation in existing riparian stands. Most river islands will expand in size, thus providing more calving areas. If any islands become connected to the river banks, their value as calving areas may decrease.

It is anticipated that the frequency of bankfull floods in the lower reaches of the Susitna between Talkeetna and Cook Inlet will decrease from one flood in two years to one flood every 5-10 years (Bredthanuer and Drager 1982). This will permit riparian communities to become established in more frequently-scoured areas and may result in a net increase in riparian habitats. Because flooding will continue, albeit at a less frequent interval, renewal of riparian areas in the Talkeetna-Cook Inlet reaches of the Susitna River is not expected to change.

Some icing of vegetation is expected to occur wherever open water persists, such as in the reach immediately downstream of the Watana dam. It is not known how far back from the river that icing will occur; local air temperature, wind direction and speed, length of open water and other environmental factors will determine the extent of the icing effect. At the Peace Canyon Dam icing has been limited to the canyon immediately adjacent to the open water (R. Movold pers comm.) Although icing of vegetation may reduce the availability of winter browse to moose, and could influence plant abundance and species composition over a long period, it is unlikely that the area of shrub communities that may be affected will be of sufficient size to substantially affect the availability of winter range for moose.

. Blockage of Movements

Information on seasonal movements of moose in the upper basin identified several sites along the river where moose crossings tended to be concentrated, Ballard et al. (1982a). Depending on the time of year, moose attempting to cross the impoundment would encounter open water or uncertain ice conditions. Because all of the recorded moose crossings of the Susitna River during 1980-81 occurred during May to November, moose will most commonly encounter open water conditions. In addition, these animals would have to descend over mud flats or ice blocks within the drawdown area. Percentage slopes of the drawdown area in the Watana impoundment will range from less than 5 percent to as high as 115 percent (Hanscom and Osterkamp 1980). As a result of both the physical and visual barrier effects of the impoundment, it is likely that some moose movement will be blocked by or the impoundment.

Moose in British Columbia do not seem to cross the open river area below dams in winter (Harper, pers. comm.). The stretch of open river between Watana and Devil Canyon during winter will interfere with moose crossings during that season.

Moose in Alaska are adapted to and are dependent on seral habitats for at least a portion of their seasonal range (LeResche et al. 1974). With the exception of riparian zones, which are seral communities with predictable locations, most successional communities are products of random events such as forest fires, slides or storms. To utilize new successional areas, moose must maintain some degree of flexibility in their seasonal and regional movement patterns. If seasonal movements of moose is blocked or altered by the project, it is not known whether these changes will have major detrimental effects on the local or regional moose populations. It is possible then that surviving moose in the vicinity of the impoundment will alter seasonal movements and crossings to maximize use of the remaining browse and forage supplies.

Blockage of seasonal movements, particularly to winter ranges or to calving areas, could severely affect moose populations if no alternative ranges are were available. Moose distributions during 1980 suggested that relatively high concentrations of moose overwintered on both sides of the proposed impoundment. Locations of moose during the calving period similarly suggested that although moose were located more often to the north of the impoundment, animals probably calved on both sides of the impoundment. Relocations of moose during 1981-82 suggest that although some moose cross the Susitna River to winter or calve, suitable habitat for calving and wintering are available on both sides of the valley. Moose have been known to starve to death in a traditional foraging area, even though adequate habitat occur nearby (Ballard, pers. comm.).

Additional information on the availability of critical winter range and calving habitats following flooding is being obtained to more accurately assess the impacts of interference with seasonal movements.

. Disturbance

Mechanical and human disturbance should decline in the impoundment and construction areas once the Watana dam is operational. Although it is not known to what extent the region will be used for recreational activities, increased access will increase levels of disturbance through at a level lower than during construction. If animals are not directly harassed, disturbances during the filling and operation stages, with the exception of hunting, will at most have a slight effect on moose distributions.

. Mortality

During the filling and operational phases of the Watana project, hunting mortality of moose may be much greater than current levels. Construction workers may hunt, and improved access will permit hunters to reach many more areas within the Susitna basin. Hunting pressure will likely increase rapidly during the first five to ten years of the project and increased kills of moose are expected. Hunting may help to remove displaced animals from the remaining range (assuming adjacent areas are over-utilized as a result of moose dispersal from the impoundment area).

Some mortality of moose may result from animals being injured on ice shelves, falling through the ice after the water level has been drawn down (Harper, pers. comm.), or from animals becoming mired in the drawdown area. Moose have also become trapped and drowned in floating debris within impoundments (K. Child, pers. comm.). The number of moose accidently killed as a result of the filling or operation of the Watana project will likely be small and the effect on the population will be minimal. However, highway or railroad kills associated with the project may be substantial (see below).

- Quantification of Project Effects

The loss or alteration of moose habitat in the upper basin during both winter and summer has been identified as the major impact of the project on moose. The population-based studies conducted to date indicate the magnitude of use of areas by the existing populations during the study, but do not allow a quantitative assessment of the potential of the habitat to support moose under varying environmental conditions. To estimate moose carrying capacity in the Susitna project area, a moose bio- energetics model is being developed. This habitat-based assessment, in combination with the population-based assessment currently underway, should provide a strong basis for impact prediction and mitigation planning.

Carrying capacity models based upon the nutrient requirements of the animal and the capacity of the range to supply these necessary nutrients have recently been developed (Moen 1973, Wallmo et al. 1977, Mautz 1978). The nutritional interfaces between the animal and range are forage selection, ingestion and digestion. Forage quality can be assured by measuring available nitrogen and energy. Other nutritional entities are requisite to the health of wild ungulates, but they are seldom the limiting factor. A simulation model of ruminant energy and nitrogen balance developed by D. M. Swift (1981) has been adapted to moose (Regelin et al. 1981, Schwartz et al. 1981). This model predicts rates of daily forage intake and changes in body weight and composition of an individual moose based upon the composition and quality of ingested forage. The basic research necessary to adapt the model to moose was conducted at the Moose Research Center near Soldotna, Alaska, during the past five years. Required information to adapt the model to moose included moose energy and protein requirements, digestive capacity, reumen turnover time, rate of passage, and partitioning of energy from gross energy intake to net energy available for production (Regelin, pers. comm.).

Specific information on the range nutrient supply must be collected from each area where carrying capacity is to be predicted. The data needs are the amount of available forage, quality of the forage and food habits of moose. The data are first used in the ruminant sub-model to predict daily intake rates. A separate model (Hobbs 1982) then estimates the potential carrying capacity of the area. The total amount of digestible energy and crude protein available to moose is calculated. The carrying capacity is determined by dividing the daily requirements for digestible energy and crude protein into the total amount available. Separate estimates are made, based upon crude protein and digestible energy. Carrying capacity can be expressed as the number of moose days of use or the number of moose. Carrying capacity can be predicted for summer or winter periods.

The ruminant sub-model has been adapted to moose and produces realistic outputs; however, the model has not been validated under field conditions. There are currently plans to validate the model using moose within four 1 mi^2 pens at the Kenai Moose Range. Potential carrying capacity will be predicted in each enclosure, and each will be stocked with moose at different densities. The moose will be weighed periodically to determine if the sub- model correctly predicts changes in the body weight.

Specific data needed to quantify the carrying capacity of moose within the "impact zone" of the Susitna Dam project are listed below (Regelin, pers. comm.):

- Detailed vegetation maps of the area within 8 km of the Watana impoundment area. The areal extent of each vegetation type must be calculated and the spatial distribution of each type must be determined.

- Standing crop biomass of moose forage within each vegetation type must be determined through appropriate sampling methods.

- Food habits of moose during October, February, May, and July need to be determined. Fresh fecal pellets should be collected at each season and analyzed by the micro-histological technique to determine food habits.

- Seasonal nutritional quality of moose forge needs to be measured. Important forage species (4-6 species) should be collected during October 1982, May and July 1983. Only plant parts eaten should be collected from several locations within the area. Samples should be ground in a Wiley mill and analyzed for N content and in vitro digestibility. Moose rumen fluid should be utilized in the in vitro digestion process.

- Average daily temperature and wind speed at or near the damsite should be collected.

\- Watana: Summary of Impacts

The construction and operation of the Watana dam will have severe impacts on moose populations in the upper Susitna basin. Based on the number of moose affected and the duration of the impact, the major impacts o the Watana development are, i3n order of decreasing severity, loss of critical habitats by clearing and inundation, blockage of movements, disturbance, accidental mortality, alteration of habitat, and increased hunting mortality.

Clearing and inundation will permanently destroy large areas of habitat that are regionally important as winter range, calving areas, and breeding areas. Although moose may not be directly killed by these impacts, dispersal of moose from the impoundment area will result in increased moose densities in surrounding areas and an increased potential for over-utilization of browse and intra-specific competition for space. In turn, these effects will probably result in increased mortality associated with nutritional stress and predation, decreased natality, and, hence, lowered productivity.

Blockage of movements may have moderate to severe impact on moose if alternative areas for wintering, calving and breeding are not readily available for migratory subpopulations of moose that cross the Susitna River. The combined effects of hunting, disturbance and accidental mortality may aggravate the effects of interference with movements.

Disturbances and accidental mortality may affect a small number of moose throughout the duration of the project. The effects of these impacts on population productivity or carrying capacity will be minimal, if at all detectable.

Alteration of habitat may adversely affect moose in some areas of the upper basin if green-up, snow-melt, and habitat composition is altered greatly by the impoundment. In contrast, moose downstream may benefit from an increase in the extent of riparian habitats during the license period.

Increased public access to the construction area will result in increased hunting pressure and increased hunter mortality. In addition, disturbance/harassment of moose by hunters will result in avoidance of more accessible areas, effectively resulting in an additional loss of habitat to that discussed above. Hunting pressure is anticipated to persist indefinitely in the area unless prohibited by government regulations or area closures. However, because hunting mortality can be easily regulated, this will not necessarily be a major impact.

(ii) Caribou

- Construction

Construction activities in the immediate vicinity of the Watana Dam are unlikely to greatly affect caribou of the Nelchina herd.

The construction site will remove only a small portion of infrequently used habitat. Although some caribou may encounter and avoid areas of intensive human activity, this should not result in any population effects. Proposed borrow sites also cover a relatively small proportion of infrequently-used caribou habitat and are temporary facilities. Borrow areas A, D, and F are more likely to be frequented by caribou than are the other potential borrow areas. Most use of these areas is attributable to summer use by bulls, and it is unlikely that the cow/calf segment of the Nelchina herd will come close to the borrow areas during annual movements. Although bull caribou appear to be less sensitive to human activity and disturbance than other portions of the herd, they may still avoid the areas during active mining to a limited extent. As a result, the borrow areas will represent an inconsequential loss of summer bull habitat. Caribou may avoid the construction camps and permanent villages, but again these areas remove a relatively small area of infrequently-used habitat. Aircraft traffic will increase considerably in the upper basin as a result of the project. The degree of response of caribou to aircraft disturbance depends on many factors including aircraft type, altitude and horizontal distance from the animals, season, group size and composition, previous activity, herd experience and habitat type. There is some evidence that aircraft disturbance could result directly in the death of young animals (DeVos 1960, Miller and Broughton 1973); however, no unequivocal evidence of this for wild animals is available, and except for intentional harassment of animals by aircraft or low- altitude flights causing groups of animals to stampede, the main concern of aircraft harassment is related to its energetic effects. Caribou and other large mammals often react to a low-flying aircraft by running. The energetic cost of running in caribou can be 8 to 20 times the basal metabolism (Geist 1975), and there is some evidence that the energy costs to animals that show no overt response at all to disturbance are nevertheless increased (e.g., MacArthur et al. 1979).

Most studies have found that fixed-wing aircraft are less disturbing than helicopters, other factors being equal (Klein 1974, McCourt et al. 1974, Surrendi and DeBock 1976, Fischer et al. 1977, Miller and Gunn 1979) although horizontal and vertical (altitude) distance have not always been distinguished. Shank (1979) generalized results of all these studies and suggested that response levels decreased rapidly with increasing distance from the aircraft up to distances of about 80 m. Beyond 80 m, response levels decreased more slowly and there was great variability in the level of response at particular altitudes. The results of both Fischer et al. (1977) and Miller and Gunn (1979) suggest that response levels decrease with increasing horizontal distance in a much more regular manner than the decrease in response with decreasing vertical distance.

From the various studies that have been conducted on large mammals, and by extrapolating from the domestic reindeer literature (Zhigunov 1968, Klein 1971), it is evident that very high levels of disturbance from low-flying aircraft could effect the productivity of caribou; however, if pilots maintain an altitude of at least 300 m agl whenever possible (600 m agl over the calving grounds during April-July), there is little evidence to suggest that caribou would be seriously effected by aircraft associated with project construction and operation.

- Filling and Operation

Information collected on the movements of the Nelchina caribou herd since 1947 indicate that the proposed Watana impoundment would intersect a major caribou migration route. This has led to concerns that the impoundment and other project facilities might serve as barriers to caribou movements, cause a decrease in use of portions of the range, increase the mortality rate, and tend to isolate one or more subherds having separate calving grounds.

However, large movements of caribou across either of the proposed impoundments areas have occurred only once since 1973 (Skoog 1968, Pitcher 1982). Hemming (1971) reported that as the herd increased in size between 1947 and 1962, shifts in range use and seasonal splitting both increased in frequency and the herd expanded its range. Conversely, as numbers decreased after 1962, the area occupied by the herd contracted toward the traditional calving area in the Talkeetna Mountains.

It thus appears that there is a close relationship between herd size and the potential for adverse impacts due to the Susitna hydroelectric project. If the herd were allowed to increase to 40,000 or more caribou, we would again expect large movements of caribou across the Watana impoundment and Denali to Watana access road. However, major movements across these facilities are not expected under the current Nelchina caribou management plan (ADF&G 1976), which includes a management guideline to harvest the annual increment after the herd reaches 20,000 adult caribou. This discussion assumes that herd numbers will remain near 20,000 during the license period in concordance with the State's herd management plan. It must be recognized, however, that a reassessment of the potential impacts of the Susitna hydroelectric project on the herd may be necessary if a management plan calling for a much larger herd size is adopted in the future.

The area to be flooded by both the Watana and Devil Canyon impoundments represents much less than one percent of the Nelchina herd's range (Pitcher 1982). Skoog (1968) considered the upper Susitna bottomland to be low quality grazing habitat, but noted its importance to migrating animals at several times of the year. The loss of caribou habitat as a result of inundation will therefore not be of major consequence to the herd, and by itself should not cause any change in herd size, productivity, or distribution patterns.

The Devil Canyon impoundment would occur in an area which has received little caribou use and would probably be of minor significance to the Nelchina caribou herd (Pitcher 1982). In contrast, the potential for the Watana reservoir to interfere with the migration of caribou between portions of the herd's range and increase mortality during migration as a result of hazards created by the impoundment, is of much greater concern. Although the large movements of caribou recorded in the past across the proposed Watana impoundment area have not occurred in recent years, the area is still used by many caribou as a travel route. Nine crossings of the proposed impoundment by six radio-collared caribou were documented during studies in 1980 and 1981, and other caribou apparently walked along the river ice between the Tyone and Oshetna Rivers area to Kosina Creek and Watana Lake, where they then moved into the Talkeetna Mountain foothills.

Crossings of the impoundment in 1980 and 1981 occurred mostly between April 10 and May 31, and between August 1 and September 30 (Pitcher 1982). About 10% of the main herd crossed the river during October 1982 (Pitcher, pers. comm.).

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 29 m (95 ft) lower than when it is full in October. The gradual winter drawdown will result in the formation of ice blocks grounded on the shore. Where the slopes of the shoreline are gradual, such as along the Watana Creek drainage, the blocks will be wide and flat and more easily traversed. Where the banks are steeper, the ice 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. It is possible that some caribou may be killed or seriously injured when crossings.

During the ice-covered reservoir period, the prevailing northeast winds will tend to sweep the reservoir clear of snow or at least will maintain a smooth flat surface. Drifting snow is thus expected to accumulate near the southwest end of the reservoir. Since the reservoir will be lowered throughout the winter, it is likely that any large drifts will remain within the reservoir area, although there will undoubtedly be some increased drifting in vegetated areas adjacent to the reservoir as well. This drifting may mask any ice shelving effects along the south bank of the reservoir near the dam, but the resulting deep snows may act as a physical barrier to caribou movements in this area if they are not wind packed.

Logs and other debris in the impoundment may present an additional hazard to caribou crossing. Williston Lake, formed by the W.A.C. Bennett Dam in northern British Columbia, presently has debris rafts covering several square miles, and the combination of logs, wide mud flats and ice shelves presents a formidable obstacle to animal crossing the reservoir. On one occasion a group of 5 caribou crossing the reservoir in mid-July got caught in some logs and all of the animals drowned (R. Bonar, pers. comm.). A program of log removal has been implemented at that project. Similar problems with debris rafts can be expected to occur on the Watana Reservoir. It is predicted that ice blocks will not melt until late June (Bredthauer and Drage 1982:5-7). Caribou may traverse more easily through standard ice than exposed mud flats.

It is not clear how caribou will respond to the changed environment which the impoundment will create. The severity of the obstacle caused by the shore ice conditions, mud flats, and log debris will vary depending on the stage of breakup and the point at which the caribou reach the impoundment. Although it is not possible to predict exactly how caribou will respond to the Watana impoundment, the possible reactions of the Nelchina herd to the impoundment have been placed in the following order based on responses of caribou to rivers and lakes in other areas (starting with the most likely reaction and proceeding to the least likely reaction; Banfield, pers. comm.; Roseneau, pers. comm.):

. The caribou will manage to cross the impoundment safely in the Watana and Kosina creek areas.

. The caribou will travel eastward and cross the Susitna River in the vicinity of the Oshetna and Tyone rivers on ice-covered flats.

. The caribou will make hazardous crossings with increased mortality.

. The caribou will refuse to cross the impoundment and reverse direction.

The Watana impoundment should not cause any substantial caribou mortality during the summer and fall open-water period, but it may greatly influence the movements of some caribou during that time. Caribou are excellent swimmers, but large lakes and swift rivers can change the direction or timing of movements. Skoog (1968) reported that "even though caribou are excellent swimmers and generally take readily to the water, frequently I have noted how a movement will change direction upon encountering a large lake or river and will parallel the waterway rather than cross it." Banfield and Jakimchuk (1980 in Pitcher 1982) state that "caribou prefer to avoid open water," and that large lakes are often crossed at narrow points or where islands provide interim stopping points. It thus seems likely that caribou approaching the reservoir in the Watana Creek vicinity, for example, might parallel the shore to an area where the impoundment is narrower.

(iii) Dall Sheep

- Construction

The three Dall sheep populations identified in the Susitna basin are most likely to be affected by the project through disturbance (i.e., aircraft traffic, construction noise, presence of workers), increased access by hunters, and habitat loss. Each of the populations will be affected to a different degree as a result of their distribution in relation to project facilities.

The Mount Watana population does not occur near the impoundments, access roads, or borrow areas at any time of the year, and is likely to be affected only be low-flying aircraft crossing between the Susitna and Talkeetna river drainages. Disturbance from low-flying aircraft is also of concern with the Portage-Tsusena Creek population; however, an additional consideration to be discussed is the close proximity of borrow area C on upper Tsusena Creek. The Watana Hills population will be most affected by the project due to the partial inundation of a major mineral lick on Jay Creek used by this population. As will be discussed, the frequent disturbance of sheep at the lick by project personnel and recreationists is expected to have a greater affect on the sheep than will the partial inundation of the lick.

The impact of intensified human activity on Dall sheep populations is not completely understood, but some general predictions can be made. If an animal is excessively aroused, as from human disturbance, the added cost of excitement or activity may interfere with health, growth, and reproductive fitness (Geist 1975). Ewes with lambs are particularly sensitive to disturbances (Smith 1954, Jones et al). Recent studies of free-ranging ungulates have found that the heart rate of an individual is a sensitive indicator of arousal, the first stage of an alarm reaction to stress (Ward et al. 1976, MacArthur et al. 1979, 1982). These and other investigators have demonstrated consistent heart rate responses to disturbing visual or auditory stimuli, often in the absence of overt behavioral reactions. MacArthur et al. (1982) reported on the heart rate response of an unhunted population of mountain sheep (Ovis canadensis) to aircraft and vehicle traffic. No heart rate responses were associated with helicopter or fixed-wing aircraft at distances exceeding 400 m from sheep. They found that direct overflights at 90-250 m by helicopters caused sheep to run for 2-15 seconds and elicited a 2-3.5 x increase in heart rate. In Alaska, six studies have included observations on the response of Dall sheep to aircraft disturbances (Andersen 1971; Linderman 1972; Nichols 1972; Price 1972; Lenarz 1974; Summerfield 1974), although only one of these (Lenarz 1974) presented quantitative data. Helicopters usually evoked a greater response from sheep than did fixed-wing aircraft. This is possibly because helicopters fly slower and closer to the sheep and are generally more noisy (especially "rotor popping") (Andersen 1971; Linderman 1972; Price 1972). No studies have been conducted to determine the responses of mountain sheep to aircraft flying at different altitudes, as have been conducted with caribou and muskoxen. The reaction of Dall sheep to low-flying aircraft is highly variable (Linderman 1972; Price 1972), although Linderman found that sheep always reacted nervously and assumed the alarm posture (Geist 1971b) until the disturbance had passed. Lenarz (1974) found that "ewes" (including young rams not discernible from females) reacted more strongly to helicopters than did rams. Andersen (1971) and Price (1972) found that sheep were more easily disturbed by aircraft when congregated at mineral licks, which are usually located lower on slopes away from escape cover.

The extraction of borrow materials from a possible site (area C) on upper Tsusena Creek could affect the distribution of the Portage-Tsusena Creek sheep population. The distance between the potential borrow site and seasonal ranges used by Dall sheep has not been clearly defined yet, but sheep may avoid areas immediately adjacent to the borrow site during construction. Lent and Summerfield (1973) reported that dynamite blasts 5.6 km away caused Dall sheep to interrupt their activities briefly, but that the intensity of their reactions tended to decrease somewhat with subsequent detonations. However, the situation on upper Tsusena Creek may be similar to that at the Usibelli coal mine near Healy, Alaska, where Dall sheep winter range is immediately adjacent to the mine. Referring to this situation, Heimer (1980) stated:

> "Displacement was probably never a serious problem here for two reasons: First, Dall sheep are so loyal to their traditional ranges that it takes an intense, prolonged disturbance to displace them from an area of traditional use. Second, the area of actual mining activity was on the edge of historic winter range. Sheep were absent during the summer when the most intense disruptive activity occurred. Only occasionally did they use the actual area where coal was being mined during winter."

The Watana Hills Sheep population will be most affected by the project due to the location of a major mineral lick on Jay Creek. The area used by sheep is a steep bluff extending from the creek bottom at 610 m to the rim at 747 m. A ridge on the east side of the creek (692 m elevation) is also used. Approximately 42% of the lick surface area will be inundated each year when the Watana impoundment is at its maximum level (668 m). However, during the months of maximum lick use (May and June), the reservoir level will be approximately 635 m (1 May) and 638 m (1 June), and thus only about 20% of the lick will be under water. Most licks are created and/or maintained by water action along creeks or lakes, and it is unlikely that sheep will discontinue use of the lick because of partial inundation. Any erosion caused by the reservoir will as likely enhance the lick as degrade it. In addition, it would be quite feasible to enlarge the lick using explosives if the loss of part of the mineral area had an effect on sheep use of the lick. Of greater consequence than the decrease in surface area of the lick is the disturbance of sheep using the lick. Frequent visits to the lick (mostly with helicopters) by researchers, other project personnel, and visitors touring the project area has undoubtedly affected the sheep using the lick. The lick is far removed from adequate escape habitat, and these frequent helicopter trips into Jay Creek for purposes of viewing the lick could result in its abandonment if continued. Recreationists accessing the area by boat after the impoundment has filled could have a similar effect.

The consequences to the Watana Hills sheep population if the Jay Creek lick is abandoned for any reason are unclear. Several other mineral licks have been identified within the range of this population, but because sheep have a demonstrated high fidelity to specific licks, it is uncertain whether these alternative licks would replace Jay Creek. Many researchers have conducted chemical analyses of mineral lick soils in an attempt to explain why sheep visit licks, but the results have been conflicting or inconclusive. Contamination of samples from urine, feces, and/or muddy water have been cited as potential sources of error in these analysis. Many studies have found that sodium is relatively abundant in lick soils and is selectively sought by ungulates (see Stockstad et al. 1953 and Tankersley 1981). Plants other than halophytic species absorb only a small percentage of the sodium present in the soil, and it is therefore possible that forage species are unable to supply the quantity of sodium needed by big game (Stockstad et al. 1953). Heimer (1973) found that soil samples from high use sites within a mineral lick contained large quantities of clay minerals called zeolites which contain biologically-available cations of sodium, potassium, calcium and magnesium.

- Filling and Operation

Potential impacts of the Watana development on Dall sheep during this period will be similar to those during construction (see Section 4.3 (a), (j)), except that the borrow areas will not be in use, the level of human activity in the area will be much lower, and partial inundation of the Jay Creek mineral lick will occur near the end of the filling period. Disturbance from aircraft is likely to remain as the most serious impact on the sheep population, particularly if frequent helicopter trips to view the Jay Creek lick are made.

(iv) Brown Bear

- Construction

The construction of the Watana dam could affect brown bears in several ways. The most serious impact will probably be direct mortality of bears resulting from bear/human conflicts at camps, construction sites, and bear concentration areas, and from increased levels of hunting. Movements to and use of seasonally-important foraging habitats may also be interrupted by project activities, but in the duration of the construction period this impact is not likely to affect bear population size and productivity.

Brown bears have one of the lowest reproductive rates of any land mammal in North America (Bunnel and Tait 1978). This, coupled with the low densities of brown bears in most parts of their range, makes them vulnerable to sustained high levels of mortality (Craighead et al. 1974). Typically, causes of direct bear mortalities during construction of projects in their range include killings in 'defense of life and property', control kills of nuisance animals by appointed agency or project personnel (Cole 1971), accidental deaths of bears during attempts to frighten or trap and transplant animals, and increased hunting and poaching pressure resulting from improved access and higher numbers of people (Nagy and Russell 1978, Rogers et al. 1976, JFWAT files). Accidental deaths of bears from blasting or destruction of dens also occur but are less common (JFWAT files).

Human activities related to the Trans-Alaska pipeline project (TAPS) resulted in a minimum of 11 brown bear and 30 black bear deaths (JFWAT files). One of the most serious problems encountered during TAPS construction reresulted from the attraction of bears to areas of human activity. Bears quickly discover and utilize improperly handled food and garbage at camps, worksites or dumps (Barnes and Bray 1967, Craighead and Craighead 1972a, Meagher and Phillips 1980). The effects of bears concentrating at artificial food sources such as dumps are not clearly understood, but there is some evidence that higher cub mortality from predation by adults, and higher disease and parasite loads may result when bears are concentrated (Cole 1971). Brown bears from hunted populations such as that in the Susitna basin are less likely to be attracted to camps and dumps than are those in unhunted populations, but some brown bears can still be expected to frequent these areas.

Human activity in bear habitat poses problems for people and thus for bears. Fatal attacks by bears occasionally occur when artificial food sources attract habituated bears to sites of human activity (Craighead and Craighead 1972a, Hamer 1974, Herrero 1976). Females with cubs, very old bears, and habituated bears pose the most serious threats (McArthur 1969). Besides serious maulings, minor injuries such as bites and scratches frequently result from attempts to feed bears (Eager and Pelton 1980). Extremely serious bear/human conflicts occurred during the TAPS project (JFWAT files).

There are several specific areas and seasons where human/bear conflicts might occur. Areas where bears congregate to feed on salmon in late summer are likely to be attractive to project personnel as fishing sites. Brown bears tend to concentrate near the river to feed on vegetation during early spring, soon after emerging from dens; thus, bear/human encounters near the construction site and borrow areas may be frequent at that time. The proposed camp is likely to be frequented by bears if proper food storage and disposal methods are not implemented. Also, the camp is located in prime berry habitat used by bears in late summer and early fall. The ongoing bear studies will provide the information needed to further identify such bear concentration areas.

Several food sources have been identified which appear to be seasonally important to brown bears in the Susitna basin. These include spawning salmon in July and August at Prairie Creek, early spring herbaceous growth and overwintering berries along the lower slopes near the river bottom, widely-scattered berry patches on the benches above the river, and vegetation along tributaries such as Deadman Creek. Some bears may avoid areas of intensive human activity, thus affecting their movements between these widely-scattered food sources. However, because brown bears range widely and frequent open habitats, it is unlikely that the intensive human activities near the damsite and borrow areas, or the presence of a cleared impoundment area, would prevent bears from reaching food sources outside of the intensively-used construction area.

The greatest impact on food sources during the construction period will occur near the dam site, where facilities and human activities will be concentrated. The availability of early spring foods to brown bears will be reduced both as a result of direct habitat removal near the construction sites, and by alterations of bear movements along the river. It is thought that the riparian areas are most important to bears in early spring, just after they emerge from dens. Snowmelt occurs sooner in these areas (particularly on south-facing slopes), making overwintering berries and green growth available to bears when they have low energy reserves. Moose calving is also concentrated in riparian areas, and brown bears have been shown to be effective predators of both adult and young moose (Ballard et al. 1980).

It is unlikely, however, that the loss of early spring feeding areas near the construction site will affect the population size or productivity of brown bears. Brown bears eat sparingly for several weeks after emerging from dens during a transition stage from hibernation to normal activity (Craighead and Mitchell 1982). As food becomes increasingly available, the bears' food consumption increases. Craighead and Mitchell (1982) reported that bears in Yellowstone Park during April and May continued to utilize body fat stored the previous fall, and that weight gains were not noticeable until late July and August. Moreover, females with cubs remain at high elevations away from the river and affected areas throughout the year (Miller and McAllister 1982). Since lactating females, which have higher energy demands than other bears, seem to prosper without access to the riparian areas, it seems that the loss of riparian areas near the dam site during the construction period could be tolerated by other bears.

Craighead and Mitchell (1982) also reported that although brown bears feeding primarily on green vegetation in spring failed to gain weight, those securing high-protein food such as carcasses, the young of big game species, or garbage maintained or increased their weight. This suggests that a decrease in ungulate populations would have a much greater affect on bear condition in the spring than would a decrease in the availability of green vegetation. If project personnel are not allowed to hunt, the effects of the project on moose during the construction phase are expected to be mostly distributional (as opposed to changes in population size), and few impacts at all on caribou are expected. Thus, it is unlikely that noticeable changes in the number of brown bears as a result of altered spring food availability will occur during the construction period.

Human activity near den sites is another potential impact of the project on brown bears. All dens located to date have been at higher elevations away from the proposed impoundment areas, but several dens have been located in the vicinity of the Watana to Denali access road segment. Brown bears in the project area do not appear to reuse existing dens, and the availability of adequate denning areas does not appear to limit the bear population, abandonment of dens by bears in winter can result from human activity near the den (Craighead and Craighead 1972b,c; Harding 1976) or from disturbance caused by helicopters (Reynolds et al. 1976). Frozen ground would then prevent the bears from digging new dens.

Bears are reported as one of the more sensitive large mammals to aircraft disturbance (Klein 1974, McCourt et al. 1974). The reactions of bears to aircraft have been recorded in several studies (Quimby 1974; Ruttan 1974c; Harding 1976); there is much individual variation in their reactions, probably related in part to previous experience (Linderman 1974, Pearson 1975, Harding and Nagy 1977). Bears seem to react more strongly to helicopters than to fixed-wing aircraft (Quimby 1974, Harding and Nagy 1977). Low-flying aircraft near feeding sites could affect the productivity of brown bears if disturbance is frequent enough.

The impacts of the project on brown bears downstream of the Watana dam will be limited mostly to aircraft disturbance and increased hunting. No measurable changes in the number of moose or other important prey species are expected, although there may be some noticeable shifts in the distribution of prey species away from the construction sites. Fish and mammal populations downstream of the Devil Canyon site would be affected primarily by increased fishing and hunting pressure, and no impact on brown bears should result given the current hunting and fishing regulations and the low densities of brown bears in the area.

- <u>Filling</u>

The impacts of the project on brown bears during the filling period are expected to be similar to those during construction, but should be less severe once construction has ended and the intensity of human activity in the basin decreases. If portions of the impoundment are cleared during this phase, there may be some distributional shifts in the home ranges of both brown bears and important prey species, and a few bear mortalities could result from bear/human conflicts. Flooding of the reservoir will displace bears from spring feeding areas, and the expected movements of some individual moose to higher elevations will affect prey availability. It is unlikely that noticeable effects on the brown bear population will occur during the filling period as a result of these changes in food supplies. There is some potential for increased cub mortality if adult males are displaced to higher elevations where females and cubs occur, since cubs are sometimes killed by male bears. Possible effects of the reservoir and changes in downstream flow will be discussed in the operation section.

- Operation

As described above, the most serious impacts to brown bears during the construction period will probably relate to direct human-caused mortality. Although direct mortality, particularly from increased hunting pressure, will still occur during the operation and maintenance period of the project, the effects of habitat loss and lower moose numbers will likely have a greater effect on brown bears during this period. There is also some potential for the impoundment to interfere with bear movements in the spring.

Hunting pressure on brown bears will probably increase in the upper Susitna basin because of the improved access afforded by the reservoir and access road. Also, many of the workers who helped to construct the dam may return to the area to hunt. This increased hunting pressure will likely result in lower bear densities and a younger age structure in the brown bear population (Miller and McAllister 1982).

The impoundment will affect the brown bear population primarily through changes in the availability of moose, berries and green vegetation (Figure E.3.W24). Although the loss of early spring feeding areas near the damsite during the construction period is not likely to measurably affect the population, the loss resulting from impoundment of the river will probably decrease carrying capacity. Brown bears must build up large fat reserves during the six-month period that they are out of dens to sustain them through the winter and early spring. Overwintering berries appear to be a particularly important food source for some bears during the spring period. Following the 1981 berry crop failure, Miller (pers. comm.) reported that two of the four females expected to have cubs in 1982 did not, suggesting that the poor nutritional condition of females in the fall may have caused a lower productivity the following year. Pelton (1982) reported for black bears that years of poor berry or acorn production can result in delayed first estrus, decreased litter sizes, and increased incidence of barren females. It thus seems that the permanent loss of habitat and early spring foods in the impoundment area will cause a decrease in the carrying capacity of the upper basin for brown bears. Substantial changes in the number of moose available to bears, in combination with the loss of berries and other vegetation in the impoundment zone, would cause an even greater reduction in the carrying capacity of the basin.

The impoundment is not expected to be an obstacle to brown bear movements, except possibly during the spring. Brown bears usually emerge from dens in April, and most have entered new dens by the end of October. Thus, the reservoir will be ice-free during most of the time bears are out of their dens. Brown bears commonly swim large distances in the ocean to offshore islands (e.g., Miller and Ballard 1981; Roseneau, pers. comm.), and the open water in the reservoir should not physically obstruct crossings. The ice on the reservoir is expected to begin melting in early March, and the reservoir should be ice-free by late May to early June (Bredthauer and Drage 1982:5-7). During April and May, bears attempting to cross the reservoir will be confronted with ice shelves and blocks, wide mudflats, and thin and broken ice conditions. There will also be open water conditions near the intake structures and downstream of the dam. It is not known if one or more of these factors might deter bear crossings, but it seems that these spring conditions would be more likely to affect movements than would the open water later in the summer.

The primary effect of the project downstream of the dam would result from increased hunting pressure. Few changes in moose populations or other prey species are expected, and important vegetative food sources will still be available to bears. Although some decreases in spawning salmon may occur, it is not clear if the bear population downstream of the dam would be affected by this change, since many healthy bear populations occur in areas where salmon are not available.

(v) Black Bears

- Construction

The long-term impact of the Watana development on black bears will be much greater than that for brown bears, since the impoundment and other project facilities will remove a large proportion of acceptable black bear habitat in the Watana area. However, habitat loss may not be the most serious impact on black bears during the first few years of the construction period, when attraction to artificial food sources, disturbance of bears at denning and feeding sites, and increased levels of hunting are more likely to have serious effects (see Figure E.3.W25).

Black bears in the vicinity of the proposed Watana impoundment are restricted to a band of conifer forest adjacent to the river. Between Watana Creek and the Tyone and Oshetna rivers area, this band of forest becomes increasingly constricted. The construction site, borrow areas, camp, airport, and other facilities will remove a large proportion of the black bear habitat, thus concentrating the bears into the limited remaining areas. Black bears are more likely to frequent the camp and construction sites than are brown bears, and this will cause problems for both people and bears (see 4.3(a), (iv)). Deliberate feeding of bears by project personnel at construction sites will intensify the problem.

Borrow areas D and F are located in the tablelands and are used by black bears foraging for berries in late summer (Miller and McAllister 1982). Bears will be affected both by the direct removal of this rich food source, and by a greater likelihood of contact with humans, which could lead to some bear mortalities. The other borrow areas are in forested areas used by black bears throughout the year, and the mining of construction materials from these sites will cause a reduction in the availability of denning sites and feeding areas.

Black bears in the Susitna basin typically den at elevations below 3,000 feet, and 9 of the 13 known black bear den sites in the Watana impoundment area will eventually be flooded. Since dens are concentrated near the river where human activity will be greatest, there is also the potential for disturbance to cause den abandonment, or to make some denning areas unacceptable. Many of the dens sites were reused by the same or a different bear, which may indicate a scarcity of acceptable sites. Human activity on the ground and low-flying aircraft can both cause den abandonment. As discussed for brown bear, den abandonment in winter when the ground is frozen may result in a bear's death.

Because black bears will be concentrated near the river, and may have increased movements while searching for food, any increase in hunting pressure during the construction period could have a substantial affect on the population. If black bears do increase their movements away from forested areas, as they do during berry crop failures (Miller and McAlister 1982), there is also a potential for increased mortality due to encounters with brown bears.

- Filling and Operation

Black bears would be impacted in several ways during the clearing of the impoundment area and initial filling period. The loss of feeding areas, disturbance at den sites, and increased contacts with people will all result in severe habitat degredation within and adjacent to the impoundment area. Bears occurring in the impoundment area will likely increase their movements away from the river, thus increasing contacts with brown bears and hunters. There is little likelihood of bears being drowned while in their dens during reservoir filling, since winter flows into the reservoir will be very low, and most of this flow will be released downstream.

After filling, it is unlikely that a viable resident black bear population will exist along much of the impoundment area. There should be adequate habitat to support resident populations to the east of the impoundment (near the Tyone River confluence) and also along the western end of the impoundment near and west of the Fog Lakes and Watana Creek. Transient bears between these areas are likely to use the other areas adjacent to the impoundment, and a few bears may reside there year-round. However, the lack of denning areas and adequate forest stands near the remaining food supplies will severely limit the resident population. These bears will also be quite susceptible to hunting along the reservoir margin. Other long-term impacts are likely to be similar to those for brown bears (see 4.3(a), (iv)). Black bears, like brown bears, are able to swim long distances, and the open water in the impoundment should not be an absolute barrier to their movements. Some effects on bear movements, however, can be expected.

Downstream effects of the Watana development on black bears are likely to be much less severe. Impacts on salmon spawning areas, aircraft disturbance, and increased hunting will probably have the greatest effect on the population. The expected successional changes in vegetation are not likely to have a noticeable affect on the population, nor will any open water areas during winter since bears will be in dens at that time. The importance of salmon to downstream bears is unknown, but several bears from the upper basin moved downstream to feed on salmon during a berry crop failure, and bears are commonly seen along spawning sloughs in late summer. Twenty percent of the salmon radio-tagged during studies downstream were eaten by bears (Miller, pers. comm.). However, bear scats found along salmon streams are comprised mostly of berries, and thus the importance of salmon to these bears in uncertain. Bear studies downstream of

Devil Canyon will be intensified in 1983, and thus the food habits of downstream bears will be better defined at that time.

(vi) Wolf

Wolves may be affected by construction and operation of the Watana development by some loss of den and rendezvous sites, by disturbance, by increased hunting (see Section 4.3(c)), and indirectly, by loss of food sources.

No known dens or rendezvous sites will be flooded or destroyed by the present construction zone plans. Some den and rendezvous sites that have not been located may be destroyed, but because potential sites are relatively abundant in the Susitna basin (Ballard et al. 1982c), this would not have a serious effect on wolf populations.

Under most circumstances, wolves readily habituate to man-made disturbance (e.g. Van Ballenberghe et al. 1975, Milke 1977). The major exceptions to this are disturbance at den sites in spring. During Susitna baseline studies, human disturbance at three den sites caused early abandonment of all three, the adults moving the pups to new locations. In these cases, the pups were probably a month old and no pup mortality was noted. Ballard et al. (1982c) speculated that younger pups might be more likely to die if moved from the whelping den prematurely. Abandonment of dens after disturbance has also been noted in other areas of Alaska and in Canada (Carbyn 1974, Chapman 1977).

A serious impact of increased interactions between humans and canids (wolves and foxes) is the threat of exposure to rabies. That wolves (and bears and foxes) do habituate to the presence of humans was demonstrated by problems encountered during the construction of the Trans-Alaska Pipeline (Milke 1977). Wolves were fed deliberately and were allowed to scavenge on unburned garbage at construction sites and camps. As a result, many animals became severe nuisances and were killed. In addition, instances of workers being bitten and requiring hospitalization and occasionally rabies vaccine occurred.

Loss of food sources through development impacts on prey species is another possible impact of the Watana development on wolves. Wolves in the upper Susitna basin prey primarily on moose and to a lesser extent on caribou. Caribou population levels are not likely to be seriously affected by the Watana development, but moose populations will probably be reduced. The extent to which this reduction actually affects wolves depends on the extent to which wolf populations are presently limited by food availability or by hunting, tripping, and poaching.

Van Ballenberghe et al. (1975) reviewed the available literature on factors controlling wolf populations. They believed that while social factors such as territoriality and stress were the ultimate factors controlling population levels, an abundant food source lowered the threshold for action of social factors. They suggest that food is the main factor permitting the development of dense wolf populations (Figure E.3.W26).

There are no data to indicate wolf population trends in relation to population trends of moose and caribou in the Susitna basin. However, the consistently high harvest on wolves through the 1970's (Section 4.2 (a), (iv)) suggests that the low caribou population and declining moose population in the early 1970's (Section 4.2(a), (i and ii)) did not cause a substantial reduction in wolf numbers.

It is more likely that wolf population levels are controlled by exploitation rates. Close to half the upper basin wolf population is removed each year by hunting (Section 4.2(a), (vi)). In the likely event that this situation continues, the reduction in the moose population, as a result of the project, should hve a lesser effect on the wolf population than will the harvest levels.

(vii) Wolverine

The Susitna Hydroelectric Project will have both positive and negative effects on the wolverine population in the upper basin. Wolverines will be most affected by changes in winter food availability, and by higher trapping mortality due to improved access and a larger human population in the area. Other factors such as a localized avoidance of camps and roads, disturbance from aircraft and construction activities, and habitat loss due to the impoundments and other project facilities are not likely to greatly affect the number or productivity of wolverines in the Susitna basin. Loss of den sites is not likely to be a problem since wolverines den in a variety of habitats, generally on the surface of the ground under snow. Downstream of Devil Canyon, wolverines are likely to be measurably affected only by any increase in trapping pressure resulting from the project. Each of these factors will be discussed in greater detail in the following sections.

The area in northwestern Montana studied by Hornocker and Hash (1981) contained a large reservoir 48 km long and up to 6.5 km wide, and thus some data is available on wolverine movements and ranges in relation to a large impoundment. They reported that "the size and shape of ranges were not affected by rivers, reservoirs, highways or major mountain ranges." Magoun (1982) stated that although topographic features were not physical barriers to wolverine movements, they did appear to influence the shape of home ranges to some extent. Rivers, ridges, drainage divides, and well-defined breaks in habitat types often coincided with home range boundaries in her study area. Male home ranges appeared to be less affected by topographical features than did female ranges. Some home range boundaries in the upper Susitna basin coincide with topographical features (see Figure E.3.W15), but no clear relationship between the major features and most home range boundaries is evident. It is possible that the Watana impoundment might serve to separate home ranges once it is in operation.

Based on the estimate of about one wolverine per 163 km^2 derived in Section 4.2(a), (vii), the direct loss of over 206 km^2 due to the impoundments, access roads, camps, and other project features would potentially affect only two wolverines. However, the affected areas are of increased importance to many wolverines in the upper basin because winter food supplies are usually greater at the lower elevations most affected by the project facilities. Changes in the availability of winter food may affect wolverine movements, densites, and productivity, and therefore it is important to consider these changes in some detail.

In the area downstream of the Watana dam, changes in the availability of winter prey are not expected to be great enough to appreciably affect the wolverines in that area. The Devil Canyon impoundment is contained within a steep canyon supporting relatively low densities of ungulates and small mammals, and the access road will pass mostly through tundra habitats. Only a small proportion of the forested habitats will be removed by the project; small mammal and grouse populations should not be greatly reduced. Also, the cleared transmission corridors will enhance moose and small mammal populations, therefore, compensating somewhat for losses caused by the Devil Canyon impoundment. Few caribou use this area, and any mortality of moose or caribou resulting from hazards such as ice or open water areas, or from increased predation by wolves and bears, would likely benefit the wolverines in that area.

The Watana impoundment will have a much greater affect on winter food availability. Because a relatively high proportion of the forested area will be inundated, there will be a substantial decrease in the availability of small mammals and grouse used by a few wolverines during winter. The size of the moose population in the vicinity of the Watana impoundment will decrease during the license period, but there may be an increase in the number of ungulate carcasses available to wolverine. Some mortality of both moose and caribou is expected from floating debris, thin ice conditions, and large mud flats in the drawdown zone, and predation by wolves and brown bears may increase along the shores of the impoundment. Higher winter mortality of moose near the impoundment is also expected during winters of moderate to deep snow. It is not clear if the more rapid turnover of the moose population in the upper basin will offset the lower density of moose and small mammals, The effects of improved access from the roads and impoundment on wolverine, including increased trapping mortality and human presence, is discussed in Section 4.3(c), (vii).

(viii) Belukha Whale

The majority of the Cook Inlet population of belukha whales appears to concentrate near the mouth of the Susitna River during the calving period. Studies were undertaken in 1982 to address the concerns that project-related changes in water temperatures or anadramous fish runs at this critical period might interfere with calving success. For example, Seargent (1973) attributed the elimination of calving by belukhas in the St. Lawrence River to hydroelectric development on the Manicougan and Outardes Rivers, and subsequent alterations in water tempertures.

The Susitna project will have no measurable effect on the belukha whale population. Post-project water temperatures, salinities, and fish abundance will not be much different than pre-project conditions during the months that belukhas concentrate at the river mouth. No changes at all in anadramous fish runs during May and June are expected (see Section 2), and it is doubtful that fish from the Susitna River comprise more than a small percentage of the whales' diet when they are away from the river's mouth at other times of the year.

Although water temperatures released from the dams will be 0-4°C warmer than natural tempertures, the dilution effect of other rivers and temperature exchange of the river with the air and ground will result in no post-project difference in water temperatures at the mouth of the river during May and June. Only 7,650 cfs of the 55,930 cfs post- project inflow into Cook Inlet in May will be from the Susitna River (both dams operating). In June, only 8,150 of 105,702 cfs will be contributed by the Susitna. Thus, the dilution factor of other water sources, and 151 miles of temperature exchange with the environment, will result in similar pre- and post-project water temperatures at the mouth of the river during calving.

(ix) Beaver

The beaver population along the Susitna River is likely to increase during the license period as a result of the Watana development. Beneficial effects will occur mostly downstream of the dam as a result of regulated flows. During the construction period, however, beavers occurring within the borrow areas and along the access road could be adversely affected.

- Construction

Beavers occurring in the vicinity of the construction site, borrow areas, camp, and other project facilities will be impacted through a loss of habitat, altered water levels along creeks, and from trapping by project personnel. Reservoir clearing activities would have immediate negative effects on beaver occurring within the proposed impoundment (e.g., Wooley 1974). However, Gipson et al. (1982) reported that no active beaver lodges were found along the river within the impoundment zone or on the lower reaches of feeder streams. In contrast, borrow sites for the dam and access road will remove habitat for approximately 50 beavers. This includes about forty of the 65 beaver occurring along Deadman Creek in the lower reach designated as road material sites, and about 10 beaver in Borrow Area C on upper Tsusena Creek. No active beaver colonies were found in the other Watana borrow sites during an 11 October 1982 aerial cache survey. The alignment of roads to these borrow areas has not yet been designated, and therefore the number of beaver affected by the borrow site activities is still unknown.

- Filling and Operation

The impoundment area currently supports few beavers, and therefore the flooding of this area will not have any substantial effect on this furbearer species. The reservoir will be of little value to beavers after filling because of the annual drawdown. A few beavers, however, may persist in using the reservoir area. Each year for the past 12 years, beavers have attempted to build lodges and food caches on Williston Lake in British Columbia, which has an annual drawdown of about 17 m (R. Bonar, pers. comm.). One innovative colony there has built its lodge on a raft of floating logs, which moves up and down with the water level, whereas another colony has a series of burrows extending down to the minimum drawdown level.

During filling, the river is to be passed directly through the dam during the winter months, and thus the only effect of the dam on downstream flows will be during summer. During the operation phase, downstream flows will be higher than present in the winter, but lower in summer.

Few beavers currently occur in the river reach between Watana and Devil Canyon, and the estimated 70 beaver between Devil Canyon and Talkeetna were found mostly in side channels, sloughs, and clearwater areas (Section 4.2(b), (i)). Although swift currents in the main channel probably contribute to these low densities, the greatly-fluctuating water levels, ice scouring events, and low abundance of early successional vegetation are probably the major limiting factors (Figure E.3.W27). Another limiting factor is the depth of water beneath the ice in winter. Beavers require at least 1 m of open water under the ice for access to food caches and lodge entrances (Scott 1940, Hakala 1952). Since winter water depths are now much less than those in summer, the winter flows determine which areas are suitable for year-round occupation by beaver.

Any site currently occupied by beaver should still be available post-project, since winter flows will be higher than at present. In addition, many areas now subject to freeze-out will also be available for colonization by beaver. The increased availability of early-successional vegetation, reduced ice-scouring, lack of an ice cover in the Watana - Devil Canyon reach, more stable year-round flows, and lack of floods which destroy food caches and other beaver structures, will all result in improved downstream habitat for beaver. Beaver habitat south of Talkeetna may also be enhanced as a result of the increased occurrance of favored food plants, but the more unstable water levels resulting from increased contributions from other rivers and tributaries will dampen this effect. A planned flow increase in late summer for fisheries mitigation purposes will likely have little impact upon beaver, as the flow will have returned to a stabilized level before lodge preparations and food cache construction have begun in earnest for the winter.

If construction camp personnel and their families are allowed to trap in the area, beaver populations will be affected both along the Susitna River itself and in the lakes and creeks on either side of the river. It is not known at present how many beaver occupy these habitats, nor how strong trapping pressure would be, given the current depressed price for beaver pelts.

(x) Muskrat

Muskrats will be affected primarily as a result of improved access for trappers. Some habitat loss within the borrow areas and impoundment zone will also occur; however, muskrats may benefit from additional beaver ponds downstream of the project (Section 3.3(a), (ix)). With the exception of trapping mortality, the net impact on the muskrat population should be minor.

Of the 103 lakes surveyed for muskrat sign in spring 1980, 29 occurred within the borrow areas or impoundment zone of the Watana project (Table E.3.W73); only 10 of these lakes had muskrat pushups. A total of 29 pushups were observed on these lakes, but the number of muskrats this represents is unknown. Pushups are temporary structures, and one muskrat can create many of these during a winter. A likely estimate of the number of muskrat to be lost as a result of this habitat loss is 10 to 20 animals. Improved downstream habitat will probably compensate for this loss.

Muskrats are extremely susceptible to water level fluctuations (Bellrose and Brown 1941), and usually find braided rivers poor habitat due to lack of forage and burrow sites (Brooks and Dodge 1981). As such, there is little potential muskrat habitat in the active flood plain downstream of the Watana damsite. Many muskrat probably occupy beaver colony sites (Curatolo et al. 1981) along the Susitna River which are outside of the active floodplain. Below Montana Creek good muskrat habitat occurs in old channels now functioning as clearwater seeps which will not be affected by the project (Bredthauer and Drage 1982).

If construction camp personnel and their families are allowed to trap in the area, muskrat populations throughout the lakes lying on either side of the Susitna River could be highly affected. Gipson et al. (1982) found muskrat sign in these lakes and noted their vulnerability to trapping.

(xi) Mink and Otter

- Upstream Effects

Because mink and otter are moderately abundant in the Upper Susitna Basin and are probably dependent on aquatic and semi-aquatic habitats along the Susitna River and its tributaries, construction and operation of the Watana dam may have substantial impacts on these species. The most important effects include loss of habitat, reduction of food supplies, increased disturbance, and barriers to movement.

Clearing and flooding of the impoundment will eliminate a substantial proportion of good quality otter and mink habitat. High quality habitats for these semi-aquatic furbearers is generally characterized by moderate to slow flowing streams and rivers with well wooded banks. Ponds with abundant food, deep and stable water conditions, and an irregular shoreline also appear to be good habitats (Hodgdon and Hunt 1953; Knudsen 1962; Barber et al. 1975). Because the impoundment will result in a large drawdown zone, it is unlikely that the reservoir will be heavily-utilized by mink or otter. Small declines in water levels (e.g. less than 1 m) may acutally benefit mink during the winter by creating air spaces under the ice that would allow them to hunt more easily (Errington 1943; Harbo 1958). However, the large drawdown area of the Watana dam would probably be detrimental to otter and mink; it would isolate their bank dens from the reservoir during the winter and would probably reduce prey availability.

The extent to which otter and mink habitat will be reduced and the effects on local populations are difficult to assess. The impoundment will flood approximately 65 m of the mainstream Susitna River. In addition, portions of a number of tributaries will be inundated by the impoundment; these include Deadman Creek (3.7 stream km will be inundated at maximum fill), Kosina Creek (6.4 km), Jay Creek (5 km), Goose Creek (2.4 km), and the Oshetna River (3.2 km). Most of Tsusena Creek will be disturbed by gravel removal. It is not known what these losses represent in terms of a proportionate reduction of available mink and otter habitat. However, because almost all otter and mink tracks were observed along the Susitna River (Table Furbearer-1), inundation will likely reduce the amount of good habitat substantially.

Clearing and flooding of the impoundment area will reduce prey availability for otter and mink. Clearing of forest cover would reduce the availability of some prey of mink such as small mammals and waterfowl. Effects of erosion and consequent siltation, as well as effects of dust that are associated with clearing may also reduce the availability of fish and crustaceans. Flooding of the reservoir will probably result in further reductions in prey availability; crustacean distributions and productivity will probably be altered by the drawdown zone, and the species composition, abundance, and distribution of fish will change. In addition, because the reservoir will greatly expand the amount of aquatic habitat, fish will be less concentrated than they are at present and more difficult for otters and mink to capture. The net result of these changes, in addition to the change of shoreline habitats, will be an avoidance of reservoirs by mink and otter. The effects on productivity associated with these dietary changes are unknown.

Clearing of the reservoir site and construction activities, particularly in close proximity to streams and rivers, may disturb mink and otter and may result in interference with daily activities or, in extreme cases, an avoidance of the area. Densities of the European otter (Lutra lutra), a species closely related to river otter, along the River Terre in England appear to be inversely related to the amount of human disturbance (recreational fisherman) and the amount of clearing of woodland cover along the river banks (MacDonald et al. 1978). Because recreational use of the upper reaches of streams along the north side of the impoundment will probably increase during construction and operation, and because the upper reaches of these streams may represent a moderate proportion of the remaining higher quality habitat for semi-aquatic furbearers, disturbance effects on mink and otter could be important.

Because mink and otter are well-adapted to aquatic habitats, the water body of the impoundment will not represent a serious barrier to movements of these species. However, access to the impoundment water body may be inhibited by the expansive drawdown zone; the large separation between the water body and the onshore vegetation and dens may prevent animals from crossing the impoundment area.

- Downstream Effects

Alteration of the river hydrology and vegetation communities as a result of the Watana dam have already been discussed (Section 3.3(a)). The effects of these alterations on mink and otter are difficult to assess. Reduced water flows in summer may initially strand dens of both species well above the water line, may reduce muskrat populations (an important prey species of mink), and may decrease the availability of certain fish species (Section 2.3(a)) and crustaceans (important prey species of mink and otter). Mink may be better able to withstand the effect of reduced water flows because of their ability to hunt in terrestrial habitats (Marshall 1936; Harbo 1958).

The area of permanently open water downstream of the Watana dam may benefit small numbers of mink and otter. Both of these furbearers commonly concentrate in open water stretches of rivers and streams in winter (Barber et al. 1975).

(xii) Red Fox and Coyote

Coyotes occur in the Watana development area but they are so uncommon that development activities are unlikely to have a quantifiable effect on them.

Coyotes do not appear to avoid areas of human activity; however, no studies have specifically evaluated the effects of human disturbance on this species. Ferris et al. (1978) demonstrated a significant preference of coyotes (based on winter track count surveys) for an area within 200 m of a section of an interstate highway in Maine relative to an area 200-400 m from the highway. Track surveys also indicated that coyotes occasionally used the right-of-way as a hunting or travel route. Penner (1976) similarly concluded that coyotes preferred large cleared areas and avoided undisturbed habitats within an oil sands development area in northwestern Alberta.

The major impacts on red foxes would probably result from trapping by construction workers and killing of nuisance animials at camps and construction sites. Habitat loss from flooding of the impoundment would not have a great impact on foxes since most individuals apparently utilize areas above the high water line of the impoundment (666 m elevation) and areas to the east of the impoundment on the Lake Louise flats. Fox dens typically occur at elevations of 1000 m to 1200 m and no foxes or fox sign were found along the Susitna River or the lower reaches of its tributaries in late winter or spring during baseline studies (Gipson et al. 1982). Foxes did occur along the Susitna at other seasons. Presumably, an abundance of prey would be available for foxes during summer and fall and loss of habitat along the river would probably have negligible or minor effects.

Red fox similarly do not appear to avoid areas of frequent human activity. Observations of red fox and the location of den sites in relation to the main road in Denali National Park, showed that red foxes did not avoid areas of frequent human use and that in some cases would habituate to human disturbances (Tracy 1977). Red foxes in Gatineau Park, Quebec, appeared to commonly use areas in the immediate vicinity of human disturbance and showed little avoidance of areas frequented by snowmobilers (Neumann and Merriam 1972).

Foxes away from den sites habituate to human activity so readily that they can become a nuisance at construction and camp sites if they are fed or allowed to feed on garbage (Milke 1977). The presence of scavenging foxes frequently leads to workers being bitten and occasionally needing hospitalization for rabies vaccine (Milke 1977). It also often leads to the destruction of the foxes.

Although the fox population in the Susitna Basin is small (Section 4.2(b), (vi), it is apparently a source of juveniles which disperse to adjacent areas (Gipson et al. 1982). An increase take of foxes from currently low levels is expected because of improved access and residency of construction personnel and may eliminate this source of dispersing individuals.

(xiii) Other Furbearers

This group includes species that occur primarily in forested habitats--marten, lynx, short-tailed weasel and least weasel. Impacts on marten are discussed in greatest detail. As mentioned previously (4.2(b), (v)) marten have historically been and continue to be economically the most important furbearer in the vicinity of the impoundment zones. Lynx are very uncommon in the upper Susitna basin. Weasels are probably quite common, but there is little specific information on their abundance and distribution in the basin.

All of these species will suffer primarily as a result of the loss of forested habitats to the impoundment (see Figure 3.E.3.W28), borrow sites and other project facilities. Gipson et al. (1982) have estimated the number of marten in the winter population directly impacted by loss of habitat in the Watana and Devil Canyon developments through a model based on the following data and assumptions:

- Adult male marten home ranges are mutually exclusive and adjoin one another so that all marten habitat in the impounded area is inhabited (trapping likely affects this assumption).

- Marten habitat is defined as forest, and marten are restricted to this habitat type.

- A 1:1 sex ratio exists in all age classes of the population.

- 65% of the population are juveniles (less than 1 year old) (Archibald pers. comm.), and juveniles appear in the harvest in proportion to their number in the population.

- The mean home range size of male marten is 682 ha (Gipson et al. 1982).

This model gives an estimated density for all age/sex groups of 0.847 marten per km^2. Using a figure of 11,798 ha of forest habitat lost to impoundment areas, borrow areas construction site and camps for Watana development, 100 marten (3.4%) would be eliminated from an estimated popoulation in the basin of 2,940.

Gipson (pers. comm.) attempted an independent population estimate in July 1982 near Watana Creek using a mark--recapture technique. An 11 km trapline with trap spacing of 0.4 km on either side of Watana Creek captured no marten in 252 trap nights (the minimum expected catch based on densities of 0.008 marten per ha was 10). This result suggests that fewer marten than calculated above may actually exist in the impoundment areas, and that fewer marten would be affected.

There are obvious difficulties with the model used for the estimate of 100 marten eliminated. Perhaps the most serious is that marten densities and home ranges vary between different forest types, being most common in dense, mature coniferous forest (deVos 1952, Douglas et al. 1976, Koiler and Hornocker 1977). The estimate for prime forest habitat only (eliminating woodland and open forest types) is 26 marten eliminated from a population of 347 (7.5%). The estimate of 100 marten lost is probably high.

Clearing of small areas of forest at construction sites and borrow areas and the associated human disturbances may effect marten home range size and distribution. However, these types of changes will be most extension in areas affected by the access route and transmission line and are discussed in Section 4.3(c) and (d).

Lynx are uncommon in the Susitna basin, probably because their major prey, snowshoe hares, have been historically uncommon. Lynx will probably not be directly affected by habitat loss, and revegetation of disturbed areas improve habitat for snowshoe hare in the basin. Major effects on the few lynx occurring in the project area are therefore not expected.

Numbers of short-tailed and least weasels may be reduced through habitat loss. Reductions are unlikely to be serious within the basin and regional effects would be minor.

Construction activities and human distrubance could result in avoidance of the construction zone by furbearers. No information is available for lynx and weasels. Evidence exists that marten are tolerant of moderate levels of disturbance in areas adjacent to logging operations (Clark and Cambell 1977, Soutiere 1978, Steventon and Major 1982).

(xiv) Raptors and Raven

The construction and operation of the Watana Dam will affect raptors through a number of mechanisms (Table E.3.W74), the most important of which are habitat loss and disturbance. Habitat loss includes the flooding of suitable nesting cliffs, removal of trees used for nesting and perching, and a loss of hunting areas. Many of the tree and cliff nests within the impoundment area may be abandoned during the construction phase as a result of disturbance, and several nest sites immediately adjacent to the access road or borrow areas may also be abandoned.

- Habitat Loss

About 38% of the known raptor and raven cliff-nesting locations and at least 40% of the known raptor tree-nesting locations in the general vicinity of the proposed project will be lost as a result of the Watana project (Table E.3.W75 and E.3.W76). The raptor species affected include golden eagles, bald eagles, gyrfalcons, goshawks, and ravens.

At least 6 (38%) of the 16 total known golden eagle nesting locations in the general vcinity of the project area will be directly lost to construction and filling of the Watana Reservoir. Five of those 6 nesting locations will be inundated, whereas one my be lost during material excavation operations at Borrow Site E (Figure E.3.W29, Tables E.3.W75 and E.3.W76).

Cliff-nesting habitat for golden eagles will become severely limited upstream of the Watana Dam site once the impoundment is full (Table E.3.W77). Loss of cliffs upstream of the Watana Dam site may increase the importance of cliffs farther downstream in Devil Canyon, along Fog Creek, Tsusena Creek and others draining into the Devil Canyon impoundment zone. However, many of the cliff areas in Devil Canyon appear to be exposed to higher levels of moisture, and some sections may lack suitable ledges on which golden eagles would construct nests.

Golden eagles often have several alternative nesting locations, some perhaps 8 km apart (see Roseneau et al. 1981); however, losses of 38% of the well-established golden eagle nesting locations along the upper Susitna

River, concommittant losses of most of the other potential nesting cliffs upstream of the Watana Dam site, and a suspected scarcity of alternate nesting locations throughout much of the remainder of the upper basin suggest that the upper Susitna River basin population of golden eagles will be reduced by 3-5 pairs as a result of the construction and filling of the Watana Reservoir (Roseneau, pers. comm.).

As many as 4 (50%) of the eight total known bald eagle nesting locations in the general vicinity of the project area will be directly lost to clearing and filling of the reservoir (see Figure E.3.W29, Tables E.3.W75 and E.3.W76). Three of these locations are tree-nests and one is the sole cliff-nesting location[1] known to be used by bald eagles in the Susitna River drainage. Furthermore, almost all white spruce and balsam poplar trees of a size suitable to bald eagles that occur in the general vicinity of Watana are located within the impoundment area on tributary deltas and islands. Construction and filling of Watana will likely limit bald eagles to one or two available nesting locations upstream of the impoundment, and one or two potential locations along the Lower Oshetna River. This may increase the importance of other potential nesting habitat downstream of the Watana Dam site, including balsam poplar stands along Portage Creek and white spruce and balsam poplar near Stephan Lake and along Prairie Creek. In any event, it appears unlikely that habitat loss as a result of construction and filling of the Watana Reservoir will have more than a local effect on the Susitna River bald eagle population, the majority of which inhabits the area downstream of Indian River (see Section 4.2(c), (i)). [[1]Bald eagle cliff- nesting locations are relatively rare throughout Alaska north of the Alaska Peninsula - for instance, in the entire Tanana River drainage where over 40 nesting locations are known (Roseneau et al. 1981), only one nesting location is on a cliff (D.G. Roseneau, pers. comm.)]

No known gyrfalcon nesting locations will be directly lost as a result of the Watana project. However, gyrfalcons often use nests constructed by other cliff-nesting species, including ravens and golden eagles (e.g., Cade 1960, White and Cade 1971, Roseneau 1972), and some of the golden eagle and raven nesting locations lost as a result of inundation or gravel mining may represent past or future locations used by gyrfalcons. In southcentral Alaska and the Alaska Range, where nesting densities are low (Roseneau 1972, Roseneau et al. 1981, Bente 1981), use of other species' nests by gyrfalcons is less is less prevalent than in more northern and western regions of the state where the majority of the Alaska gyrfalcon population breeds and winters (see Roseneau et al. 1981). It is therefore unlikely that habitat loss as a result of construction and filling of the Watana Reservoir will have more than minimal effect on the upper Susitna River gyrfalcon population.

One (33%) of three known goshawk nesting locations in the general vicinity of the Watana project will be directly lost to clearing and filling of the Watana Reservoir (Figure E.3.W29, Tables E.3.W75 and W.3.W76). The nest location that will be lost is the only one discovered, to date, upstream of the Watana Dam site, beyond which potential nesting habitat becomes very scarce (D.G. Roseneau, pers. obs.).

As many as 10 (48%) of 21 previously used raven nesting locations in the general vicinity of the Watana project will be lost as a result of construction and filling of the Watana Reservoir (Figure E.3.W29, Tables E.3.W75 and E.3.W76). All will be lost by inundation, and one additional nest may be inundated at times of maximum flood stage (see Figure E.3.W29) or be so close to maximum operating water level as to be unuseable.

Although a considerable number of raven nesting locations and cliff habitat will be lost as a result of Watana Reservoir filling (Table E.3.W77), the consequences of this loss to ravens will be minor in comparison to those for other cliff-nesting species (particularly golden eagles). Ravens commonly nest in a wide variety of situations in Alaska, including man-made structures (see Roseneau et al. 1981). Tree-nesting is common, and ravens consistently nest on small cliffs that are unsuitable for raptors (Roseneau pers. comm.). Construction and filling of Watana without development of Devil Canyon is more likely to result in increased use of cliffs along Devil Canyon and trees downstream of the Watana Dam site along the river and tributaries, than reduce the upper Susitna River basin raven population.

In addition to loss of nesting habitat, it is anticipated that some loss of perching and hunting habitat for raptors will also occur as a result of construction and filling of the Watana Reservoir. Perching habitat will primarily be lost as a result of inundation of cliffs (see Table E.3.W77), and the clearing of trees prior to reservoir inundation. Loss of hunting habitat is more difficult to determine. No data was collected in the Upper Susitna River Basin to determine raptor hunting ranges and foraging areas; however, the general degree of impact for at least three species may be inferred from other information.

. Golden Eagles

Golden eagles are opportunistic hunters. When available, mammals are an important component of their diet (up to 70-98% by weight), but birds and carrion can also be important (cf. Brown and Amadon 1968).

In Alaska, there are few reports of prey items found at nests. Common items found in nests have included ground squirrels, marmots, snowshoe hares, ptarmigan, ducks and other waterfowl. Occasionally both arctic and red foxes are taken; one pair on the Seward Peninsula took as many as 5-6 red foxes during the summer, and the fledgling from that nest attacked a red fox -- 1-2 wk after it had left the nest (Roseneau and Springer, unpubl. data). Pairs nesting along sea coasts also take a variety of seabirds (both alive and as carrion).

Carrion, often in the form of large game animals, is particularly important during the early spring and the fall. Carrion also appears to be very important to subadult golden eagles. Large numbers of subadults frequent the calving and post-calving grounds of caribou herds. Up to six subadults have been found feeding at one time on wolf-killed and bear-killed caribou, and subadults also occasionally have been observed to kill caribou calves (Roseneau and Curatolo 1976).

Non-breeding of golden eagles occurs in some years, and there is some evidence to suggest that prey availability may influence breeding success (cf. Brown and Amadon 1968; Mosher and White 1976).

Golden eagles probably hunt throughout the Upper Susitna River Basin; however, they may avoid heavily treed areas and may tend to spend more effort above and outside of the impoundment area than in it. A tendency to hunt over open treeless areas coupled with their varied diet suggests that the loss of hunting habitat as a result of construction and filling of the Watana Reservoir will have minor effects on golden eagles.

. Bald Eagles

Bald eagles are opportunistic in their feeding habits, and diets may vary from region to region according to the availability and vulnerability of prey species.

Although they take a variety of live prey, bald eagles often rely heavily on local sources of carrion, may be attracted to dumps, and may pirate prey from other raptors, particularly ospreys (cf. Bent 1937; Brown and Amadon 1968; Sherrod et al. 1976). Fish are a principal component of their diet in most regions.

In Alaska, bald eagles rely heavily on dead or dying salmon when they are available, and take other species of fish as they can in shallow water or as carrion along shorelines. Waterfowl and seabirds (alcids and larids) are also important components of their diet, particularly in some coastal regions (e.g., the Aleutian Islands). Dead, dying or injured birds are often taken from the water surface, but eagles are also capable of surprising and taking uninjured waterfowl and seabirds from the water surface or in the air. Geese may also occasionally be taken in flights (Brown and Amadon 1968), and swans and sandhill cranes have sometimes been taken (D. Haynes, pers. comm., Springer, pers. comm).

In the Susitna River Valley, salmon are undoubtedly important to bald eagles in late summer, fall and winter. Earlier in the year, other fish species (particularly whitefish, suckers and grayling) and waterfowl probably constitute the bulk of their diet. Snowshoe hares and muskrats may also be taken on occasion.

Bald eagles may hunt throughout the upper Susitna River basin; however, they may tend to spend greater amounts of time at lower elevations near water bodies than golden eagles. Losses of hunting habitat to those bald eagles nesting in the upper river basin may be greater than losses to golden eagles as a result of construction and filling of the Watana Reservoir; however, attraction of waterfowl to the impoundment may compensate in part for such losses. Overall, bald eagles in the upper basin are probably more limited by availability of nesting habitat than by availability of food. Hunting habitat including tributaries and water bodies near the impoundment zone may be adequate for those eagles that remain after construction and filling of the Watana Reservoir.

. Gyrfalcons

Gyrfalcons are year-around residents of the arctic and subarctic and are opportunistic hunters. During the summer their diets vary according to the prey availability and vulnerability (cf. Roseneau 1972), but they typically rely on only a few principal prey species for the bulk of their food (cf. Cade 1960; White and Cade 1971; Roseneau 1972).

The principal summer prey species include ptarmigan (often 70-90% by weight of their diet), arctic ground squirrels, and, in some regions, long-tailed jaegers (cf. White and Cade 1971; Roseneau 1972). In some regions of interior Alaska (e.g., the Alaska Range) ground squirrels surpass ptarmigan in importance (cf. Cade 1960; Roseneau 1972). Migratory birds usually constitute no more than 15-20% by weight of their summer diet. In the winter, gyrfalcons are almost solely dependent on ptarmigan (cf. Platt 1976; Walker 1977), although in some regions arctic hares are also an important component of the diet (Muir 1973).

Despite the reliance on a few principal prey species, gyrfalcons are capable of shifting to other food sources during the breeding season if the availability of a few prey species changes dramatically -- provided that other prey species are present (cf. White and Cade 1971; Roseneau 1972). It has also been suggested that gyrfalcons may not breed in some years when prey availability is low (cf. Hagen 1952; Cade 1960; Roseneau 1972).

The reliance on ptarmigan, and the high utilization of small mammals, particularly ground squirrels, in the summer diet are important factors that have helped gyrfalcons to avoid serious biocide contamination and thus maintain healthy, non-endangered populations in the arctic (cf. Cade et al. 1971; Walker 1977).

Gyrfalcons may hunt up to 24 km from their nest locations. Nelson (1978) used a helicopter to follow a male that hunted as far as 24 km from the nest. Another male hunted at or beyond 8 km from a nest in the Alaska Range, but the female hunted only within 2-3 km of the nest (Bente 1981).

Gyrfalcons may also hunt throughout the upper Susitna River basin, but they tend to avoid wooded areas and probably spend most of their effort well above the impoundment zone. Their tendancy to hunt open, treeless areas, including the Alpine zone, coupled with their opportunistic nature suggest that the loss of hunting habitat as a result of construction and filling of the Watana Reservoir will not be a serious impact.

- Disturbance

Bald eagles and golden eagles are specifically protected under the U.S. Bald Eagle Act of 1940 (as subsequently amended). A part of this act prohibits the "taking" of any bald or golden eagle or the nests or eggs of such birds without a permit. "Take" is defined to include molest or disturb. There are also state laws that provide similar protection for these and the other raptor species.

Much of the information on kinds and effects of disturbance to raptors has been reviewed and summarized by Roseneau et al. (1981). Most information is anecdotal. Responses of raptors to various types of disturbance are complex -- several factors may affect the sensitivity of raptors to disturbance (Table E.3.W78). Timing of the disturbance is an important factor (Table E.3.W79). Furthermore, effects of disturbance may be additive.

Responses of raptors to disturbance and the effects of these responses are often highly variable. In many cases, nesting raptors have shown a surprising degree of tolerance and habituation to disturbances (see Roseneau et al. 1981), yet in other cases the same types and levels of disturbance have had detrimental effects (see Roseneau et al. 1981). In general, a mounting body of evidence suggests that raptors will habituate to and tolerate at least moderate forms of disturbance. The same body of evidence suggests that the most detrimental forms of disturbance are those that occur within (i.e., nesting locations) territorial defense zones. Prolonged disturbances, multiple disturbances, and direct overt harassment from either the ground or the air are particularly harmful.

Some species of raptors appear to be less tolerant of disturbance than others. Among the species in Alaska, golden eagles appear to be the most sensitive, especially to aircraft disturbance and human presence (see Roseneau et al. 1981). Although golden eagles, like most raptor species, are reluctant to flush from nests as a result of aircraft passage during incubation, they often leave their nests well in advance of approaching aircraft during the nestling period (Roseneau et al. 1981). Furthermore, they often leave their nesting areas quickly when people approach, often at considerable distances (e.g., as much as 0.8 km; Roseneau pers. obs.) from the nest. Several documented nesting failures of golden eagles in some areas have been blamed on human interference (see Roseneau et al. 1981).

Nesting locations of raptors and ravens that may be subjected to disturbance by the construction and filling of the Watana Reservoir (with the exception of reservoir clearing operations) are listed in Table E.3.W76. Nesting locations were selected for inclusion on the basis of distance from project actions. Judgements as to the general level of disturbance were made on the basis of nest elevation above potential disturbance, distance to the disturbance, and general nature and scale of the disturbance, assuming year-round activity (clearing, material excavation and dam construction).

Seven golden eagle nesting locations within or on the edges of the Watana impoundment may be susceptible to disturbance from reservoir clearing operations (see Figure E.3.W29: the exceptions are GE-7 and GE-10). Five of those locations will be inundated later. Two of the five locations will also be susceptible to considerable disturbance from material excavation at Watana Borrow Site J (see Table E.3.W76); however, both locations (GE-8 and GE-9) will be inundated. An eighth golden eagle nesting location (GE-11) will be susceptible to considerable disturbance at Watana Borrow Site E. This latter location will probably be physically destroyed by material excavation unless some action is taken to specifically preserve it (e.g., the establishment of a buffer zone around the nesting cliff).

Four bald eagle nesting locations within the Watana impoundment are susceptible to disturbance from reservoir clearing operations (see Figure E.3.W29: the exception is BE-1). At least two of the four locations are tree-nests that will eventually be flooded (BE-3 and BE-5), and one is a cliff nest that will eventually be inundated (BE-4). The fourth location (BE-2) is also likely to be inundated or may be lost because of shoreline erosion unless specific safeguards are taken.

No known gyrfalcon nesting locations appear susceptible to major disturbance from Watana construction; however, one location (GYR-1) may be susceptible to some disturbance during reservoir clearing.

At least one known goshawk nesting location will be susceptible to disturbance from reservoir clearing (GOS-1); this nest will eventually be inundated (Figure E.3.W29). A second nesting location (GOS-2) is located in the Devil

Canyon Reservoir, but may be susceptible to some disturbance as a result of material excavation at Watana Borrow Site I (see Table E.3.W76).

Twelve common raven nesting locations within or on the edges of the Watana impoundment may be susceptible to disturbance from reservoir clearing operations, but as many as 11 of them will eventually be inundated (see Figure E.3.W29: the exception is R-1). Three (R-9, R-10 and R-11) of the locations that will eventually be inundated will also be susceptible to considerable disturbance associated with material excavation at Watana Borrow Site J (see Table E.3.W76). Two other nesting locations (R-14 and R-15) are located downstream of the Watana Dam site, but they may be susceptible to considerable disturbance during excavation of materials from Watana Borrow Site H.

(xv) Waterbirds

Because of the low numbers and diversity of waterbirds in the Susitna basin (Section 4.2(c), (ii)), impacts from the Watana development will not have a major effect on regional populations. Waterbirds that do occur in the Susitna basin will be affected during construction of the Watana development by some loss of habitat, alteration of habitat and disturbance.

- Habitat Loss

Loons, grebes, swans and several of the duck species in the Susitna basin occur primarily on lakes (Appendix EF). These species will not be affected seriously by loss of habitat since only 38 ha of lakes will be flooded by the Watana impoundment. Most species using the river will be more affected by habitat alteration (see below) than direct loss. However, some tree nesting ducks (goldeneyes, common merganser) will probably lose nesting trees during reservoir clearing. Goldeneyes prefer to nest in relatively large diameter cavities. Prince (1968) reported the smallest cavity diameter in his study to be 15.2 cm. Most large trees are probably on the lower slopes of the Susitna valley and will be flooded.

- Habitat Alteration

During construction and filling, habitat alteration will occur primarily from clearing, flooding of shorelines and possibly siltation and shoreline changes in lakes where borrow areas are immediately adjacent.

Clearing will have little effect on waterbirds with the possible exception, as noted in the previous section, of cutting nest trees of some duck species. Flooding will eliminate shoreline nesting areas of common and red-breasted mergansers and harlequin ducks, and will probably affect the fish-eating mergansers through some loss of food resources. Mainstream fish populations are not expected to be seriously affected by flooding but portions of the grayling populations in tributary streams may be lost (Section 2.3). Nevertheless, fish populations will probably remain sufficient to support the low merganser numbers in the area and this impact will not be significant.

If borrow areas were constructed on the shores of lakes or streams, habitat for nesting waterbirds will be at least temporarily lost. The preliminary determination of potential borrow areas indicates that a number of lakes, creeks, and wetlands may be affected. Specific information about bird populations for most of these areas is lacking, but the generally low numbers of waterbirds found in Susitna Basin lakes suggests that few birds would be affected.

Open water areas below the dam and near the intake will provide habitat for spring migrants when other waterbirds are still frozen. The reservoir will be of low quality to nesting waterfowl, but will provide habitat for migrating birds and molting waterfowl.

- Disturbance

A number of sources of disturbance to waterbirds will exist during Watana construction, but whether any of these will be sufficient to cause habitat abandonment is unknown. The main sources of disturbance will be borrow extraction from wetland areas, transport of borrow and other materials, and if done in summer, reservoir clearing. The construction of the dam itself is a sufficiently localized disturbance and few waterfowl will be affected.

Waterbirds in tundra areas have been shown to avoid immediate areas of intense human activity (Barry and Spencer 1976) and similar avoidance would probably occur in other areas of open wetland. Most quantitative studies have been of aircraft disturbance. Results of most of these studies on ducks (e.g., Gollop et. al 1974, Schweinsburg 1974, Schweinsburg, et al. 1974, Ward and Sharp 1974) have found changes in behavior, but little effect on distribution of nesting or moulting ducks. Geese and whistling swans occur in only small numbers during migration in the Susitna area and are unlikely to be much affected by disturbance. Trumpeter swans nest in the upper basin, but primarily to the east of the project area; only small numbers occur in the Watana area during migration. Geese and swans are unlikely to be seriously affected by disturbance.

(xvi) Other Birds

- Construction

Terrestrial and shoreline birds will be affected by habitat loss through clearing of the reservoir area and areas for access roads, camps, borrow pits, and other facilities. Changes caused by clearing in closed forests will also affect birds by permitting species that are associated with edges to invade and, depending on the extent of clearing, perhaps excluding species that require a closed canopy. Birds near the construction zones will also be affected by sensory disturbance from traffic, noise, air emissions, and people.

. Habitat Loss

Table E.3.W78 shows the proportionate loss of each habitat type. Forest habitats, especially deciduous (birch) and mixed forests will be most affected. These types support among the highest density and diversity of breeding birds in the upper Susitna area. Although only two species (hairy woodpecker and northern waterthrush) nested exclusively in deciduous or mixed forests, a number of species occurred much more commonly in one or both of these habitats than elsewhere. These included spruce grouse, boreal chickadee, brown creeper, hermit and Swainson's thrushes, yellow-rumped and blackpol warblers, and dark-eyed junco (see Section 4.2 (c), (iii)).

An attempt was made to estimate the numbers of breeding pairs lost to the Watana development in relation to the population of the entire upper basin (Tables E.3.W79 and E.3.W80). The estimates were calculated using the density of each species in the various vegetation types, and the areal extent of each vegetation type to be affected. Because only one or two census plots were established in each vegetation type, the estimates probably represent only the correct order of magnitude of loss for each species.

The substantial variation in breeding bird densities between 1981 and 1982 (see Section 4.2 (c), (iii)) results in an equally substantial variation in the estimates of breeding pairs lost in the two years.

Data from 17 years of roadside bird counts in the Fairbanks area (Kessel, pers. comm.) suggest that 1981 was a good year in terms of bird abundance for most species. Overall, an estimated 28,334 to 37,845 pairs of small and medium-sized upland birds will be lost because of flooding or clearing of habitat for the Watana development. In total, this represents 1.1% of the bird populations of forest, shrubland, and mat and cusion tundra in the upper basin. No estimates are available for other tundra habitats but only very small areas of tundra will be affected by the project. The species that will suffer the greatest numerical losses tend to be those that occur in high densities in widespread habitats. Large numerical losses of Swainson's thrushes, ruby-crowned kinglets, yellow- rumped warblers, Wilson's warblers, dark-eyed juncos, tree sparrows, and a few other species will occur (see Table E.3.W79). However, most of these species are abundant throughout the upper basin. Of the 12 species that will lose 2000 or more pairs, the loss represents 5% or more of the basin population for only three: Swainson's thrush, yellow-rumped warbler, and fox sparrow (Table E.3.W80).

Species that will experience the largest proportionate loss are, not surprisingly, primarily those whose main habitats will be most affected. In addition to the three species mentioned above, more than 5% of the estimated upper basin population of spruce grouse, hairy woodpecker, boreal chickadee, brown creeper, and northern waterthrush populations will be lost. Although these losses represent a fairly substantial proportion of the local population of these species, none are rare in adjacent areas of Alaska and these impacts will not have a serious effect on local populations.

. Habitat Alteration

Habitat alteration resulting from clearing and construction of buildings, dams and borrow pits will have negative effects on some species and positive effects on others. Species of closed forests will be somewhat reduced in numbers near the cleared areas where clearings are in forested habitat, whereas species associated with edges will probably increase. In some locations, local increases in species diversity may occur as a result of the increased interspersion of forest and edge habitat.

Some species are capable of utilizing artificial habitats created by man and these species may benefit from certain habitat changes. For example, bank swallows and kingfishers may dig their nest cavities in sand walls of borrow areas that are not in active use or even in less disturbed areas of large pits that are in active use. Cliff swallows readily nest on buidlings. Ravens (and possibly bald and golden eagles) will feed on road-killed wildlife; Ravens and gulls will feed at refuse dumps if these are not properly maintained.

- Disturbance

Disturbance to upland birds will result primarily from road traffice and is discussed in Section 4.3 (c). Some disturbance may also result from activities of people at borrow pits and the construction site but there is little quantitative information about the effects of such disturbance. Local disturbance of this nature will not have any serious effect on populations of upland birds.

- Filling

Since the reservoir is to be cleared, most of the habitat loss associated with the Susitna project will occur during the construction phase and was discussed above. During filling, the species that will be affected are those that had invaded the cutover area (mainly birds and shrub habitats) and birds dependent on shorelines, mudbars, and streams. These are primarily shorebirds and the dipper. Dippers inhabit fast-running mountain streams and dipper habitat will be lost to the extent that the lower reaches of such streams are flooded. Dippers also winter in the Susitna area along the open water or fast running streams and the Susitna River itself. Loss of some of these areas of open water could result in lowered population, but alternate areas of open water will be available elsewhere.

During filling, the sandbars, islands, and shorelines used by shorebirds will be flooded. Three breeding species (spotted sandpiper, greater yellowlegs, and semipalmated plover) and about seven migrant species will be affected. The Susitna River does not seem to be a major staging area for shorebirds and the loss of habitat for migrants will have insignificant effects. All of the breeding shorebird habitat in the impoundment area will be lost but all species are present in adjacent areas.

- Operation

During operation of the Watana development, some feeding habitat for spring migrant shorebirds will probably be created in the drawdown zone. Feeding habitats for fall migrants will not be created because the reservoir will be full in fall.

The abundance and species composition of birds along the downstream reaches of the river will change as new riparian vegetation invades areas of the floodplain and proceeds through the successional stages described in Section 3.2. These changes will be most visible in the reaches north of Talkeetna where changes in vegetation will be most pronounced. Because bird densities and species diversities are highest in tall shrub and mature forest stands (see Section 4.2 (c), (iii)), the vegetation changes over 100-200 years could be considered beneficial to breeding birds. However, the proportionate changes in species abundance in the study area as a whole will be very small during the license period.

(xvi) Non-game (small) Mammals

Population densities of most species of small rodents fluctuate widely under natural circumstances (Krebs and Myers 1974, Kessel et al. 1982), and it is consequently difficult to predict post-construction population levels. Although the populations of some species will be diminished due to the project, most species respond quickly to disturbance, abandoning some areas and colonizing new ones. In addition, reproductive rates of small mammals are high and most populations can recover quickly from population reductions if sufficient food resources and space are available.

Only those species of small mammals that are restricted to dense forest habitats are expected to show marked decreases, primarily due to loss of forest to the impoundment and construction sites. These decreases may, in turn, be reflected in certain carnivore or raptor species that depend on small mammals for prey.

During the construction phase, small mammals will mainly be affected by the clearing of the impoundment area, the borrow pits and the construction camp. Over 110 km^2 of forest will be cleared. The species that are restricted to forest habitats and will thus be most affected are porcupines, snowshoe hares, pygmy shrews, and red squirrels. Small numbers of hares and porcupines, and extremely small numbers of pygmy shrews were observed in the project area. Because the area does not seem to be prime habitat for the former two species (Kessel et al. 1982), their regional densities are not expected to be affected by the project.

Red squirrels are common throughout the forested areas of the project area. Over 80 km^2 (3.5 percent) of their preferred spruce habitat will be cleared.

The other species that will be affected by the clearing during Watana construction will be the northern red-backed vole. Red-backed voles were found in nearly every habitat type in the Watana area, but were most common in spruce and cottonwood forests. Some decrease in overall abundance of this species is expected.

During the three-year filling stage, many of the areas cleared during construction will be colonized by early successional plant species and small mammals. Meadow voles are expected to thrive in such areas (Dabbs et al. 1974). Tundra voles, masked shrews, and arctic shrews may also recolonize these areas. As water levels rise during the filling stage, these populations of small mammals will be displaced, and most will be drowned. However, no substantial reductions in regional populations are expected as a result of these effects.

The major impact on small mammals during the operation phase of Watana Dam will be the changes caused by succession of disturbed areas such as the borrow pits and camps, and of the newly exposed land downstream of the dam. Species that occur in grasslands and early successional communities will be favored initially. These include meadow voles, and in some cases, tundra voles, masked shrews and arctic shrews. As succession progresses to shrublands, the habitat will improve for species such as northern red-backed voles and masked shrews. Any revegetation using non-native grass species will favor meadow voles, perhaps to the exclusion of other species (Bodrer and Wooley 1974). Attempts to reforest areas using tree seedlings are unlikely to succeed because of girdling by the high densities of meadow voles expected in disturbed areas.

(b) Devil Canyon Development

(i) Moose

Because of steep topography and extensive mature forests in the Devil Canyon area, fewer moose occur in this portion of the Susitna basin than in the area to the east of Watana Creek (Ballard et al. 1982a). Distributions of moose observed during surveys in March 1981 suggest that moose were not common in the vicinity of the Devil Canyon dam site but became more abundant in upstream areas near the Watana dam site. Ballard et al. (1982a) estimated that 30 moose were present within the Devil Canyon impoundment area during a census in late March 1981. Because of the mild winter conditions, this census probably underestimates the number of moose that would be present during winters with deeper snows.

Because of the low numbers of moose in the Devil Canyon area, impacts on moose in this region are of less concern than in the Watana development area. The range of impacts to moose that may result from the Devil Canyon project are similar to those already discussed for the Watana project. Potential impacts include loss of habitat, alteration of habitat, interference with seasonal movements, mechanical and human disturbance, hazards associated with the drawdown zone, and hunting mortality. Impacts associated with the access roads, the railway and transmission lines are discussed in Section 4.3 (c) and (d).

- Construction

Construction of the Devil Canyon dam will involve intense construction activity at the actual dam site, establishment of a temporary camp, removal of the forest cover in the impoundment, and the excavation and transportation of borrow material. The most important effects of construction on moose will be habitat loss, mortality, interference with seasonal movements, and disturbance. As discussed for the Watana project, alteration of habitat resulting from construction activities will be minimal and effects on moose will be negligible.

. Habitat Loss

An estimated 32 km^2 will be cleared within the Devil Canyon impoundment area and an additional 214 ha will be used for operational areas, campsites and borrow pits. Losses of major forest cover types in relation to their availability indicate that the greatest proportion of losses will occur in woodland spruce, open spruce, and mixed forest cover types (Table 1). Because moose in the Susitna basin were most commonly relocated in spruce forest than in any other forest cover type (Ballard et al. 1982a), the loss of spruce habitat in the vicinity of Devil Canyon may be important to moose. However, the limited area of bottomland habitats and the steep slopes of the Susitna River valley in the Devil Canyon area probably limits present use by moose, and the loss of valley habitats in the impoundment area may not be as serious as it initially appears. Although almost all of the low elevation habitat will be lost, moose do not appear to commonly winter in the Devil Canyon area. As a result, loss of low elevation habitats probably will not appreciably alter overwinter survival of moose in the Devil Canyon area.

- Interference with Movements

  The Devil Canyon impoundment generally will not exceed 1.6 km in width. Clearing of vegetation in the impoundment area may present a visual barrier to moose movements, and disturbances associated with clearing operations and construction could block or alter migration paths across or along the river. Moose relocations in the Devil Canyon area suggest that no major movement corridors for moose exist within the Devil Canyon impoundment area, but more frequent crossings may occur once the Watana impoundment is present.

- Disturbance

  Effects of disturbance on moose in the Devil Canyon area will be minimal and will be similar to those impacts discussed for the Watana project.

- Mortality

  Although a few moose may be killed as a result of collisions with vehicles or other accidents associated with construction areas, the effect of those mortalities on moose populations will be negligible. The major mortality factor associated with the construction of the Devil Canyon dam will be the probable increase in hunting associated with the influx of construction workers and other personnel to a previously remote area. Because moose will be more abundant in the Watana area than in the Devil Canyon area, hunting activity by Devil Canyon personnel will likely be concentrated to the east of the project area. Effects of hunting on moose are described in more detail for the two development areas in Section 4.3(c), (i).

- Filling Operation

The filling phase of the Devil Canyon impoundment is estimated to be approximately 2 months (as opposed to 3-4 years for the Watana project). In addition, the drawdown zone (to 15 m in some years during August and September) will be less than 1 m for most of the year. Because of the smaller area, local topography, the small drawdown zone during most of the year, and the rapid filling sequence, the effects of the Devil Canyon project on moose will be much less severe than those of the Watana project. The major impacts to moose will be alteration of habitat, loss of habitat, blockage of movements, mortality, and disturbance.

. Alteration of Habitat

As discussed for the Watana project, the Devil Canyon impoundment will cause some alterations of vegetation in the vicinity of the impoundment and in areas downstream from the dam.

Alteration of vegetation in the vicinity of the impoundment may occur as a result of several microclimatic changes such as seasonal temperatures, wind direction and speed, and ice fog. Effects of these changes on moose will probably be minimal (Section 4.3 (a), (i)).

Alteration of vegetation downstream of the Devil Canyon site, however, may affect the distribution, abundance, and quality of moose habitat. The combined effects of the Watana and Devil Canyon dams will result in increased water temperatures in downstream portions of the river, and it is anticipated that the Susitna River will remain open from the Devil Canyon dam to Talkeetna. Flow regimes following completion of the Devil Canyon dam are not expected to differ greatly from flow regimes of the Watana project. Hence, no additional differences in vegetation resulting from lower water flows are expected when the Devil Canyon dam becomes operational.

Open water in the Devil Canyon-Talkeetna reach of the Susitna River will affect vegetation in several ways. Steam fog will be common over the open water reach during winter. Because of the high moisture content of the air, icing of vegetation along the river will occur. However, the area of riparian habitat that will be affected depends on several topographical and climatic factors, and cannot be accurately predicted. It is also not known if plant productivity will be detrimentally affected by icing or if moose will utilize iced winter browse. As a result, impacts on moose associated with vegetation icing along the Devil Canyon-Talkeetna portion of the Susitna River are difficult to assess.

Because of the open water conditions in the Devil Canyon-Talkeetna reach, ice scouring of lower level riparian areas will not occur during the spring. Annual disturbance of successional growth in these areas will be reduced (although flooding will still scour some areas) and the area may succeed to riparian shrub communities. If this is the case, moose may benefit from an increased availability of riparian habitat.

As discussed for the Watana project, bankfull flooding will be reduced by the Susitna project. Riparian communities on higher ground of the river channel will gradually succeed to cottonwood forest but at the same time will extend downward into the newly-exposed areas of the river channel. Periodic flooding for fisheries management may provide sufficient disturbances of these riparian communities to maintain productive riparian growth.

. Interference with Movements

Movements of moose in the vicinity of the Devil Canyon impoundment and downstream of the dam may be affected by the Devil Canyon project. Moose attempting to cross the impoundment area may be inhibited by visual factors such as the 1.6 km wide impoundment or the presence of open water areas in winter. The width of the impoundment is not likely to present a physical barrier to moose in summer, but winter open water areas could deflect movements.

Moose in the Devil Canyon-Talkeetna reach of the Susitna River overwinter in riparian habitats and on river islands of the Susitna River (Modafferi 1982). Parturient cows apparently prefer to calve on river islands or in riparian areas, presumably because of the availability of high quality forage and reduced numbers of predators (Stringham 1974). The presence of open water between the dam and Talkeetna may interfere with use of these river island habitats during the winter and the early portion of the calving period. Moose in northern British Columbia are not known to cross sections of open water downstream of dams during winter (F. Harper, pers. comm.). The effects of exposure to sub-zero temperatures following crossing of open water would presumably physiologically stress moose during a period when their energy balance is already precarious.

. Disturbance

Mechanical and human disturbance should decline in the Devil Canyon area once the dam becomes operational. Although it is not known to what extent the region will be used for recreational activities, increased access would maintain disturbance levels at a higher level than is currently encountered, but at a level much lower than during construction. If animals are not directly harassed, disturbances during the filling and operation stages will at most have a slight effect on moose distributions.

. Mortality

During the filling and operation of the Devil Canyon dam, moose mortality may increase as a result of hunting and accidental deaths (see Section 4.3 (a), (i)).

. Devil Canyon: Summary of Impacts

The construction and operation of the Devil Canyon dam will likely have only a moderate to minimal impact on moose populations in the upper Susitna basin. Because the Devil Canyon project will follow the Watana development, moose populations will already have been greatly reduced. By comparison, further reductions resulting from the Devil Canyon dam will be minimal. The most substantial impacts of the Devil Canyon project are, in order of decreasing severity, loss of habitat, blockage of movements, alteration of habitat, accidental mortality, and hunting mortality.

Effects of habitat alteration will be minimal in the vicinity of the impoundment. In downstream areas, however, increased water temperatures with subsequent open water conditions could reduce the availability and productivity of winter browse in the Devil Canyon-Talkeetna reach of the river. Moose in this area overwinter and calve in these riparian communities and generally spend most of the year within a narrow corridor bordering these areas. Effects on the few moose occurring in this area would be moderate to severe.

Clearing and inundation of the impoundment area will result in the permanent loss of small areas of winter range, calving areas, and breeding areas. Effects on moose may be moderate to minimal.

Hunter mortality, blockage of movements, and accidental mortality will have only minimal impacts on moose.

(ii) Caribou

Few impacts of the Devil Canyon development on caribou are expected. The impoundment area, particularly the area near the dam site, has received little use by caribou either historically or in recent years. A small portion of the Nelchina herd may occasionally cross the impoundment, but because the crossing hazards are expected to be less severe than those associated with the Watana impoundment, no subtantial impacts are expected. There may be some impacts on caribou resulting from aircraft disturbance and the Watana to Devil Canyon road segment -- these will be similar to those associated with the Watana development, and are discussed in Section 4.3 (a), (ii) and 4.3 (c), (ii).

(iii) Dall Sheep

The construction, filling and operation of the Devil Canyon Dam will have no direct impact on any of the three Dall sheep populations in the upper Susitna basin. All three populations are far removed from the dam site.

Any increase in air traffic to the Watana airstrip due to the construction of the Devil Canyon dam has the potential for disturbing the Mt. Watana-Grebe Mt. population (coming from the south) or the Portage-Tsusena Creek population (coming from the north). The effects of aircraft traffic on Dall sheep are discussed in Section 4.3(a), (iii).

(iv) Brown Bears

The impacts of the construction of the Devil Canyon dam on brown bears will be similar to those during construction of the Watana dam, except that the number of bears affected will be much smaller. The area near the Devil Canyon site is at lower elevations and is not prime habitat for brown bears.

Some human/bear contact is likely to occur during the construction of the dam, leading to increased bear mortality. As discussed in Section 4.3(a), (iv). improper food and garbage handling practices will increase problems with bears. Avoidance of areas of human activity by bears will cause some habitat loss, but because a relatively small area of low value to brown bears will be affected, no population effect is likely.

Steep canyon walls will confine most of the Devil Canyon impoundment, thus minimizing the area inundated. There will be some loss of riparian areas, with its associated food sources - berries, early spring greenery, and moose calves. No potential denning areas will be affected. Other long-term effects of the Devil Canyon development, such as increased hunting and aircraft disturbance, will be similar to those associated with the Watana development, but at a reduced scale.

(v) Black Bears

The impacts of the Devil Canyon development on the local black bear population will be substantially less than those for Watana, because only a small portion of acceptable black bear habitat in that area will be lost. The impact on denning areas will also be considerably less; only one of 16 den sites found in the vicinity of the Devil Canyon impoundment will be flooded. Most of the potential impacts discussed for the Watana development will exist, but at a much-reduced level. Downstream effects of the Devil Canyon impoundment should be the same as those discussed in Section 4.3(a), (v).

(vi) Wolf

Impacts from the Devil Canyon development will be very similar to those from the Watana development. No known dens or rendezvous sites will be affected, but this area has not been intensively searched for dens. Nevertheless, loss of den sites is not expected to have significant effects on wolf populations. Similarly, disturbance is not expected to affect wolves except possibly at den sites during May and June. Wolf pups moved from dens because of disturbance when they are very young may not survive (Ballard et al. 1982b).

It was argued in Section 4.3(a), (vi) that wolf populations are unlikely, at their present levels, to be seriously affected by loss of prey species. The same situation holds for the Devil Canyon development; only in the event that management objectives require higher wolf populations would loss of prey species become a potentially significant impact.

(vii) Wolverine

The effects of the Devil Canyon development on wolverine will be insignificant except for the potential of increased trapping as discussed in Section 4.3(c), (vii). Because wolverines range over large areas, the relatively minor changes in food availability and the effects of intensive human activity near the construction site should not noticeably affect the few wolverines near the Devil Canyon development area.

(viii) Belukha Whale

As discussed in Section 4.3(a), (viii), the combined operation of Watana and Devil Canyon should have no detectable effect on belukha whales in Cook Inlet.

(ix) Beaver

The Devil Canyon project could have a beneficial effect on beaver if the reservoir level is stable within 1 m for most of the year as proposed. Several beaver colonies now occurring within Borrow Area K and near the camp site will be adversely affected, but a slight improvement in downstream habitat resulting from a lack of ice cover down to Talkeetna, and the possible use of the reservoir by beavers, will offset these impacts.

No beaver are known to occupy the Devil Canyon Reservoir and thus no adverse impact is expected as a result of inundation. However, during the period between the filling of the Watana and Devil Canyon reservoirs, some beavers may colonize this reach and be initially displaced. Approximately 10 beaver are known to occupy the lakes in and adjacent to Borrow Area K and the proposed construction camp, and these areas will probably be lost during construction.

Downstream effects should be the same as with Watana only, except that the lack of ice cover from Devil Canyon to Talkeetna may allow beaver use of some sloughs and side channels that are subject to freeze-out when ice cover is present.

(x) Muskrat

Construction of the Devil Canyon Dam should have no direct impacts upon muskrats as no suitable habitat is known from the construction or borrow sites (Table M-1). Some habitat loss may occur from building camp facilities if ponds and lakes are filled in for roads, work pads, etc. Downstream effects will be similar to those described in Section 4.3(a), (x).

If construction camp personnel and their families are allowed to trap in the area, muskrat populations throughout the lakes lying on either side of the Susitna River could be affected. Gipson et al. (1982) found muskrat sign in these lakes, and noted their vulnerability to trapping.

No impact is foreseen from vegetation removal in the impoundment zone, or from subsequent flooding.

(xi) Mink and Otter

Effects of the Devil Canyon project on mink and otter will be similar to those already discussed for the Watana project (Section 4.3(a), (xi)), but because of the smaller size of the impoundment and the more stable water level, effects will be less severe. Because mink are most abundant east of Kosina Creek, the Devil Canyon project will probably have little effect on the regional population. Major impacts to otter and mink are loss of habitat, reduction in prey availability, increased human disturbance, and barriers to movement.

Because the combined Devil Canyon project and the Watana project will probably result in permanently open water from Devil Canyon to Talkeetna, mink and otter may be positively affected. Both species prefer areas of open water in rivers and streams in winter (Barber et al. 1975). Open water areas in the reservoir during winter should also have beneficial effects.

(xii) Coyote and Red Fox

Coyotes are probably slightly more common in the Devil Canyon area than in the Watana area but they are still sufficiently uncommon that the project is unlikely to have any effect on them. As in the case of the Watana development, foxes will be affected primarily by increased trapping and by destruction of nuisance animals if garbage is not regularly incinerated and regulations against feeding enforced. Habitat loss will not be a major impact since foxes tend to occur at mid and high elevations rather than in the forested areas along the river.

(xiii) Other Terrestrial Furbearers

Lynx, weasels, and marten will all be affected by the Devil Canyon development primarily by loss of habitat. As in the case of the Watana development, no estimates of the potential reduction in numbers of lynx and weasels can be made. Approximately 14 marten will be lost to the impoundment and construction sites, borrow pits, etc. If both Watana and Devil Canyon are built, about 11.5 percent of the Upper Susitna Basin marten population will be lost (access road and transmission line not included). Both of these estimates are based on the conservative marten density derived in Section 4.3(a), (xiii).

Marten, lynx, and weasels may be disturbed by construction activity but there is no evidence that they will vacate areas as a result of these disturbances.

(xiv) Raptors and Ravens

- Construction and Filling

Construction and filling of the Devil Canyon reservoir would have the same kind of effect on raptors and ravens as the Watana development, and would increase overall impact to those species; however, the increase would repesent a relatively small proportion of the total impact of both developments.

. <u>Habitat Loss</u>

At least 2 (12%) of the 16 total known golden eagles nesting locations in the general vicinity of the Devil Canyon impoundment will be directly lost (Table E.3.W76). The cumulative loss of golden eagle nests to both projects represents 41-50% of known nest locations in the project area (Table E.3.W75).

No bald eagle nesting locations will be lost as a result of Devil Canyon construction and filling.

No know gyrfalcon nesting locations will be inundated by the Devil Canyon reservoir, but one of three total locations may be located in Borrow site K (see Table E.3.W76). If so, this nesting location may be lost during material excavation, but overall impact to this species in the upper basin will remain minimal.

Over (33%) of three known goshawk nesting locations in the general vicinity of the Devil Canyon project will be directly lost to clearing and filling of the Devil Canyon reservoir (Figure E.3.W30, Table E.3.W75 and E.3.W76). The nest location that will be lost is one of two discovered to date upstream of the Devil Canyon dam site. Although the loss of this goshawk nesting location doubles the number lost as a result of both reservoirs, total impacts to this woodland species are anticipated to remain minimal because appropriate nesting habitat appears to be relatively limited in both impoundments.

Four (19%) of 21 previously used raven nesting locations in the general vicinity of the Devil Canyon project will be lost as a result of construction and filling of the Devil Canyon Reservoir (Figure E.3.W30 Tables E.3.W75 and E.3.W76). All four will be lost by inundation, and one additional nest (R-19) will remain only a few meters above maximum flood level (see Figure E.3.W30).

Although construction and filling of the Devil Canyon Reservoir will increase the number of used nesting locations to 13-14 (62-67% of the previous total) (see Table E.3.W75), total impact to ravens is still anticipated to be relatively low. Loss of nesting locations in Devil Canyon will probably increase the importance of remaining cliff areas to there (see Table E.3.W77) and in side tributaries. It may also increase the importance of trees for nesting (see Section 4.3 4.3(a), (xiv)).

. <u>Disturbance</u>

Five golden eagle nesting locations within or on the edges of the Devil Canyon impoundment may be susceptible to disturbance from reservoir clearing operations (see Figure E.3.W30: the two exceptions are GE-19 and GE-18). One and perhaps two of those locations will be inundated later (GE-13 and GE-14). One of the five locations (GE-11) may be susceptible to disturbance from the clearing operations in the Devil Canyon area only if it remains following the excavation of materials from Watana Borrow Site E. One other gryfalcon nesting location (GE-18) is about 0.9 km downstream of the Devil Canyon dam site and may be susceptible to considerable disturbance as a result of activities associated with the construction of the dam itself.

No known bald eagle nesting locations appear susceptible to disturbance as a result of activities associated with the construction of the Devil Canyon dam, clearing operations within the impoundment zone, or filling of the reservoir.

Two known gyrfalcon nesting locations in the Devil Canyon impoundment area may be susceptible to disturbance. One of those locations (Gyr-2) may be susceptible to some disturbance during the reservoir clearing, and the subsequent increase in human presence as recreation activities develop and increase along the impoundment edges. A second location (Gyr-3) may be susceptible to considerable disturbance from excavation and transport of materials from Devil Canyon Quarry Site K.

At least two known goshawk nesting locations (tree nests) may be susceptible to disturbance from construction and filling of the Devil Canyon Reservoir. One of these nesting locations (GOS-2) is within the Devil Canyon reservoir. It may be susceptible to disturbance from material excavation (0.2 km to the west) at Watana Borrow Site I (see Watana disturbance goshawks) and will eventually be cut down during reservoir clearing operations prior to inundation (Figure E.3.W30). The other nesting location (GOS-3) is situated well above the reservoir level, but disturbance from human presence may increase as recreational activities develop along the impoundment edges.

Six raven nesting locations within or on the edges of the Devil Canyon impoundment may be susceptible to disturbance from reservoir clearing operations, but four of these will eventually be inunudated (see Figure E.3.W30: the exceptions are R-19 and R-21). One of the locations not inundated (R-19) will remain only a few meters above maximum flood level. The other nesting locations that is not inundated (R-21) is about 0.7 km downstream of the Devil Canyon dam site and may be susceptible to disturbance during construction of the dam.

(xv) Waterbirds

The Devil Canyon impoundment will benefit the waterbirds in the upper basin, although initially the clearing and construction activities may cause a temporary loss of suitable habitat. The open water area near each end of the reservoir should benefit some early and later migrants when other waterbirds are frozen.

Downstream effects will be similar to those discussed in Section 4.3(a), (xv). These will consist mostly of distributional shifts and minor changes in relative abundance of riparian species as newly-formed vegetation proceeds through the successional sequence described in Section 3.2.

(xvi) Other Birds

The Devil Canyon development will result in the same types of impacts (habitat loss, habitat alteration, disturbance, direct mortalilty) with the same types of effects on terrestrial and shoreline birds as the Watana development (see Section 4.3(a), (xvi)).

Flooding of the Devil Canyon impoundment will increase the proportionate loss of mixed forest in the upper basin by 3% over that lost to the Watana development (Table E.3.W78). The Devil Canyon impoundment area contains only small stands of a few hectares of birch forest, the habitat with the largest proportionate loss to the Watana development. These additional birch forest stands will be lost by flooding of the Devil Canyon impoundment. Overall, an estimated 5248 to 7602 breeding pairs (0.2% of the upper basin population) will be lost to the Devil Canyon development (Table E.3.W79). For a few species, the proportionate loss to Devil Canyon results in a substantial increase over the loss to the Watana Development alone. For example, if both developments are built, an estimated 19.9% of the upper basin brown creeper population will be lost (Table E.3.W80). Devil Canyon will also result in a 3-5% increase in the number of spruce grouse, yellow-rumped warblers and northern water thrushes lost.

The drawdown of the Devil Canyon impoundment will be small and no feeding habitat for shorebirds will be created. As is the case for the Watana development, the dipper will be affected by loss of breeding habitat in the lower reaches of feeder streams and loss of winter habitat (open water) in both feeder streams and the Susitna River itself. However, open water in the reservoir may compensate for this loss.

(xvii) Non-Game (small) Mammals

The types of impacts on small mammals that will result from construction of Devil Canyon Dam will be similar to those already discussed for the Watana Dam (see Section 4.3(a), (xvii). The major impact will be loss of habitat due to clearing operations. The total area affected (approximately 34 km^2) and percent of forested land affected (0.7 percent) are much smaller than in the Watana reservoir area. The impacts on small mammals are thus expected to be proportionately smaller.

(c) Access

(i) Moose

Construction and operation of the gravel the Watana access road from the Denali Highway to the Watana dam site and the later construction and operation of the Devil Canyon access road will have few direct impacts on moose populations in the Susitna basin. Possible impacts include a loss of habitat, alteration of habitat, disturbance and subsequent avoidance of the highway, interference with seasonal movements, and mortality. Moose will be affected to a much greater degree by the indirect effects of the access road, particularly hunting. Moose numbers would decline as a result of hunting mortality and avoidance of the corridor by moose. The railway from the Gold Creek area will have similar effects to those mentioned for the access roads, except that hunting mortality should be lower (as a result of poor vehicular access) and collision mortality during the winter may be higher.

- Mortality

The primary impact of the access roads will be the provision of improved public access to previously remote areas in the Susitna basin. In turn, improved access will probably result in localized declines in moose as a result of hunting and avoidance of the highway corridor because of disturbance. Declines in moose along newly-opened roads or along roads in areas opened for hunting have been reported for a number of northern areas (Goddard 1970; Cumming 1974; Ritchey 1974; Beak 1979). Although a good portion of these declines in moose were the result of hunting mortality, moose probably also avoid areas in the vicinity of access corridors during the hunting period.

A decline in moose numbers during construction of the Watana access road can be expected as a result of hunting. Effects would probably be most severe in the vicinity of campsites or the townsite. Public access to the Susitna basin will increase once the road is operational and further increases in hunting pressure will occur with resultant increases in hunting mortality of moose. Because the moose population will already be stressed by impacts associated with the Watana development and the subsequent redistribution of moose within the Susitna basin, disturbances associated with hunting and hunting mortality may further aggravate impacts to the moose population. Because the Watana development will reduce the carrying capacity of the Susitna basin for moose, it is possible that moose numbers will exceed those optimal for sustained productivity. Assuming that surplus moose may be present, carefully managed hunting may effectively mitigate for some indirect project effects.

Construction and operation of the Watana-Devil Canyon access road segment and the railway will result in similar but less severe impacts on moose. The Devil Canyon segment will provide new access to a relatively smaller area, much of which is poorer quality moose habitat than in the Watana dam area. The railway will not provide as easy an access route to the general public as the roadways, and its use can be better controlled. Hunting pressure consequently will not increase as in the case of the access roads. In addition, much of the area that will be affected by railway access supports relatively low numbers of moose as compared to lower reaches of the Susitna River.

During the construction and operation of the access roads and railway, moose may be killed as a result of collisions with vehicles. However, low volumes of road traffic (fewer daily trips than now occurring on the Denali Highway) are expected along the Watana and Devil Canyon access roads even during construction of the dams, and the numbers of kills will likely be small. Consequently, effects on the population will be negligible.

In contrast, collision mortalities along the railway could be substantial. An additional 8 train trips per week in each direction are expected during the construction of the Devil Canyon dam. Rausch (1958) reported adjusted kill totals of 366 and 179 moose kills along a 86.9 km section of the Alaska Railway (Houston to Talkeetna) during the winters 1955-56 and 1956-57, respectively. During the winters of 1970-1971 through 1978-79, annual moose kills along the Willow-Talkeetna portion of the Alaska railway ranged from 0 to 151 animals (Alaska Dept. Fish and Game, unpubl. data). Because moose are easily trapped in the steep snow embankments along railway lines and are usually more abundant in valley bottom habitats during winters with high snows, higher numbers of collision mortalities occur along rights-of-ways in low elevation areas during severe winters. Moose in the Devil Canyon-Talkeetna area are believed to winter in lower elevation habitats along the valley bottoms (Modafferi 1982). As a result, it is likely that the operation of a low elevation railway linking Devil Canyon to the Alaska railway will result in numbers of collision mortalities of moose that will vary in relation to snow depths and winter severity.

- Loss of Habitat

Construction of the Watana and Devil Canyon access roads and the railway will result in loss of habitat associated with the construction corridor and borrow pits. Although the actual removal of moose browse will be small in relation to its availability in other areas of the Susitna basin, the effective loss may be greater if moose avoid the access corridors or if migration routes are blocked. As discussed above, moose will tolerate disturbance along access corridors if they are not hunted. However, if hunting is permitted, moose may avoid an area of several kilometers from the corridor, consequently increasing the effective area of lost habitat.

Based on existing information, no special use areas for moose such as wintering range, calving areas, or breeding concentrations will be rendered unusable by the road access corridors. However, because most special use areas will be inundated by the impoundments, these road corridors could affect the location of new special use areas. Anticipating such changes is obviously difficult.

The problem of railway corridors in moose wintering areas and resulting collision mortalities has already been discussed. Because a low volume of train traffic is anticipated, it is unlikely that the railway will interfere with movements to or from wintering range or calving areas.

- Alteration of Habitat

Construction of the access road and railway will necessitate the use of gravel berms which may impede or alter drainage systems (Boelter and Close 1974, Kemper et al. 1977). Permanent flooding of forested areas may result in the loss of some moose habitat through killing of trees and shrubs. However, growth of aquatic plants within flooded areas may partially compensate this loss by providing additional summer forage. Drainage of wetland areas may result in a temporary increase in the growth of seral shrub communities, but without periodic flooding or disturbance, these areas will eventually develop into forest stands with low browse production.

- Interference with Seasonal Movements

The proposed road access corridors will cross several areas where moose migrate seasonally between summer and winter ranges (Ballard et al. 1982a). Concentrations of movements by radio-collared moose that may be affected by the Watana road include the Watana-Butte Creeks area, and the Watana-Deadman Creeks area (Section 4.2 (a), (i)).

During construction, mechanical activities may prevent some moose from crossing the road corridors, primarily as a result of moose avoiding the construction area. Avoidance of the road corridor would probably be most severe during the hunting season, if hunting is permitted. Steeply-sloped road berms and/or the creation of deep snow embankments from road-plowing may act as physical barriers to moose crossings. As discussed earlier, the railway may interfere with movements of moose during the winter and early spring periods when snow embankments may either block movements by moose or trap animals within the cleared right-of-way.

(ii) Caribou

The access road between the Denali Highway and the two dam sites is likely to have a substantial effect on caribou movements. Few caribou movements have been recorded in the area traversed by the Devil Canyon to Watana Dam segment, and thus the northern segment between the two dams and Gold Creek should not pose a serious problem to caribou. The segment between the Denali Highway and Watana Dam, however, traverses an historically-important area of the herd's range, which is currently used by a resident subherd of up to 2500 caribou and also by some caribou from the main herd. The road is most likely to affect the herd by increasing mortality from collisions with vehicles and from hunting, and by altering movements between the area west of the road and the remainder of the herd's range. There may also be a slight increase in wolf predation in the area, since wolves often use roads to their advantage while hunting caribou (e.g., Roby 1978).

The most detailed information on the effects of roads and associated human activities (e.g., vehicle traffic, construction activity, presence of workers) on caribou comes primarily from four sources: (1) studies by the Alaska Department of Fish and Game (ADF&G) along the Trans-Alaska Pipeline (TAPS) corridor since 1974, and along the Kuparuk oilfield access road since 1978; (2) a two-year study by Fancy (in press) in a floodplain area used by large numbers of caribou moving to and from insect-relief areas; (3) data from a study by Roby (1978), who worked with ADF&G along the TAPS corridor; and (4) a two-year study conducted along the Kuparuk Oilfield access road by Curatolo et al. (1982). Alyeska Pipeline Service Company is also funding a three-year study along the TAPS corridor as a "second opinion" to the ADF&G studies; however, no reports have been released after two years of study. All of these studies involve the Central Arctic Herd on Alaska's North Slope.

The results of these studies are somewhat contradictory, and as a result, caribou biologists disagree on the severity of road effects on caribou. ADF&G studies (Cameron and Whitten 1979, 1980; Cameron et al. 1979) have concluded that caribou cows and calves avoid the Prudhoe Bay oilfield, based on a lower percentage of calves in caribou groups observed from the roads in their study area as compared to aerial sightings over a larger area. However, the calf percentage may sometimes vary independently of human developments and activities (Fancy, in press), and different habitat preferences and the latitudinal segregation of bull and cow groups makes it difficult to interpret differences in the calf percentage over a large study area. Along the Kuparuk oilfield access road (oriented E-W and thus not confused by latitudinal biases), calf percentages have not been found to differ from those expected in three years of study (Cameron et al. 1981). During an aerial calving survey along that road in 1980, no calves were seen within 4 km either side of the road, but this was not the case in 1978 and 1979. Few calves have been born within the Prudhoe Bay complex in recent years; however, equally low numbers of neonatal calves are sighted between the Sagavanirktok and Shaviovik Rivers (east of the oilfield), where no roads or other developments occur. The Central Arctic Herd has been steadily increasing in size each year, and productivity has been "excellent" (Cameron et al. 1981), in spite of the localized effects on caribou distribution and group composition.

Recent detailed studies involving continuous observations of caribou as they approach roads and pipelines have found that most caribou will cross roads with light to moderate vehicle traffic, but that caribou will often first try to find a way around the obstacle (paralleling movements), and some groups (10-14% for the most detailed study) may refuse to cross at all (Fancy, in press). Preliminary results by Curatolo et al. (1982) have found that the proportion of groups that crossed the Kuparuk oilfield road and pipeline was significantly less than that expected (control). Many groups left their study area paralleling the road and pipeline, and thus the proportion of groups that eventually crossed could not be determined.

The responses of individual caribou to roads and traffic are extremely variable; some animals appear to avoid lightly travelled roads entirely, whereas others will cross roads during rates of traffic exceeding one vehicle per minute with no observable response. In general, however, moving vehicles and/or the presence of workers will alter the local movements and behavior of caribou. Horejsi (1981) reported that 88% of the caribou he observed along the Dempster Highway reacted to a moving pickup truck by running or trotting away. A fleeing animal can expend eight to twenty times the cost of basal metabolism, at the expense of body growth, development, and reproduction (Geist 1975).

The greatest concern for disturbance effects on caribou is for cows in late pregnancy and cows with young calves. Female caribou are particularly sensitive to disturbances during the calving period (Lent 1966, Bergerud 1974, Calef et al. 1976, Surrendi and DeBock 1976), and disturbances at this time are more likely to result in lowered recruitment because of premature travel by calves, disruption of cow/calf bonds, or trampling (Lent 1966, Geist 1971, Bergerud 1974, Surrendi and DeBock 1976). Some calving has been documented north of the Susitna River, but the road has been realigned so that it is to the west of the areas where most calving has recently occurred. Cows calving in the area may avoid the road during the period of heavy use, but this should not affect herd productivity.

About 20-30 truck trips per day are scheduled during the construction period for the Watana dam. The frequency of all traffic (scheduled and unscheduled) is not known, but several trips per hour are likely. If the road is opened to the public during or after construction, even higher traffic rates are likely. Some caribou will cross the road regardless of high traffic frequencies, but the majority would probably cross only if lulls in traffic were provided. Since the area west of the road is currently a peripheral part of the herd's range, failure of some animals to cross the road should not cause a major impact to the herd. If the herd management plan is revised to allow a large increase in the herd size, however, the importance of the area to the herd will greatly increase. It is thus important to design and operate the road so as to permit free crossings by caribou during the operation phase of the project.

The physical presence of a raised gravel road, in the absence of vehicles and human activities, would not be an insurmountable barrier to caribou movements (e.g., Surrendi and DeBock 1976). The exception to this is that plowed or blown snow along the road could, in combination with the raised road surface, act as a physical barrier to caribou movements (Surrendi and DeBock 1976). Caribou tend to select the lowest berms when crossing roads (Cameron and Whitten 1976; Surrendi and DeBock 1976; Roby 1978), and various studies have shown that caribou are wary of berms they cannot see over (e.g., Hanson 1981). It is thus important to keep berm heights as low as possible and to utilize an inobtrusive design which makes the road less conspicuous in areas of heavy caribou use.

The Nelchina herd has been important to both sport and subsistence hunters because of its size and proximity to population centers. In 1981, 6,662 people applied for 1,600 permits to hunt for Nelchina caribou. The permit system currently in use will have to be continued if only the annual increment is to be harvested as stated in the herd management plan (ADF&G 1976). Public access provided by the Denali access road will have a greater effect on the distribution of hunting pressure than it will on the actual number of caribou harvested, since hunter success is currently very high. The Susitna-Nenana subherd is resident in the access road area and, although the rate of exchange of individuals with the main herd is unknown, the presence of the Watana impoundment in conjunction with heavy hunting pressure will probably result in a substantial decrease in this subherd.

(iii) Dall Sheep

The effect of vehicle traffic along the access road should be insignificant since sheep are not expected to occur close to the roads. MacArthur et al. (1982) found that only 19 of 215 documented passes (8.8%) of sheep by vehicles evoked heart rate responses, usually of low amplitude. Moreover, 73.7% of all heart rate responses occurred when vehicles passed within 25 m of the sheep. They reported that only 2 of the 215 vehicle passes (0.9%) they recorded evoked withdrawal responses by sheep. In Denali National Park, Tracy (1977) found that the strength of reactions and the percentage of sheep showing visible reactions to buses and visitors decreased with increasing distances between the sheep and the road. She recorded no reactions by sheep at distances exceeding 750 m from the road, whereas strong reactions were only recorded at distances less than 400 m. Dall sheep have continued to use lambing and wintering areas along the Dalton Highway (Hemming and Morehouse 1976; Fancy 1980), in spite of intensive pipeline construction and vehicle traffic along that road.

If the project area is opened to the public following construction, there will likely be an increase in hunting pressure in locations adjacent to the access roads and the reservoir. The number of sheep harvested in the area is not expected to greatly increase, however, because all or most legal rams in the area are already being harvested each year. Serious population depletions resulting from the increased hunting pressure are thus not expected to occur.

(iv) Brown Bears

Both the Denali-Watana and Watana-Devil Canyon access road segments traverse prime brown bear habitat. Potential impacts of the access roads on brown bears include interference with movements, increased hunting mortality, a decrease in acceptable denning and feeding areas, and direct mortalities from collisions with vehicles. Direct mortality from hunting will probably have the greatest effect on the population in the long-term.

Tracy (1977) reported on the reactions of brown bears to the Denali Park road. She found that the densities of bears in study plots away from the road were consistently greater than densities along the road, suggesting an avoidance of roads by bears even where no hunting occurs. Many bears have habituated to the road, however, and those seen near the road were frequently engaged in such activities as nursing, playing, and sleeping, which suggest security and relaxation. The literature also includes a paper by Elgmork (1976), who reported that construction of a network of logging roads in Norway resulted in a lower density of brown bears, and a report by Miller and Ballard (1982) on the apparent short-term deflection of brown bear movements by the Glenn Highway in Alaska.

The access road is likely to cause some alterations in the movements of brown bears, but there is little evidence to suggest that it will block bear movements altogether. However, because brown bears in the upper basin are hunted, they are not likely to feed on berries and other foods occurring adjacent to the road, and thus there will be a decrease in the availability of foods as a result of the road. It is also likely that brown bears will find the denning area used by three different bears in 1980 and 1981 near the proposed road unacceptable once the road is present. However, acceptable denning areas appear to be widely available in the upper basin, and the loss of areas near the road would be serious only if bears already in their dens abandoned them during road construction.

Although some brown bears are now harvested from the remote areas of the upper basin, most hunting occurs along or near the Denali Highway. The improved access resulting from the road and reservoir will probably cause a large increase in the number of brown bears killed by hunters in the basin.

(v) Black Bears

The access road will impact black bears primarily through improved access for hunters. Black bears do not usually occur near the proposed road north of the Deadman Lake area, and much of the Watana-Devil Canyon segment is at elevations above acceptable black bear habitat. Road construction could cause abandonment of dens, particularly in the lower Deadman Creek area and near the Devil Canyon damsite. The probability of bear mortalities due to collisions with vehicles is low.

(vi) Wolf

The major effect of the access route on wolves will be an increase in the numbers of hunters, trappers and construction workers able to shoot wolves in the area. However, wolves may also be affected by disturbance from construction activities and traffic, and small numbers may be killed by vehicles. The numbers killed by vehicles is likely to be greater if wolves become habituated to vehicles through being fed. Since wolves do habituate readily to traffic and noise under most circumstances, disturbance is unlikely to have major effects. However, wolves appear to be more sensitive to disturbance during the denning season. Carbyn (1964) documented abandonment of two wolf dens near highways after the roads were upgraded and traffic volumes increased. The proposed Susitna access route passes through the home ranges of at least three wolf packs. Two den sites and one rendezvous site are known from the general vicinity of the access route. Additional sites most likely exist and should be identified before the access route is finalized.

Impacts from increased access by hunters and trappers cannot be quantified but may be severe. As many as 8-10 wolves per year have been taken in the immediate vicinity of the proposed impoundments since 1976-77 (Ballard et al. 1982) in spite of the relative inaccessibility of the area at present. Increases in the number taken may be beyond the capability of the population to replace, or may reduce the ability of this population to produce excess animals that presently disperse to areas even more heavily hunted.

(vii) Wolverine

The direct loss of habitat due to the access road will have an insignificant effect on wolverine. Hornocker and Hash's (1981) statement that "the size and shape of (wolverine home) ranges were not affected by rivers, reservoirs, highways or mountain ranges" suggests that the road and associated traffic will also have an insignificant effect on wolverine movements and availability of prey. It is not clear if wolverine will utilize carcasses of animals killed by collisions with vehicles, but this is a possibility, especially during periods of infrequent vehicle use. The potential for wolverines to be killed by vehicles is very low, considering the low densities of wolverine and their wariness.

Increases in trapping pressure as a result of improved access is more likely to affect wolverines than any other project-related activity. Wolverines are highly susceptible to trapping because they travel widely and are readily attracted to baits. Hornocker and Hash (1981) reported that all of the wolverines they captured were missing one or more toes, and many had broken teeth; many of these mutilations were attributed to encounters with leg-hold traps. Van Zyll de Jong (1975) stated that "predation by humans appears to be the most likely factor to have affected the number of wolverines. Direct evidence of negative effects of human exploitation on wolverine populations is not available, but indirect evidence from declining production of wolverine pelts and the disappearance of the species from areas with relatively dense human populations strongly suggests that exploitation by man contributed to the decline." Fifteen of the 18 known wolverine mortalities in Hornocker and Hash's (1981) study were human caused. Increased trapping pressure in the Susitna basin will probably cause some instability in the social structure of the population, thus causing noticeable shifts in home ranges. However, effects of trapping mortality would be offset somewhat by emigration of wolverine from the large parcels of wolverine habitat surrounding the basin into the affected areas.

Wilderness or remote country where human activity is limited appears essential to the maintenance of viable wolverine populations (Van Zyll de Jong 1975, Hornocker and Hash 1981). However, Hornocker and Hash (1981) reported that they found "no differences in wolverine density between the wilderness and nonwilderness portions of our study area, nor was wolverine movement, habitat use, and behavior different. Marked wolverines used both areas and several individuals' home areas overlapped both wilderness and nonwilderness. The nonwilderness portion, about one-half of the study area, is used by humans primarily for logging and recreation. logging roads and foot trails provide access to river and stream bottoms and lower elevations during summer and fall months. Loggers, summer recreationists, and hunters make considerable use of those areas." They went on to say, however, that wolverines and humans were effectively separated because the wolverines were at higher elevations away from people during summer and fall, and little use of the area by humans occurs during winter when wolverines move to the lower elevations. A similar situation will exist in the upper Susitna basin; the most intensive human use of the area will occur in summer when wolverines are using primarily tundra habitats. Winter use of the impoundment areas, except for trapping, should be considerably less than that during snow-free periods.

(viii) Furbearers

The construction of the two access roads and the railway will result in some habitat loss for terrestrial furbearers, and may result in habitat loss for aquatic furbearers if wetlands are degraded. Minor effects on the local distribution of some species may also occur along the road. For example, Hawley and Newby (1957) believed that habitat openings were a psychological barrier to marten. Although subsequent studies have found that marten regularly cross openings 100 to 200 m wide (Koehler et al. 1975, Soutiere 1978), the access route may result in a redistribution of home ranges such that they are aligned with the road.

Similarly, some foxes may avoid the road area but most will probably habituate to traffic. Tracy (1977) found several fox dens within 100 m of the road in Denali National Park and observed foxes traveling along the road while vehicles were using it. However, such habituation to human presence probably occurs only in the absence of trapping pressure.

Access to the Watana site from the Denali Highway has the potential to negatively impact large numbers of beaver. Approximately 65 beaver occupy 18.4 km of upper Deadmen Creek, a relatively broad stretch along which the access route is proposed. Similar beaver densities may occur in adjacent areas designated as material sites. Use of the valley bottom for the road and material sites will negatively impact at least 40 beavers.

Two opposing scenarios are reported in the literature on possible effects of road construction on beaver habitat. In one (Watson et al. 1973), diversion or impoundment of stream and subsurface water flows by road berms has a negative effect on downstream beaver ponds and lakes through the introduction of heavy sediment loads and increased turbidity. These are the effects of bank instability caused by the clearing of riparian vegetation associated with rights-of-way construction and maintenance. Heavy sediment loads result in the gradual filling of downstream ponds and lakes; increased turbidity reduces light penetration and inhibits growth of aquatic vegetation.

Alternatively, ponding at culverts and bridges and restricted subsurface flows caused by road berms has often created attractive sites for beaver colonization. The use of bridges and culverts as dam sites by beaver is well documented (Bradt 1947, Hodgdon and Hunt 1953, Huey 1956, Longley and Moyle 1963, Rutherford 1964, Johnson and Gunson 1976). However, habitat improvement through the introduction of a road in beaver habitat along upper Deadman Creek is unlikely and a reduction in beaver numbers is expected there.

Muskrat along the proposed access routes will be impacted through habitat loss and increased trapping mortality. Gipson et al. (1982) found sign of over-wintering muskrat in several of the lakes lying along the proposed route from Watana Dam to Devil Canyon Dam. Many of these muskrat occur in conjunction with the high beaver densities noted along the proposed route from the Denali Highway to Watana Dam.

In addition to being very sensitive to water level changes which could occur due to draining or filling of ponds and lakes (Bellrose and Brown 1941), or den (MacArthur 1978). The small foraging area of muskrat, usually within 10 m of their house, makes them sensitive to loss of their preferred foods of aquatic and emergent plants (Butler 1940).

No substantial effects are anticipated on mink or otter populations with the possible exception of increased public access to streams that may be important to these species. Present information is insufficient to address these site-specific concerns but surveys during winter 1981 suggest that both mink and otter are primarily restricted to the mainstream of the Susitna River which is some distance from the access roads. The railway could potentially interfere with some areas of good mink and otter habitat.

The major impact of the access routes on furbearers is related to the probable increase in trapping pressure. The Susitna Basin is not heavily trapped at present and, for some species, the area may be a source from which animals disperse into more heavily trapped adjacent areas. The species that will be most affected by increased trapping pressure are probably marten, beaver, muskrat, and red fox. Marten are the most economically important furbearer in the basin; beavers and foxes are also heavily exploited in adjacent areas. Mink and otter may be affected to a lesser extent since they do not appear to be particularly desirable species in this part of Alaska (Gipson et al. 1982).

(ix) Raptors and Ravens

- Denali Highway to Watana Dam Site

Some nesting habitat for ground-nesting raptors (e.g., merlins, northern harriers, short-eared owls) may occur along the Denali-Watana section of the access road and may be lost; however, cliff-nesting habitat does not appear to occur within at least a few kilometers of the route, and only one tree-nest appears to be associated with it (Roseneau, pers. comm.).

No golden eagles, gyrfalcon, goshawk, or raven nesting locations will be lost as a result of road construction between the Denali Highway and the Watana Camp Site - Watana Dam Site.

One bald eagle nesting location (BE-6, see Table E.3.W76) in Deadman Creek will be physically destroyed by access road construction between the Denali Highway and the Watana dam site unless specific protective actions (e.g., realigning the access road westward) are taken. The active nest is located in a balsam poplar tree in a small stand of poplar and white spruce. The current road alignment passes directly through the stand of trees. This stand appears to be the best (and possibly only) potential bald eagle nesting habitat along Deadman Creek.

- Watana Dam Site to Devil Canyon Dam Site

  . Habitat Loss

  Some nesting habitat for ground-nesting raptors (e.g., merlins, northern harriers, short-eared owls) and tree-nesting raptors (e.g., merlins, goshawks, sharp-shinned hawks and owls) may occur along the Watana-Devil Canyon section of the access road and may be lost; however, no known cliff-nesting habitat will be lost.

  . Disturbance

  Two nesting locations, one golden eagle (GE-18) and one of raven (R-21) may be susceptible to disturbance from the Watana-Devil Canyon section of the access road. Both are near the western end of the road, within about 0.2 km of the centerline (see Table E.3.W76). Furthermore, a bridge will be built across the river about 0.9 km downstream of the golden eagle location; the activity during construction may result in temporary abandondment of this site.

- Devil Canyon Dam Site to Gold Creek

  . Habitat Loss

  Some nesting habitat for ground and tree-nesting raptors may occur along the proposed railroad access route from Devil Canyon to Gold Creek; however, no known nesting locations will be lost. No known cliff-nesting locations occur in this section of the access road.

  . Disturbance

  The proposed railroad link between Devil Canyon and Gold Creek will pass about 0.5 km southeast across the river from one bald eagle location (BE-8, see Table E.3.W76). Disturbance is likely to be minimal.

(x) Waterbirds and Other Birds

Impacts of access roads on birds result from habitat loss and alteration, disturbance from traffic and people associated with the project, direct mortality from both collisions with vehicles and increased hunting pressure, and indirect effects on nesting success because of increased recreational use. The most significant of these impacts vary with species group (Table E.3.W79), but for most species, none will be as serious as the impacts resulting from the flooding of the impoundments.

An estimated 1710 to 2607 pairs of breeding birds will be lost from the local population due to habitat loss from construction of the access road (Table E.3.W79). The access road will cause the loss of more than 1% of the estimated upper Susitna population of only three species: spruce grouse, brown creeper, and northern waterthrush (Table E.3.W80).

Habitat alteration will include some opening of the canopy where the road passes through closed forest and shrubland and, as pointed out in Section 4.3 (a), (xvi), this may result in a change in species composition of breeding birds. In at least one instance (Jeglum 1975), building of a road that blocked drainage through a portion of the boreal forest has been shown to improve habitat for some waterbirds.

Effects of disturbances from road traffic will probably be minor for most species but there are few quantitative data to support this argument. In one of the few quantitative studies of disturbance to songbirds, Ferris (1979) reported no differences in breeding bird densities adjacent and distant from 4-lane and 2-lane highways in Maine. He did find a small difference in species composition which was ascribed to edge effects adjacent to the highway.

Some species of low open habitats may be more affected. Van der Zande et al. (1980) found that two and possibly three of the four shorebird species they studied nested at lower densities up to at least 1 km from both busy and relatively quiet roads. In some cases, nesting density was reduced by 60%. Quantitative studies of species nesting in open habitats in Alaska are not available, but similar effects could occur with ptarmigan, some shorebird species, and some passerine species.

Some birds will undoubtedly be killed by road traffic. Species such as spruce grouse will be attracted to the road as a source of gravel (Carbyn 1968), whereas scavengers, including ravens and possibly eagles, will be attracted by road killed wildlife. However, mortality from collisions will probably have a lesser effect on game birds than will increased hunting pressure. The Upper Susitna Basin is relatively inaccessible at present and it is likely that little game bird hunting occurs there. When road access is provided, hunting will undoubtedly increase and will probably be concentrated along the road. Weeden (1972) found that hunters killed a much larger proportion of ptarmigan within 800 m of the Steese Highway than further away. The same would likely be true for other game birds.

Increased recreational use or human disturbance in wilderness areas in other parts of North America has been associated with various behavioral effects, and in some cases in reduced nesting success. Loons and grebes appear to be particularly affected by boating activity. Nesting success in both groups has been shown to decrease with increasing presence of boats and canoes (Ream 1976, Euler 1978, McIntyre 1978). Power boats may also destroy loon nests through wave action (Vermeer 1973).

Recreational activities, particularly in open habitats, may result in nest destruction by predators after incubating adults are flushed. This has been documented for at least two duck species and the Canada goose (Hammond and Forward 1956, MacInnes and Misra 1972). Presumably, similar nest losses could occur in upland tundra species flushed from their nests by all-terrain vehicles or other recreational activities.

(xi) Non-Game (small) Mammals

The proposed access roads to the Susitna Dams will traverse a wide variety of small mammal habitats, but will mostly be in tundra. Although all species of small mammals are expected to be affected to some extent, only the species most affected (those living in tundra habitats) will be discussed below. Impacts include increased mortality, impeded dispersal, presence of new habitats, and changes in drainage patterns.

In areas of moist tundra, the gravel berm that will constitute the road bed will act as a barrier to dispersal of small mammals. Traffic on the road will cause increased mortality in local populations. However, no serious changes in regional population sizes or structures are expected.

The well-drained gravel of the road bed will provide ideal burrow sites for arctic ground squirrels and singing voles. Hoary marmots may also use the coarser gravel section of the road bed for den sites. The well-drained vegetative communities created on the edges of the gravel berm may also be colonized by meadow voles and some species of shrews.

Portions of the road will likely cause subtle changes in drainage patterns in lateral areas which in turn may result in alterations to vegetation. The types of vegetation that become established will depend on whether water levels increase or decrease as a result of the road. Species composition of small mammals in these areas will shift accordingly, with brown lemmings, bog lemmings, and tundra voles preferring the wetter areas, and red-backed voles, singing voles, and shrews attracted to the well-drained areas.

(d) Transmission Lines

The construction and operation of the transmission lines associated with the project will impact a wide variety of wildlife. The four segments of transmission lines -- Cook Inlet to Willow, Healy to Fairbanks, Willow to Healy (the Intertie), and Watana to the Intertie -- extend over 700 km, traversing habitats ranging from closed forests to tundra (see Table E.3.W29). Several types of impacts can be expected, including habitat alterations, disturbance during construction, direct impacts due to the presence of the transmission lines, and indirect impacts due to improved access.

(i) Big Game

- Cook Inlet to Willow

The southernmost segment of the transmission corridor, from Cook Inlet to Willow, traverses mostly forest vegetation types. The most common community types are closed and open mixed forest and closed birch forest. The big game species that are most likely to be affected by the clearing of these forest types are moose and black bears. Both of these species utilize browse in early to mid-successional stands, and would likely benefit from the vegetative communities present in the transmission corridor after clearing (Scotter 1970, Lindzey and Meslow 1977). There is little data quantifying the effects of such clearings in terms of population productivity, but the general conclusion is that transmission line clearing should increase carrying capacity for moose and black bears (Sopuck et al. 1979).

The disturbances due to human activities during construction will be temporary effects. Most big game animals will relocate during the construction phase, but are expected to return once construction is completed (Commonwealth et al. 1982). Serious impacts are expected only if clearing and construction occur near moose calving grounds or bear denning sites. Disturbance of animals at such sites could cause decreases in productivity. The increase in human activity in the area between Willow-Cook Inlet during the construction of the transmission line is unlikely to affect regional distribution of big game species. This area is already subject to high levels of human activity. The most abundant big game species -- moose and black bear -- are fairly tolerant of human disturbance; those species easily disturbed (i.e., wolf, wolverine, brown bear) are already rare in the area.

- Healy to Fairbanks

The transmission line right-of-way in this area will traverse mostly open spruce forests, along with mixed low shrub, open mixed forest, and open deciduous forest. In all cases, community types that will be affected by clearing operations are widespread and abundant in the area.

Impacts are expected to be similar to those discussed in the Cook Inlet to Willow section (above). Most of the direct impacts will occur during the construction period, when disturbance will cause big game species to relocate. After construction, moose and bears are expected to benefit from the early successional communities along the corridor.

- Willow to Healy

The transmission corridor from Willow to Healy (the Intertie) will have to be upgraded to accommodate the power from the Susitna project. Most of the intertie is located in forest types: bottomland lowland, and upland spruce-hardwood forests (Commonwealth et al. 1982).

The additional clearing required will affect local populations of moose, caribou, Dall sheep, brown bears, and black bears. Animals that relocate due to disturbance from construction activities can be expected to return.

Most of the major impacts associated with transmission corridors (discussed in the proceeding sections) will already be effective due to the existence of the intertie. Thus, the modification required for the Susitna project are not expected to increase access, hunting, or long-term human disturbance levels.

- Watana Dam to the Intertie

The transmission corridor from Watana Dam to the Intertie traverses mixed spruce-hardwood forests and brush communities, paralleling the road and railroad access routes. Clearing required in forested areas will probably have a beneficial effect on black bear and moose.

(ii) Furbearers

Furbearers will be impacted by construction of transmission lines due to habitat alteration and increased trapping pressure resulting from improved access. Denver (1976) found that most furbearers avoided cleared or disturbed areas. Although it has been shown that clear cut areas are not a barrier to travel by short-tailed weasel, least weasel, mink, marten, or other mustelids, cleared areas are usually not used for hunting (Soutiere 1978). Forested areas offer better sub-nivian hunting conditions because the bases of trees, logs, and windfalls provide numerous entry points (Koehler et al. 1975).

Foxes and coyotes are sometimes attracted to cleared areas as movement corridors (Penner 1976). Both foxes and coyotes may benefit from the removal of forest vegetation since they feed heavily on microtine rodents.

Transmission lines will increase access for trappers and could result in local population reductions of some furbearers, particularly in presently remote areas. Marten and beaver will probably suffer the greatest impact since they are currently the target of most trapper effort.

The impact of trapping on coyote, red fox, and lynx will probably be less severe since they are wider ranging than the smaller mustelids. Least weasels, short-tailed weasels, and mink have historically received little trapping pressure.

(iii) Birds

The construction and operation of the transmission corridors will affect birds mostly as a result of changes in vegetation height, disturbance during initial construction, and the electrocution or collision mortality of some birds from the wires. Since much of the transmission corridor passes through forest, selective clearing of trees may result in an increase in species diversity near the lines.

Only one known raptor nest occurs near the proposed transmission route, but this nest is of special concern because it was once occupied by the endangered peregrine falcon. The nest occurs along the Tanana River on the east side of the corridor between Healy and Fairbanks. This nest was first discovered around 1967, but has not been used since the mid-70's (Roseneau, pers. comm.). 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 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 likelihood 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.

Minimal disturbance of raptors and ravens in the study area is anticipated as a result of the winter construction of the high voltage transmission lines. Two gyrfalcon nesting locations (GYR-2 and GYR-3) are within 0.6 km of the transmission corridor. Gyrfalcons may be susceptible to some impact as a result of disturbance from winter construction activities because adults are known to frequent eyries throughout the winter months (see Roseneau et al. 1981).

Birds of prey and swans (Harrison 1963) are susceptible to electrocution as a result of perching on the structures. Electrocution is probably the greatest potential impact of the power lines on both raptors and ravens. Larger size is the greatest factor affecting species vulnerability to electrocution (Olendorff et al. 1981). Consequently, golden and bald eagles are the most susceptible of the raptors inhabiting the area being considered. In addition, immature or subadult eagles are more susceptible to electrocution than adults. Buteos (e.g., red-tailed hawk and rough-legged hawk) are also vulnerable, but accipiters (e.g., goshawk and sharp-skinned hawks) and even the larger falcons (e.g., peregrines and gyrfalcons) are rarely electrocuted (Olendorff et al. 1981).

(iv) Non-Game (small) Mammals

The transmission lines for the Susitna project will traverse a wide variety of small mammal habitats. These transmission corridors will be selectively cleared of trees and tall shrubs. Because most small mammals are ecotone species, they are expected to benefit from the edge effects created by the clearings. One example is the snowshoe hare, which relies on dense black spruce forests for cover, but prefers more open areas for forage (Kessel et al. 1982). Overall, transmission corridors are not expected to adversely impact small mammals.

(e) Impact Summary

This section summarizes those impacts on wildlife populations predicted to be of sufficient magnitude to influence mitigation planning. The emphasis is on impacts to wildlife population levels; both positive and negative impacts are discussed.

Whether impacts to wildlife are judged to be positive or negative depends on the perspective of judgment. For example, increased access by hunters and trappers usually depresses population levels of big game species and furbearers. But at the same time, increased access has the potential to increase the long-term yield and value of this wildlife to consumptive users.

Herein we address impacts only from the perspective of the wildlife populations per se. An increase in wildlife abundance or production is a positive impact; a decrease in wildlife abundance or production is a negative impact. Project actions known or speculated to cause measurable changes in project area wildlife population or production levels are discussed, but those actions thought to cause negligible or no changes are not.

(i) Big Game

The big game populations expected to be affected by the Susitna project are moose, black bear, brown bear, wolf, wolverine, Dall sheep, and caribou. The main influence on these species will be through habitat loss by inundation, increased necessity for killing nuisance animals, increased access afforded to hunters, and/or possibly by blockage of migration routes by roads or reservoirs.

The greatest impact on moose will probably be caused by loss of winter habitat inundated by impoundments. Potentially critical winter habitat for a substantial number of moose (approximately 260 in most years) will be inundated by Watana; a smaller amount of winter habitat (used by about 30 moose in most years) will be lost to the Devil Canyon reservoir.

We judge the next most important effect on moose to be a decrease in populations caused by greater ease of hunter access. Changes in vegetation downstream of reservoirs may have a small population-level effect. Other actions are not thought likely to have important effects.

Major impacts on caribou are not predicted. Minor population changes caused by increased hunter access, blockage of the movements of some caribou by access roads and the Watana impoundment, and some mortality during crossings of the impoundment area at certain times of the year are possible.

Dall sheep may abandon the Jay Creek lick area as a result of frequent human disturbances or partial inundation of the lick. The population impact of this is uncertain. Large increases in mortality caused by greater ease of hunter access are not expected.

Black bears and brown bears are most likely to suffer from increased hunter access, from nuisance animal control measures, from inundation of portions of habitat, and from reductions in salmon available at traditional feeding sites. Black bears in the area will loose a substantial portion of their forest habitat, including a large proportion of den sites in the Watana impoundment area. These losses are likely to cause a large reduction in the black bear population now occurring in the Watana vicinity. Brown bears will lose important early-spring feeding areas to inundation. Both black and brown bears may lose some of their salmon food supply. Other impacts are not likely to cause significant population changes.

Wolves typically suffer most from increased access by construction workers and hunters. Large population reductions by hunter harvest are expected. They are probably insensitive to most other changes.

Wolverine populations may decline because of increased trapping pressures, but probably not for other reasons.

(ii) Furbearers

All upland furbearer populations are expected to decline for two main reasons--inundation of portions of their habitats by impoundments, and increased trapping pressure caused by easier trapper access. Red foxes may additionally be removed as nuisance animals, but the proportion of the population in the Susitna Basin affected by such removal will probably be small.

Impacts to aquatic furbearers are not clear. Populations of beaver, muskrat, and possibly mink and otters may increase downstream of the reservoir because of more stable water levels, higher winter flows, increased availability of favored food plants, and the lack of an ice-cover in winter. Impoundments will inundate streamside habitats of mink and otter and others in the upper basin, but whether substantial populations exist there now is uncertain, and whether the Watana impoundment itself is inhabitable by these species is uncertain. The stable water level in the Devil Canyon reservoir during most of the year will probably have beneficial effects on aquatic furbearer species. The impoundment areas presently support only a few muskrat and beaver. In the upper basin, these species will be most affected by removal of road materials from streams and increased trapper access.

(iii) Birds

The major impact to upland bird species will be inundation of habitat in the reservoir area. Changes in bird community composition will probably occur wherever vegetation community changes are expected (e.g., downstream riparian, construction and borrow sites, etc.) but these changes will be localized and/or relatively insignificant to bird density and diversity.

Inundation of stream habitats by impoundments will remove some nesting waterfowl (mergansers), and may cover winter habitat for dippers, but these impacts are considered minor. Moreover, downstream habitats may improve for some of these species (i.e., wintering dippers).

(iv) Non-Game Mammals

The major expected impact of the Susitna project on non-game mammals will be via habitat loss in the impoundment areas. Effects of other changes on population levels in the project area will almost certainly be minimal.

4.4 - Mitigation Plan

(a) Big Game

(i) Moose

Direct impacts to moose resulting from the Susitna Hydroelectric Project will be, in order of decreasing severity, permanent loss of habitat, alteration of habitat, blockage of traditional migration routes, disturbance by machines and humans, and hazards associated with the Watana and Devil Canyon drawdown zones. The major secondary impact of the project will be the provision of access to a previously remote area and, without agency regulation, a significant increase in hunting pressure with resultant increases in moose mortaility.

Permanent loss or alteration of habitat suitable as browse, wintering range, calving areas, and breeding areas will result from the Watana and Devil Canyon impoundments. Habitat loss cannot be avoided, minimized, rectified, or reduced over time through management measures; yet such loss is certain to occur. Compensation by habitat replacement and enhancement, therefore, must receive highest priority as a strategy to mitigate this impact.

Computer-assisted simulation modeling is being used to help quantify the probable impact of habitat loss at the population level, and to help develop criteria for the selection of replacement lands for habitat compensation and enchancement. Leading specialists in of Alaskan moose are participating in this process, and the day-to-day management and refinement of the moose model is being conducted by the Alaska Department of Fish and Game (ESSA/WELUT/LGL 1982). The modeling program is the focus for interagency coordination to identify replacement lands and procedures for habitat enhancement.

The provision of winter and early spring browse is the primary objective of replacement and enhancement planning, because impoundment will remove low-elevation areas with early-stage riparian vegetation accessible to moose in severe winters. These areas are used by moose with home ranges bordering the impoundment areas, and will no longer be accessible to moose seasonally migrating into the Susitna Basin from neighboring regions.

Controlled burning, clearing of merchantable timber, and mechanical crushing of vegetation are techniques under consideration for moose habitat enhancement. These procedures have been examined on an experimental basis during recent studies at the Moose Research Center and Kenai Moose

Range near Soldotna, Alaska (Regelin et al. 1981; Schwartz et al. 1981). The Bureau of Land Management is prepared to conduct a controlled burn in the Alphabet Hills area immediately east of the Susitna project area.

Criteria for replacement land selection have been established, and quantification of optimum areal dimensions relative to enhancement effectiveness is in progress. Criteria for selection of replacement lands are defined by vegetation cover type and age, complexity of terrain, and location. It is estimated that peak browse production for moose is reached 20 to 25 years after a fire (Wolff 1976; Wolff and Cezada 1979). Moderately complex terrain with extensive flatlands, riparian bottomlands, and gentle slopes of diverse aspect provide variation in species composition and succession rate. Habitat enhancement measures conducted on lands within or bordering the project area will have the greatest potential for mitigating impacts to moose affected by project development. Lands which satisfy all of the these criteria to varying degrees are available in and around the project area.

To utilize new successional areas, moose must maintain flexibility in their seasonal and regional movement patterns. Such movements across the Susitna River in the vicinity of the Watana impoundment or upper Devil Canyon Reservoir would be blocked or significantly impeded. The provision of alternative moose range on both sides of the Susitna River will help to compensate for blockage of seasonal movements across the river.

Construction- and operation-related activities will produce a significant potential for disturbance to moose, especially where avoidance of prime range occurs. Mitigative features have been incorporated into engineering design and construction planning to avoid or minimize this impact potential. The access route has been selected and modified specifically to avoid important moose concentration areas along Deadman Creek, upper Watana Creek, Portage Creek, and the Indian River. The Fog Lakes area, Stephan Lake, and other moose habitat south of the Susitna River are entirely avoided.

Facilities have been consolidated within two infrastructures which will minimize the areal extent of disturbances associated with the Watana and Devil Canyon developments. Project policies and stipulations will further minimize human disturbances. An Environmental Briefings Program is planned to familiarize project personnel with environmentally sensitive features and wildlife of the project areas, federal and state regulations, agency permit stipulations, and specific project policies and restrictions regarding protection of fish, wildlife, habitat, and cultural resources. Hunting of moose and other wildlife, possession of firearms on the project location, and deliberate attraction or harassment of wildlife by project personnel will be prohibited.

Public access into the project area during operation will provide increased hunting opportunity in a previously remote area. The Alaska Power Authority will assist the Alaska Department of Fish and Game in regulating access, restricting off-road or all-terrain vehicle use, and other measures to ensure that hunting pressure on moose is properly controlled. Bag limits and permit systems are available resource management options to moderate hunting pressure within the project area.

(ii) Caribou

The primary impact issue relating to caribou is potential blockage of migratory movements by the Denali Highway-to-Watana segment of the access road. A bermed road in low terrain could impede the free passage of caribou. The effectiveness of the berm as a physical and visual barrier will increase with height and steepness of the side-slopes. With steeper slopes, cleared snow alongside the road may be sufficiently deep to inhibit the ability of caribou to cross the road.

The Denali Highway-to-Watana access route has been designed to avoid low areas and to follow the contours of the slopes to the west of the Brushkana, Seattle, and Deadman Creek drainages. This routing will minimize bermed road construction. Where berming is necessary to avoid sidehill cuts through permafrost, road profile elevations and side-slope grades will be reduced as much as load requirements will allow.

(iii) Dall Sheep

Restrictions on aircraft elevations and access will be enforced during project construction to protect Dall sheep lambing areas. In addition, all visits to the Jay Creek mineral lick will be prohibited. Use of the mineral lick will be monitored before and during inundation of the Watana impoundment area, to determine whether use patterns change. Measures to expose new portions of the mineral lick will be implemented if necessary.

(iv) Brown and Black Bear

Measures incorporated into overall engineering design and construction planning will help to minimize disturbances to bears. The access route avoids the important Prairie Creek brown bear concentration area and stays well to the west of brown and black bear habitat on lower Deadman Creek.

To minimize attraction and scavenging, with resultant adverse contacts between people and bears, all putrescible kitchen wastes will be stored indoors in sealed containers, and incinerated on the same day they are produced. Camp incinerators will be properly sized and operated by trained personnel to ensure that all putrescible wastes are completely burned to mineral ash. Incinerator capacities will be specified to accommodate peak camp occupancy. There will be no open burning of food wastes. Only inert, non-attractive materials will be deposited at solid waste disposal sites. Camps will be surrounded with bear-resistant fencing to minimize human-bear interactions.

Mitigative measures to maintain moose productivity will partially compensate for loss of bear habitat, both by maintaining the availability of young moose as prey, and by increasing vegetation diversity, fishery enhancement measures (Exhibit E, Section 2) will help to maintain salmon availability downstream from Portage Creek.

(v) Wolf

Wolf dens and rendezvous sites will be seasonally protected from May through July to avoid disturbance to wolf pups during the first months of life. Moose habitat enhancement will help to compensate for loss of moose as prey. Hunting and trapping restrictions may be imposed by the Alaska Department of Fish and Game to protect wolves within the project vicinity and allow the formation of new home ranges and hunting patterns.

(b) Furbearers

Beaver and pine marten are the furbearer species judged to be of greatest importance for mitigation planning. These species are common in the project area and are sought by trappers. Beaver activity such as the damming of streams often benefits other aquatic furbearer species (e.g., river otter, mink, muskrat), and beavers are also known to enhance areas for moose by cutting down large trees (often increasing the growth of favored browse species). The beaver population downstream of Devil Canyon is expected to benefit from the altered flow and temperature regime, but beavers along Deadman Creek and near the Devil Canyon construction site could be adversely affected. No beaver are known to occur in the Watana or Devil Canyon impoundment areas.

Habitat for approximately 26-100 marten will be lost when the Watana impoundment area is filled. An estimated 14 marten currently occur in the Devil Canyon impoundment area. A few additional marten will be affected by habitat loss to access roads and transmission corridors. Complete avoidance of impacts to marten can only be accomplished by selecting the no project alternative. Habitat loss to the transmission corridors and access roads will be minimized by (1) aligning the access road primarily through tundra and low shrub cover types; (2) selectively cutting trees and tall shrubs in the transmission corridors, as opposed to total clearing; (3) constructing the transmission lines in winter in order to minimize surface disturbances; and (4) keeping the corridor along the access road to a minimum in forested areas.

One of the identified impacts on marten and other furbearers is that of increased trapping mortality as a result of improved access. But note that marten are considered an important furbearer because of their economic value to trappers. The improved access may result in a greater sustained harvest of marten from the project area than now occurs, even though a smaller population would be supported by the area. Improved access can thus be viewed as either adverse or beneficial by various user groups. To insure that martens are not overharvested near the temporary and permanent worker facilities, the applicant will prohibit workers and their families from trapping or hunting while working in the project area.

Impacts to beaver, river otter, and mink near the access road will be avoided or minimized by (1) prohibiting gravel extraction from Deadman Creek; and (2) minimizing the disturbance of riparian vegetation along this creek.

The anticipated increase in aquatic furbearer populations downstream of Devil Canyon will provide in-kind compensation for upstream impacts. The beaver population will be monitored by the applicant to verify that beavers are positively affected by the project. The monitoring program will include the development and testing of a model that predicts changes in beaver populations over time as a result of different flow releases and water temperatures.

Red foxes, wolves, coyotes, and possibly other furbearers may be adversely impacted if food is improperly stored and disposed of. These impacts will be avoided or minimized by (1) fencing the camp and dump; (2) incinerating garbage daily to prevent scavengers from being attracted to it; (3) strictly enforcing the animal feeding regulations, and educating workers about these regulations; and (4) establishing an animal control strategy, which will include one or two full-time biologists trained and equipped to deal with human/animal conflicts.

(c) Birds

(i) Raptors and Raven

The major impacts of the Susitna project on raptors and ravens are anticipated to be (1) loss of nesting habitat to the impoundment, borrow sites, and other facilities adjacent to the dams, access routes, and transmission corridors; (2) disturbance and/or harassment resulting from aircraft passage, construction activities, vehicular traffic, and increased human presence; (3) electrocution and collisions of raptors with transmission lines. These impacts will be mitigated through a number of practices including (1) construction of artificial cliff and tree nesting locations near the impoundment, realignment of roads and transmission corridors to avoid known nesting locations of eagles nd falcons; (2) limitations on ground activities near raptor nests during sensitive time periods, and establishment of minimum flight ceilings for aircraft during the nesting season; and (3) use of transmission tower designs that minimize electrocutions and encourage nesting and perching by certain raptor species. An active monitoring program will be undertaken to insure that these measures are successfully implemented.

- Creating Artificial Cliff-Nesting Locations

The concept of modifying or creating raptor nesting locations on cliffs is a recent but feasible means of compensating for nesting habitat loss. One technique uses explosives to remove overburden and rubble to expose bedrock cliffs; small shaped explosive charges are then used to build a nesting ledge. Another possibility is to create an artificial cliff using cinder block, concrete, fiberglass and metal, or other materials (such cliffs have been constructed for rock-climbing schools). These artificial cliffs could be placed in areas where suitable rock for nesting could not be exposed; one or two nesting ledges could even be located on the downstream face of the Watana or Devil Canyon dam.

The applicant will initiate a program to mitigate for losses of cliff-nesting eagles and falcons beginning in 1983. Accurate elevations (present elevations are accurate only to within 15 m) will be obtained for nests within the impoundment zone and borrow sites to determine the number of nests to be lost. A survey of the upper basin by a recognized raptor biologist will be made to identify potential sites for cliff modifications. Because some raptors will successfully defend several alternate nest sites within an area, the newly-created nest sites must be widely-spaced along the impoundment.

Several artificial cliffs may be needed in the Watana Reservoir area, where potential new nesting locations appear to be limited.

Because all of the borrow areas may not be used, and because some nests may be destroyed by slope instability after filling, the exact number of raptor nests lost cannot yet be determined. The applicant will establish a program to (1) identify the impacts of the project during the construction, filling, and operation phases; (2) modify or create new nesting locations to compensate for these losses; and (3) monitor the success of these mitigative measures. The number of new successful nesting sites created will match or exceed the number of sites lost to the project.

- Creating Artificial Tree-Nesting Locations

It is possible to mitigate for the loss to the project of approximately 4 bald eagle nests by constructing artificial nests. Bald eagles have shown little reluctance to use nests reconstructed after having been down (e.g., Olendorff et al. 1980). Natural-appearing nests could be constructed in appropriate trees (especially large balsam poplar) downstream of the dam site or along tributaries such as Portage Creek (presently unused by bald eagles). The nests that will be inundated can be reconstructed in other areas. Another technique is to remove the top and upper limbs of large balsam poplar and white spruce trees to make them more attractive to bald eagles. A combination of these techniques will be used in conjunction with a monitoring program to replace the losses of bald eagle nests resulting from the project.

Successful attempts to provide nests for tree-nesting goshawks, American kestrels, red-tailed hawks and great gray owls have been made (e.g., Olendorff et al. 1980). Nesting habitat for goshawks can be improved both by establishing artificial nests and by increasing the edge effect in large forest stands (D. Weir, pers. comm.; D. Roseneau, unpubl. data). Great horned and great gray owls commonly use abandoned goshawk nests in Alaska (Roseneau and Bente 1981), and would therefore also benefit from increased edge.

Tree-nesting species will also use artificial nesting platforms constructed on transmission towers (Table E.3.W81). Selective clearing of the transmission corridors will serve to create the edge preferred by goshawks, and thus the transmission lines may compensate in part for losses of some raptors to other project facilities. The applicant will install 20 wooden platforms on the transmission towers, and will monitor their success. Twenty nest boxes for cavity-nesting kestrels and boreal owls will also be built and monitored. Cavities will be created in the tops of several mature birch or spruce trees in an attempt to attract hawk owls, boreal owls, American kestrels, and other cavity-nesting birds.

- Seasonal Restrictions

Impacts to certain raptor nesting locations will be avoided or minimized by limiting ground and air activities during sensitive periods. Raptor nests will be assumed to be occupied until 1 June each year. After that date, protection measures for a specific nest site will be withdrawn for the remainder of the year if the nest is documented to be inactive. For the purposes of this discussion, minor ground activity includes short-term reconnaissance and exploration-type programs such as field inventories. Major ground activity involves large numbers of personnel, equipment, surface disturbance, noise, or vehicular activity, such as clearing, pad construction, blasting, and facility construction.

. Golden Eagle - Sensitive time period is from 15 April to 31 August. No facility siting or major ground activity within 0.5 miles during this period. No minor ground activity within 0.25 mi. Aircraft should remain at least 1000 vertical feet or 0.5 horizontal miles away.

. Bald Eagle - Sensitive time period is from 15 March to 15 August. No facility siting within 0.5 mi; 0.25 mi for major ground activity, 0.13 mi for minor activity. Aircraft should remain 1000 vertical feet or 0.25 horizontal mi away.

. Gyrfalcon - Sensitive period is from 15 February to 15 August. Restrictions are the same as for bald eagles.

- Electrocution

Considerable efforts have been made in the past decade to minimize electrocutions of large raptors along transmission lines (see Olendorff et al. 1981). Golden and bald eagles typically represent 70-90% of electrocution mortalities in some areas (Ansel and Smith 1980, Benson 1981). The applicant will avoid or minimize electrocution impacts on eagles through the use of appropriate tower configurations, and the use of supplemental wire guards and perches on the towers. The transmission lines will be constructed during winter to avoid disturbance of nesting raptors.

(ii) Waterbirds

Major impacts of the project on waterbirds are not expected (see Section 4.3(c), (xv)), and thus little mitigation is required. Many of the waterbird species occurring in the project area will benefit from the reservoirs and winter open water areas, but minor impacts resulting from disturbance and loss of tree-cavities for certain cavity-nesting species will occur. Of particular concern are impacts of disturbance on trumpeter swans.

The applicant will avoid or minimize the effects of disturbance on trumpeter swans by limiting ground and air activities near those waterbodies used by swans during the nesting season and other times when swans are present. Nest boxes will be built for cavity-nesting waterbirds in an attempt to encourage those species to nest near lakes and tributaries outside of the impoundment area.

(iii) Other Birds

Although large numerical losses of breeding birds will result from inundation and various project facilities, all of the species affected are common outside of the affected areas. Because these birds are judged to have lower importance to most people (in comparison to big game species, furbearers, and raptors), specific compensation measures are not planned. Breeding birds have been taken into account, however, in the design of the project. For example, the access road has been aligned primarily in tundra and low shrub vegetation types, which support relatively low numbers and diversities of breeding birds.

(d) Small (non-game) Mammals

Because of the assumed low priority of this wildlife group, no compensation is proposed to offset the loss of habitat resulting from the project. Small mammals are most abundant and diverse in forest stands; this factor was used in the decision to align the access road primarily in tundra and low-shrub vegetation types.

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TABLE E.3.1: MITIGATION OPTIONS ANALYSIS STRUCTURE RECOMMENDED BY SUSITNA HYDROELECTRIC PROJECT, ALASKA DEPARTMENT OF FISH AND GAME (ADF&G) AND THE U.S. FISH AND WILDLIFE SERVICE (USFWS). DESIRABILITY OF OPTIONS DECREASES FROM TOP TO BOTTOM. EXPLANATIONS OR EXAMPLES OF EACH OPTION AS DESCRIBED BY AGENCIES ARE SHOWN.

OPTION	DEFINITION: ALASKA DEPARTMENT OF FISH AND GAME	DEFINITION: U.S. FISH & WILDLIFE SERVICE
AVOIDANCE	Avoid Impact by Not Taking a Certain Action - Keep as much existing natural habitat as possible. - Maintain fish and game populations and critical habitat.	Modify Project Design to Avoid - No-project alternative is one mode. - Design modifications in action type, magnitude, timing and locations are options.
MINIMIZATION	Minimize Impacts by Limiting Magnitude of Action - Maintain habitat diversity and the capacity of each system to restore itself naturally.	Modify Project Deign to Minimize Impacts - Design modifications in action type, magnitude, timing and location are options.
RECTIFICATION	Rectify Impacts by Rehabilitating Environment - Repair, rehabilitate or restore abused aquatic or terrestrial systems. - Restore the same functions or structure of habitats (unless concomitant restoration of animnis using that habitat is impossible).	Restore Damaged Environments - Reclaim disturbed sites by seeding, etc. - Restock lost fish and wildlife.
RESTRICTION	Reduce (or Eliminate) Impact Over Time by Maintenance - Operate and maintain mitigation measures to reduce impacts over time.	Maintain Mitigation Effort to Reduce Impact - Monitor/repair mitigation) features. - Train mitigation personnel.
COMPENSATION	Compensate for Impact by Substitute Resources - Create or restore fish, wildlife and habitat values, and resource use opportunities that were unavoidably lost. - Compensation by providing substitute resources or environments is least desirable; the preferred mode is on-site mitigation.	Replace Lost Volumes by Management or Replacement - Intensify production by management. - Initiate hatcheries; restocking programs. - Lease or buy new lands for enhanced management.

TABLE E.3.2: COMMON AND SCIENTIFIC NAMES OF FISH SPECIES APPEARING IN THE TEXT

SCIENTIFIC NAME	COMMON NAME
Petromyzontidae	
Lampetra japonica	Arctic Lamprey
Salmonidae	
Coregonus laurettae	Bering Cisco
Coregonus pidschian	Humpback Whitefish
Oncorhynchus gorbuscha	Pink Salmon
Oncorhynchus keta	Chum Salmon
Oncorhynchus kisutch	Coho Salmon
Oncorhynchus nerka	Sockeye Salmon
Oncorhynchus tshawytscha	Chinook Salmon
Prosopium cylindraceum	Round Whitefish
Salmo gairdneri	Rainbow Trout
Salvelinus malma	Dolly Varden
Salvelinus namaycush	Lake Trout
Thymallus arcticus	Arctic Grayling
Osmeridae	
Thaleichthys pacificus	Eulachon
Esocidae	
Esox lucius	Northern Pike
Catostomidae	
Catostomus catostomus	Longnose Sucker
Gadidae	
Lota lota	Burbot
Gasterosteidae	
Gasterosteus aculeatus	Threespine Stickleback
Cottidae	
Cottus sp.	Sculpin

TABLE E.3.3: COMMERCIAL CATCH OF UPPER COOK INLET SALMON IN NUMBERS OF FISH BY SPECIES, 1960-1981, ADULT ANADROMOUS INVESTIGATIONS, SU HYDRO STUDIES, 1982

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
1960	27,512	923,314	311,461	1,411,605	659,597	3,333,889
1961	19.737	1,162,303	117,778	34,017	349,628	1,683,463
1962	20,210	1,147,573	350,324	2,711,689	970,582	5,200,378
1963	17,536	942,980	197,140	30,436	387,027	1,575,119
1964	4,531	970,055	452,654	3,231,961	1,079,084	5,738,285
1965	9,741	1,412,350	153,619	23,963	316,444	1,916,117
1966	9,541	1,851,990	289,690	2,006,580	531,825	4,689,626
1967	7,859	1,380,062	177,729	32,229	296,837	1,894,716
1968	4,536	1,104,904	470,450	2,278,197	1,119,114	4,977,201
1969	12,398	692,254	100,952	33,422	269.855	1,108,881
1970	8,348	731,214	275,296	813,895	775,167	2,603,920
1971	19.765	636,303	100,636	35,624	327,029	1,119.357
1972	16,086	879,824	80,933	628,580	630,148	2,235,571
1973	5,194	670,025	104,420	326,184	667,573	1,773,396
1974	6,596	497,185	200,125	483,730	396,840	1,584,476
1975	4,790	684,818	227,372	336,359	951,796	2,205,135
1976	10,867	1,664.150	208,710	1,256,744	469.807	3,610,278
1977	14.972	2,054,020	192,975	554,184	1,233,733	4.049,704
1978	17,308	2,622,487	219,234	1,687,092	571,925	5,118.041
1979	13,713	920,780	259,956	74,318	654,462	1,923,229
1980	12,497	1,584,392	283,623	1,871,058	387,078	4,138.648
1981	11,548	1,443,294	494,294	127,857	842,849	2,919.621

1979-1981; Preliminary data.

SOURCE: ADF&G 1982a

TABLE E.3.4: PETERSON POPULATION ESTIMATES AND CORRESPONDINGLY 95% CONFIDENCE INTERVALS OF CHINOOK, SOCKEYE, COHO, CHUM AND PINK SALMON MIGRATING TO SUNSHINE, TALKEETNA AND CURRY STATIONS, 1981 - 1982

Station		Chinook[1]		Sockeye		Coho		Chum		Pink	
		1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
Sunshine Station	No.	-	49,400	133,000	152,000	19,800	45,800	263,000	431,000	49,500	444,000
	Confidence		44,800	120,000	139,000	18,000	42,000	235,000	408,000	46,400	408,000
	Interval		55,000	150,000	167,000	22,000	50,400	298,000	456,000	53,100	487,000
Talkeetna Station	No.	-	10,200	4,800	3,100	3,300	~~20,800~~ 5100	~~49,200~~ 20,800	~~2,300~~ 49.2	2,300	73,100
	Confidence		8,500	4,300	2,800	2,800	18,400	~~45,200~~ 18.5	~~1,900~~ 45.2	1,900	70,500
	Interval		12,800	5,400	3,500	6,200	22,800	~~53,900~~ 22.8	~~2,943~~ 53.2	2,943	75,800
Curry Station	No.	-	11,200	2,800	1,300	1,100	2,510	13,100	29,500	1,000	59,000
	Confidence		8,500	2,600	1,100	700	1,810	11,800	26,800	700	43,700
	Interval		16,500	3,100	1,500	2,500	4,000	14,600	32,800	2,100	65,400

1 Chinook migrations were underwayu prior to installation of sonar equipment and should only be considered as abundance indices during the period the equipment was operational.

Source: ADF&G 1981a, Trent 1982

TABLE E.3.5: CHINOOK SALMON EXCAPEMENT COUNTS OF SUSITNA RIVER BASIN STREAMS FROM 1976 TO 1982, ADULT ANADROMOUS INVESTIGATIONS, SU HYDRO STUDIES, 1982

	Year						
STREAM	1979	1977	1978	1979	1980	1981	1982
Alexander Creek	5,412	9,246	5,854	6,215	a/	a/	2,546
Deshka River	21,693	39,642	24,639	27,385	a/	a/	a/
Willow Creek	1,660	1,065	1,661	1,086	a/	1,357	592d/
Little Willow Creek	833	598	436	324c/	a/	459	316d/
Kashwitna River (North Fork)	203	336	362	457	a/	557	156d/
Sheep Creek	455	630	1,209	778	a/	1,013	527d/
Goose Creek	160	133	283	b/	a/	262	140d/
Montana Creek	1,445	1,443	881	1,094c/	a/	814	887d/
Lane Creek	b/	b/	b/	b/	b/	40	47
Indian River	537	393	114	285	a/	422	1,053
Portage Creek	702	374	140	190	a/	659	1,111
Prairie Creek	6,513	5,790	5,154	a/	a/	1,900	3,844
Clear Creek	1,237	769	997	864c/	a/	a/	982
Chulitna River (East Fork)	112	168	59	a/	a/	a/	119d/
Chulitna River (MF)	1,870	1,782	900	a/	a/	a/	644d/
Chulitna River	124	229	62	a/	a/	a/	100d/
Honolulu Creek	24	36	13	37	a/	a/	27d/
Byers Creek	53	69	a/	28	a/	a/	7d/
Troublesome Creek	92	95	a/	a/	a/	a/	36d/
Bunco Creek	112	136	a/	58	a/	a/	198
Peters Creek	2,280	4,102	1,335	a/	a/	a/	a/
Lake Creek	3,735	7,391	8,931	4,196	a/	a/	3,577
Talachulitna River	1,319	1,856	1,375	1,648	a/	2,129	3,101
Canyon Creek	44	135	b/	b/	b/	84	b/
Quartz Creek	b/	8	b/	b/	b/	8	b/
Red Creek	b/	1,511	385	b/	b/	749	b/

1/ 1976-1980 counts - Kubik, S.W.
a/ No total count due to high turbid water
b/ Not counted
c/ Poor counting conditions
d/ Counts conducted after peak spawning

Source: Trent 1982

TABLE E.3.6: 1982 CHINOOK SALMON ESCAPEMENT SURVEYS OF SUSITNA RIVER BASIN STREAMS, ADULT ANADROMOUS INVESTIGATIONS, SU HYDRO STUDIES, 1982

Stream Surveyed	Survey Date	Survey Method	Survey Conditions	Chinook Salmon Counted Live	Chinook Salmon Counted Dead	Chinook Salmon Counted Total
Alexander Creek (Mouth to Lake)	7/31	Hel.	Good	1,687	0	1,687
Wolverine Creek (Alexander Creek drainage)	7/28	Hel.	Good	537	0	537
Sucker Creek (Alexander Creek drainage)	7/28	Hel.	Good	322	0	322
Bunco Creek	8/7	Hel.	Fair	168	30	198
Byers Creek	8/12	Hel.	Excellent	7	0	7
Chase Creek	8/11	Foot	Good	8	7	15
Cheechako Creek (Devil Canyon)	8/6	Hel.	Good	16	0	16
Chinook Creek (Devil Canyon)	8/6	Hel	Good	5	0	5
Chulitna River	8/12	Hel.	Excellent	49	51	100
Chulitna River (East Fork)	8/12	Hel.	Excellent	67	52	119
Chulitna River (Middle Fork)	8/12	Hel.	Excellent	385	259	644
Clear Creek	7/21	Hel.	Fair	978	4	982
Deshka River 1/	8/5-9	Hel.	Fair 2/	10,471	200	10,671
Gold Creek	8/3	Hel.	Good	122	20	142
Goose Creek	8/7	Hel.	Good	98	42	140
Honolulu Creek	8/12	Hel.	Excellent	11	16	27
Indian River	7/21	Hel.	Good	1,049	4	1,053
Jack Long Creek	8/4	Foot	Excellent	2	0	2
4th of July Creek	7/29	Foot	Good	55	1	56
Kashwitna River (North Fork)	8/10	Hel.	Excellent	128	28	156

SOURCE: TRENT 1982

TABLE E.3.6 (Cont'd)

Stream Surveyed	Survey Date	Method	Conditions	Chinook Salmon Counted Live	Dead	Total
Lake Creek	8/2	Hel.	Good	2,267	50	2,317
Camp Creek (Lake Creek drainage)	8/2	Hel.	Excellent	517	0	517
Sunflower Creek (Lake Creek drainage)	8/2	Hel.	Excellent	743	0	743
Lane Creek	7/12	Foot	Excellent	47	0	47
	7/28	Foot	Excellent	40	1	41
Little Willow Creek	8/7	Hel.	Good	190	126	316
Montana Creek	8/5	Foot	Good	829	58	887
Portage Creek	7/21	Hel.	Excellent	955	0	955
	8/8	Hel.	Excellent	1,081	30	1,111
Praire Creek	7/31	Hel.	Excellent	3,782	62	3,844
Sheep Creek	8/7	Hel.	Good	316	211	527
Spink Creek	8/7	Hel.	Excellent	12	0	12
Troublesome Creek	8/12	Hel.	Excellent	34	2	36
Talachulitna River	8/1	Hel.	Excellent	3,101	0	3,101
Willow Creek	8/6	Foot	Fair	506	86	592
Deception Creek (Willow Creek Drainage)	8/6	Foot	Fair	212	17	229

1/ Partial count; Mainstem Deshka from Trapper Creek to Forks; Trapper Creek not surveyable.

2/ Survey conditions on Deshka River and tributaries ranged from good to poor.

SOURCE: TRENT 1982

TABLE E.3.7: APPORTIONED SONAR COUNTS BY SPECIES AND SAMPLING LOCATION 1981 - 1982

Station	River Mile	Chinook 1981	Chinook 1982	Sockeye 1981	Sockeye 1982	Coho 1981	Coho 1982	Chum 1981	Chum 1982	Pink 1981	Pink 1982
Sunshine Station	26	-	900	340,000	124,000	33,500	33,100	46,500	29,200	113,000	493,000
Yentna Station	04	-	1,200	139,000	114,000	17,000	34,100	19,800	27,800	36,100	447,000
Sunshine Station	80	-	2,900	89,900	75,900	22,800	42,400	59,600	178,000	72,900	352,000
Talkeetna Station	103	-	2,900	3,500	3,300	3,500	7,200	10,000	28,800	2,500	85,400

Source: ADF&G 1981a, Trent 1982

TABLE E.3.8: COHO SALMON JUVENILES, PERCENT INCIDENCE AT HABITAT LOCATION SITES ON THE MAINSTEM SUSITNA RIVER AND ITS TRIBUTARY MOUTHS BETWEEN COOK INLET AND DEVIL CANYON, NOVEMBER, 1980 TO MAY, 1981

	Percent Incidence						
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Cook Inlet to Talkeetna	83.3	0.0[a]	42.9	60.0	63.6	0.0[b]	57.7
Tributary Mouth Sites	100.0	0.0	66.7	66.7	66.7	0.0	83.3
Mainstem and Slough Sites	50.0	0.0	25.0	50.0	50.0	0.0	50.0
Talkeetna to Devil Canyon	-	-	0.0	42.9	50.0	42.9	-
Tributary Mouth Sites	-	-	0.0	0.0	25.0	0.0	-
Mainstem and Slough Sites	-	-	0.0	75.0	66.7	50.0	-

[a] Extreme cold (-25° to -40°F) hampered sampling efforts during December, 1980.

[b] Hazardous ice conditions prior to spring breakup limited sampling efforts to three habitat location sites in April, 1981.

SOURCE: ADF&G 1981f

TABLE E.3.9: COHO SALMON JUVENILES, PERCENT INCIDENCE AT HABITAT LOCATION SITES ON THE MAINSTEM SUSITNA RIVER AND ITS TRIBUTARY MOUTHS BETWEEN COOK INLET AND TALKEETNA, JUNE TO SEPTEMBER, 1981

	Percent Incidence							
	June 1-15	June 16-30	July 1-15	July 16-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	Sept. 16-31
Tributary (mouth) Habitat Sites	80.0	66.7	80.0	81.3	93.8	100.0	100.0	91.7
Mainstem Habitat Sites	40.0	11.1	55.6	20.0	18.2	22.2	50.0	62.5
Combined Habitat Sites	60.0	42.9	70.8	57.7	63.0	72.0	83.3	80.0

SOURCE: ADF&G 1981f

TABLE E.3.10: EUCHALON SET NET CATCHES IN SUSITNA RIVER ESTUARY, ADULT ANADROMOUS INVESTIGATIONS, SU HYDRO STUDIES, 1982

	Tide[1]		Location		Fishing Time[2]			Eulachon Catch			
Date	Ht.	Time[2]	Site No.[3]	RM[4]	In	Out	Total Min.	Pre-Spawners	Post-Spawners	Total	C.P.U.E.[5] (Pre-Spawners)
5/16	22.6	1214	1	4.0	1320	1350	30	42	0	42	1.1
5/16	22.6	1214	2	4.5	1200	1230	32	24	0	24	
5/17	23.0	1333	1	4.0	1248	1322	34	72	0	72	1.5
5/17	23.0	1333	2	4.5	1348	1418	30	22	0	22	
5/19	27.8	0344	1	4.0	0257	0327	30	47	0	47	1.2
5/19	27.8	0344	2	4.5	0359	0429	30	27	0	27	
5/20	28.0	1642	1	4.0	1557	1627	30	31	0	31	1.4
5/20	28.0	1642	2	4.5	1704	1734	30	50	0	50	
5/22	31.5	0532	1	4.0	0447	0517	30	60	0	60	1.3
5/22	31.5	0532	2	4.5	0546	0614	28	15	0	15	
5/23	30.8	1906	1	4.0	1821	1852	31	38	8	46	0.7
5/23	30.8	1906	2	4.5	1921	1951	30	7	18	25	
5/26	32.0	0825	1	4.0	0740	0810	30	32	1	33	1.0
5/26	32.0	0825	2	4.5	0840	0910	30	25	15	40	
5/28	28.7	1014	1	4.0	0929	1000	31	2	3	5	0.4
5/28	28.7	1014	2	4.5	1029	1059	30	24	48	72	
5/30	25.4	1245	1	4.0	1200	1230	30	1	4	5	0.1
5/30	25.4	1245	2	4.5	1300	1330	30	6	23	29	
6/2	28.6	0344	1	4.0	0259	0303	4	98	1	99	17.9
6/2	28.6	0344	2	4.5	0359	0403	4	45	0	45	
6/5	28.2	1753	1	4.0	1711	1741	30	30	11	41	2.6
6/5	28.2	1753	2	4.5	1820	1850	30	124	94	218	
6/7	29.4	0634	1	4.0	0549	0619	30	4	63	67	2.5
6/7	29.4	0634	2	4.5	0649	0719	30	143	148	291	
6/9	28.6	0741	1	4.0	0640	0710	30	0	2	2	0.0
6/9	28.6	0741	2	4.5	0736	0802	26	1	16	17	

1/ High Tide
2/ Military Time

3/ Site No: 1 (T14N R7W Section 5 DAC)
Site No: 2 (T14N R7W Section 5 AAC)

4/ River Mile
5/ C.P.U.E.: Mean number of pre-spawners/net/minute

Source: Trent 1982

TABLE E.3.11: SEX COMPOSITION AND SPAWNING CONDITION OF EULACHON SAMPLED AT VARIOUS SUSITNA RIVER LOCATIONS, ADULT ANADROMOUS INVESTIGATION, SUSITNA HYDRO STUDIES, 1982

Date	Location (R.M.)1/	Sample Size	Number		Sex Ratio (M:F)	SPAWNING CONDITION 2/ (%)			
						Males		Females	
			Males	Females		Pre.	Post.	Pre.	Post.
5/16	4.5	110	74	36	2.1:1	100	0	100	0
5/17	4.5	173	98	75	1.3:1	100	0	100	0
5/18	25.5	11	9	2	4.5:1				
5/18	28.0	53	42	11	3.8:1				
5/18	28.5	106	85	21	4:1				
5/19	4.5	103	51	52	1:1.02	100	0	100	0
5/19	25.5	117	61	56	1.1:1				
5/20	4.5	151	82	69	1.2:1	100	0	100	0
5/20	36.7	47	37	10	3.7:1	100	0	100	0
5/20	40.4	8	6	2	3:1	100	0	100	0
5/20	40.5	16	12	4	3:1	100	0	100	0
5/21	25.5	360	211	149	1.4:1	100	0	98.0	2.0
5/22	25.5	100	42	58	1:1.4	92.9	7.1	84.5	15.5
5/23	20.5	119	22	97	1:4.4	100	0	88.7	11.3
5/23	21.9	144	132	12	11:1				
5/23	16.3	148	112	36	3.1:1	96.4	3.6	94.4	5.6
5/24	25.5	139	87	52	1.7:1	100	0	53.9	46.1
5/25	25.5	104	80	24	3.3:1	76.2	23.8	79.2	20.8
5/25	27.0	356	352	4	88:1	92.3	7.7	75.	25
5/25	26.5	84	78	6	13:1	79.5	20.5	50	50
5/26	4.5	114	52	62	1:1.2	94.2	5.8	88.7	11.3
5/26	8.5	32	10	22	1:2.2	90	10	59.1	40.9
5/26	10.8	66	34	32	1.06:1	91.2	8.8	96.9	3.1
5/26	13.15	15	12	3	1.4:1	66.7	33.3	100	0
5/26	16.35	203	119	84	1.4:1	88.2	11.8	100	0
5/26	18.3	222	200	22	9.1:1	85.5	14.5	95.5	4.5
5/26	19.5	112	92	20	45:1	56	44	80	20
5/26	22.5	100	49	51	1:1.04	75.5	24.5	98	2
5/27	25.5	105	40	65	1:1.7	47.5	52.5	100	0
5/28	16.3	105	73	32	2.3:1	38.4	61.6	100	0
5/28	18.5	115	113	2	56.5:1	70.8	29.2	50	50
5/28	25.5	145	77	68	1.1:1	84.4	15.6	91.2	8.8
5/29	27.0	244	236	8	29.5:1	80.1	19.9	50	50
5/30	22.8	73	38	35	1.1:1	65.8	34.2	97.1	2.9
5/30	24.8	10	10	0		40	60		
5/30	16.3	103	92	11	8.3:1	68.5	31.5	90.9	9.1
5/30	18.5	117	117	0		83.8	16.2		
5/30	19.8	25	16	9	1.8:1	68.7	31.3	33.3	66.7
5/31	25.5	65	59	6	9.8:1				
5/31	26.5	124	123	1	123:1				
5/31	25.8	46	45	1	45:1	80	20	100	0
5/31	25.9	45	43	2	21.5:1	48.8	51.2	0	100

SOURCE: TRENT 1982

TABLE E.3.11 (Cont'd)

Date	Location (R.M.)1/	Sample Size	Number		Sex Ratio (M:F)	SPAWNING CONDITION 2/ (%)			
						Males		Females	
			Males	Females		Pre.	Post.	Pre.	Post.
6/1	16.3	486	255	231	1.1:1	98.8	1.2	100	
6/1	18.5	214	112	102	1.1:1	98.2	1.8	100	
6/1	19.5	209	112	97	1.1:1	100	0	100	0
6/1	21.0	259	174	85	2.04:1	97.1	2.9	98.8	1.2
6/1	21.0	265	174	91	1.9:1	97.1	2.9	98.9	1.1
6/1	25.5	143	103	40	2.6:1	97.1	2.9	100	0
6/2	25.5	109	55	54	1.02:1	96.4	3.6	100	0
6/2	30.1	179	84	95	1:1.3	100	0	100	0
6/2	36.8	104	49	55	1:1.1	100	0	100	0
6/2	41.4	236	105	131	1:1.2	100	0	100	0
6/2	45.8	6	3	3	1:1	100	0	100	0
6/2	47.9	17	9	8	1.1:1				
6/3	25.5	216	106	110	1:1.04	100	0	98.2	1.8
6/3	36.8	155	93	62	1.5:1	100	0	100	0
6/3	38.4	3	2	1	2:1				
6/3	41.4	139	71	68	1.04:1	100	0	100	0
6/3	44.0	143	85	58	1.4:1	100	0	100	0
6/4	36.8	156	85	71	1.2:1	95.3	4.7	100	0
6/4	41.4	136	88	48	1.8:1	100	0	100	0
6/4	25.5	187	111	76	1.5:1	100	0	100	0
6/4	45.0	147	106	41	2.6:1	99.1	0.9	97.6	2.4
6/4	48.0	145	99	46	2.1:1	100	0	97.8	2.2
6/5	9.5	156	71	85	1:1.2	33.8	66.2	70.6	29.4
6/5	15.0	104	82	22	3.7:1	85.4	14.6	86.4	13.6
6/5	25.5	167	68	99	1:1.4	75.0	25.0	76.7	30.3
6/5	27.9	177	112	65	1.7:1	77.7	22.3	32.3	67.7
6/5	31.0	145	72	73	1:1.01				
6/5	31.8	193	92	101	1:1.1				
6/6	15.0	314	288	26	11.1:1	81.6	18.4	61.5	38.5
6/6	16.3	212	142	70	2:1	82.4	17.6	92.9	7.1
6/6	25.5	143	85	58	1.5:1	44.7	55.3	55.2	44.8
6/7	35.5	161	98	63	1.5:1	63.3	36.7	95.2	4.8
6/7	47.3	17	15	2	7.5:1	0	100	100	0
6/8	18.3	150	144	6	24:1	51.4	48.6	83.3	16.7
6/8	20	94	90	4	22.5:1	48.9	51.1	100	
6/8	21.7	62	59	3	19.6:1	0	100	66.7	33.3
6/8	31.2	7	5	2	2.5:1				
6/9	15.0	156	145	11	13.2:1	26.9	73.1	0	100

1/ River Mile

2/ Pre-spawning condition: gravid
Post-spawning condition: spent

SOURCE: TRENT 1982

TABLE E.3.12: ARCTIC GRAYLING HOOK AND LINE TOTAL CATCH BY TRIBUTARY BETWEEN THE MOUTH AND PROPOSED IMPOUNDMENT ELEVATIONS (PIE*) AND MONTH IN THE IMPOUNDMENT STUDY AREA, 1981 (ADAPTED FROM ADF&G 1981g)

	CATCH					
TRIBUTARY	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL
Fog Creek	22	17	23	5	5	72
Tsusena Creek	23	19	74	18	1	135
Deadman Creek	53	86	42	6	3	190
Watana Creek	1	49	16	172	28	266
Kosina Creek	136	246	143	67	187	779
Jay Creek	3	178	70	16	50	317
Goose Creek	121	136	82	37	6	382
Oshetna River	19	92	155	73	167	506
TOTAL CATCH	378	823	605	394	447	2,647

* PIE for Fog and Tsusena Creeks = 1455 ft; all other tributaries = 2185 ft.

SOURCE: ADF&G 1981f

TABLE E.3.13: ARCTIC GRAYLING POPULATION ESTIMATES FOR TRIBUTARIES IN THE IMPOUNDMENT STUDY AREA, (ADAPTED FROM ADF&G 1981g)*

STREAM	POPULATION ESTIMATE	CONFIDENCE** INTERVAL
Fog Creek	176	115- 369
Tsusena Creek	1,000	743-1,530
Deadman Creek	979	604-2,575
Kosina Creek	2,787	2,228-3,720
Jay Creek	1,089	868-1,462
Goose Creek	1,327	1,016-1,913
Oshetna River	2,017	1,525-2,976

* Watana Creek estimate is not included because the number of recaptures was too low.

** Based on June through September recoveries.

SOURCE: ADF&G 1981f

TABLE E.3.14: EFFECTS OF SURFACING AND EARTHWORK ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF AQUATIC HABITAT (MODIFIED FROM DARNELL ET AL. 1978)

Construction Activity/ Physical and Chemical Effects	Cleaning	Earthwork	Rock Excavation	Subgrade Stabilization	Aggregate Production	Equipment Areas	Borrow Pits & Landfills	Long-Term Effects
Increased Surface Runoff	X	X		X	X	X	X	X
Lowering of Water Table	X	X						X
Leaching of Soil Mineral	X	X						
Fluctuation in Streamflow	X	X		X	X	X		X
Fluctuation in Water Level	X	X		X	X	X		X
Downstream Flooding	X	X			X	X		X
Increased Sedimentation	X	X	X	X	X	X		
Reduced Habitat Diversity	X	X	X		X	X		X
Increased Turbidity	X	X	X	X	X	X	X	
Changes in Water Temperatures	X	X	X		X	X		
Changes in pH	X	X	X		X	X		
Changes in Chemical Composition	X	X	X	X	X	X	X	X
Addition of Hydrocarbons						X		X
Increased Oxygen Demand	X	X	X		X		X	

TABLE E.3.15

Increase in water surface elevation during initial filling of Watana Reservoir.*

1ST YEAR

Month	Rate (ft/day)	WSEL (ft)	Increase In WSEL (ft)
APR	-	1460	-
MAY	5.4	1626	166
JUN	2.4	1699	73
JUL	4.0	1823	124
AUG	0.9	1851	28
SEPT	0.6	1868	17
OCT	0.2	1875	7

Total increase in water surface elevation for the year is 415 ft

2ND YEAR

Month	Rate (ft/day)	WSEL (ft)	Increase In WSEL (ft)
MAR	-	1875	-
APR	<0.1	1876	1
MAY	1.0	1907	31
JUN	2.5	1983	76
JUL	1.7	2036	53
AUG	0.8	2062	26
SEPT	0.3	2070	8
OCT	0.3	2079	9
NOV	0.1	2082	3
DEC	<0.1	2083	1

Total increase in water surface elevation for the year is 208 ft

3RD YEAR

Month	Rate (ft/day)	WSEL (ft)	Increase In WSEL (ft)
MAR	-	2083	-
APR	<0.1	2084	1
MAY	0.5	2100	16
JUN	1.3	2140	40
JUL	1.0	2172	32
AUG	0.4	2185	13

Total increase in water surface elevation for the year is 102 ft

*Under median flow conditions.

TABLE E.3.16: IMPORTANT TRIBUTARIES INUNDATED BY WATANA RESERVOIR

	mi.
Deadman Creek (RM 186.7)	2.3
Watana Creek (RM 194.1)	10
Kosina Creek (RM 206.9)	4.2
Jay Creek (RM 208.6)	3.2
Goose Creek (RM 231.2)	1.2
Oshetna River (RM 233.5)	2.0

TABLE E.3.16a: MAJOR IMPACT ISSUES DURING FILLING OF WATANA RESERVOIR REGARDING SALMONIDS IN THE TALKEETNA-TO-DEVIL CANYON REACH (o - NO IMPACT, + = BENEFICIAL IMPACT, - = ADVERSE IMPACT, BLANK = NOT PRESENT IN THE HABITAT CONSIDERED)

Species	Passage Into Sloughs	Passage Into Tributaries	Reduced Slough + Mainstem Spawning Habitat	Reduced Ground-Water Upwelling	Rearing in Mainstem	Increased Winter Water Temperature	Decreased Summer Water Temperature	Decreased Mainstem Turbidity	Decreased Mainstem Scouring	Downstream Passage in Mainstem	Downstream Passage From Sloughs
Chum Salmon											
- Adult	-	o	-				-				
- Embryo				-		-			+		
- Juvenile				o		-		o		o	-
Sockeye Salmon											
- Adult	-		-				-				
- Embryo				-		-					
- Juvenile	-			o	o			+		o	-
Chinook Salmon											
- Adult		o	o				-				
- Juvenile	o	o		-	+	+	-	+	+	o	o
Coho Salmon											
- Adult		o	o				-				
- Juvenile	o	o		-	+	+	-	+	+	o	o
Pink Salmon											
- Adult	-	o	-				-				
- Embryo				o		-			+		
- Juvenile						-		o		o	-
Rainbow Trout											
- Adult	-	o	o	o	+	+	-	+	+	o	o
- Juvenile	o	o		o	+	+	-	+	+	o	o

TABLE E.3.17

Comparison of average monthly streamflows at Gold Creek during initial filling of Watana Reservoir.*

Month	Pre-Project (cfs)	Proposed Minimum (cfs)	Forecast Streamflows 1st yr (cfs)	% Change	2nd yr (cfs)	% Change	3rd yr (cfs)	% Change
OCT	5800	2000	5800	0	4300	-26	2000	-66
NOV	2600	1000	2600	0	2600	0	1500	-42
DEC	1800	1000	1800	0	1800	0	1300	-28
JAN	1500	1000	1500	0	1500	0	1300	-13
FEB	1200	1000	1200	0	1200	0	1200	0
MAR	1100	1000	1100	0	1100	0	1100	0
APR	1400	1000	1400	0	1200	-14	1200	-14
MAY	13200	6000	9800	-26	6000	-55	6000	-55
JUN	27800	6000	22200	-20	6000	-78	6800	-76
JUL	24400	6500	7300	-70	6500	-73	6500	-73
AUG	22200	12000	16800	-24	12000	-46	14100	-36
SEPT	13300	9300	9300	-30	9300	-30	13300	0
AVERAGE ANNUAL	9700	4000	6900	-29	4500	-54	4700	-52

*Under median flow conditions.

TABLE E.3.18

Comparison of average monthly streamflows at Sunshine Station during initial filling of Watana Reservoir.*

Month	Pre-Project (cfs)	Proposed Minimum (cfs)	Forecast Streamflows					
			1st yr (cfs)	% Change	2nd yr (cfs)	% Change	3rd yr (cfs)	% Change
OCT	13700	10100	13700	0	12400	-9	10100	-26
NOV	5800	4400	5800	0	5800	0	4900	-16
DEC	4200	3400	4200	0	4200	0	3700	-12
JAN	3500	3000	3500	0	3500	0	3300	-6
FEB	3000	2700	3000	0	3000	0	3000	0
MAR	2600	2500	2600	0	2600	0	2600	0
APR	3200	2800	3200	0	3000	-6	3000	-6
MAY	27700	20400	24200	-13	20400	-26	20400	-26
JUN	64200	42300	58500	-9	42300	-34	43100	-33
JUL	63200	45800	46600	-26	45800	-28	45800	-28
AUG	55900	46400	51200	-8	46400	-17	48500	-13
SEPT	32300	28400	28400	-12	28400	-12	32300	0
AVERAGE ANNUAL	23300	17700	20400	-12	18200	-22	18400	-21

*Under median flow conditions.

TABLE E.3.19

Comparison of average monthly streamflows at Susitna Station during initial filling of Watana Reservoir.*

Month	Pre-Project (cfs)	Proposed Minimum (cfs)	Forecast Streamflows 1st yr (cfs)	% Change	2nd yr (cfs)	% Change	3rd yr (cfs)	% Change
OCT	30100	26400	30100	0	28700	-5	26400	-12
NOV	12700	11200	12700	0	12700	0	11700	-8
DEC	8200	7400	8200	0	8200	0	7700	-6
JAN	7900	7500	7900	0	7900	0	7800	-1
FEB	7000	6800	7000	0	7000	0	7000	0
MAR	6300	6200	6300	0	6300	0	7000	0
APR	7000	6600	7000	0	6800	-3	6800	-3
MAY	60500	53100	56900	-6	53100	-12	53100	-12
JUN	123700	101800	118000	-5	101800	-18	102600	-17
JUL	131900	114600	115400	-13	114600	-13	114600	-13
AUG	110800	101400	106200	-4	101400	-8	103500	-7
SEPT	66000	62100	62100	-6	62100	-6	66000	0
AVERAGE ANNUAL	47700	42100	44800	-6	42600	-11	40100	-16

*Under median flow conditions.

TABLE E.3.20: STREAM HABITAT AFFECT BY OPERATION OF WATANA RESERVOIR

	Mi of tributary inundated	
	May-June	Total
Watana Creek	.5	.7
Kosina Creek	.4	.8
Jay Creek	.4	.8
Goose Creek	.3	.8
Osletna River	.6	1.6

TABLE E.3.21: MAJOR IMPACT ISSUES DURING OPERATION OF WATANA RESERVOIR REGARDING SALMONIDS IN THE TALKEETNA-TO-DEVIL CANYON REACH (o - NO IMPACT, + = BENEFICIAL IMPACT, - = ADVERSE IMPACT, BLANK = NOT PRESENT IN THE HABITAT CONSIDERED)

Species	Passage Into Sloughs	Passage Into Tributaries	Reduced Slough Spawning Habitat	Reduced Ground-Water Upwelling	Rearing in Mainstem	Over-wintering Habitat	Decreased Mainstem Turbidity	Decreased Mainstem Scouring	Downstream Passage in Mainstem	Downstream Passage From Sloughs
Chum Salmon										
- Adult	-	o	-	-						
- Embryo				-				+		
- Juvenile							o		o	-
Sockeye Salmon										
- Adult	-		-	-						
- Embryo				-						
- Juvenile					o		+		o	-
Chinook Salmon										
- Adult		o	o							
- Juvenile	o	o			+	+	+	+	o	o
Coho Salmon										
- Adult		o	o							
- Juvenile	o	o			+	+	+	+	o	o
Pink Salmon										
- Adult	-	o	-	o						
- Embryo				o				+		
- Juvenile							o		o	-
Rainbow Trout										
- Adult	-	o	o	o		+	+	+	o	o
- Juvenile	o	o		o	+	+	+	+	o	o

TABLE E.3.24: COMPARISON OF AVERAGE MONTHLY STREAMFLOWS AT GOLD CREEK STATION UNDER OPERATION OF WATANA DAM

Month	Pre-Project (cfs)	Post-Project (cfs)	% Change
OCT	5800	8000	+38
NOV	2600	9200	+254
DEC	1800	10700	+494
JAN	1500	9700	+547
FEB	1200	9000	+650
MAR	1100	8300	+655
APR	1400	7700	+450
MAY	13200	10400	-21
JUN	27800	11400	-59
JUL	24400	9200	-62
AUG	22200	13400	-40
SEPT	13300	9800	-26

TABLE E.3.25: COMPARISON OF AVERAGE MONTHLY STREAMFLOWS AT SUNSHINE STATION UNDER OPERATION OF WATANA DAM

Month	Pre-Project (cfs)	Post-Project (cfs)	% Change
OCT	13700	16000	+17
NOV	5800	12400	+114
DEC	4200	13000	+210
JAN	3500	11700	+234
FEB	3000	10600	+253
MAR	2600	9800	+277
APR	3200	9500	+197
MAY	27700	24900	-10
JUN	64200	47900	-25
JUL	63200	48300	-24
AUG	55900	47400	-15
SEPT	32300	29000	-10

TABLE E.3.26: COMPARISON OF AVERAGE MONTHLY STREAMFLOWS AT SUSITNA STATION UNDER OPERATION OF WATANA DAM

Month	Pre-Project (cfs)	Post-Project (cfs)	% Change
OCT	30100	32400	+8
NOV	12700	19200	+51
DEC	8200	17000	+107
JAN	7900	16100	+104
FEB	7000	14700	+110
MAR	6300	13500	+114
APR	7000	13300	+90
MAY	60500	57600	-5
JUN	123700	107400	-13
JUL	131900	117000	-11
AUG	110800	102300	-8
SEPT	66000	62600	-5

TABLE E.3.27: COMPARISON OF AVERAGE MONTHLY STREAMFLOWS AT GOLD CREEK OF THE TWO OPERATIONAL WATANA AND DEVIL CANYON DAMS

Month	Watana Alone (cfs)	Watana/Devil Canyon (cfs)	% Change
OCT	8000	7800	-3
NOV	9200	9600	+4
DEC	10700	11300	+6
JAN	9700	10600	+9
FEB	9000	10200	+13
MAR	8300	9300	+12
APR	7700	8100	+5
MAY	10400	8700	-16
JUN	11400	9900	-13
JUL	9200	8400	-9
AUG	13400	12600	-6
SEPT	9800	10500	+7

TABLE E.3.28: COMPARISON OF AVERAGE MONTHLY STREAMFLOWS AT SUNSHINE STATION OF THE TWO OPERATIONAL WATANA AND DEVIL CANYON DAMS

Month	Watana Alone (cfs)	Watana/Devil Canyon (cfs)	% Change
OCT	16000	15800	-1
NOV	12400	12900	+4
DEC	13000	13600	+5
JAN	11700	12600	+8
FEB	10600	11800	+11
MAR	9800	10700	+9
APR	9500	9800	+3
MAY	24900	23200	-7
JUN	47900	46200	-4
JUL	48300	47600	-1
AUG	47400	46800	-1
SEPT	29000	29600	+2

TABLE E.3.29: COMPARISON OF AVERAGE MONTHLY STREAMFLOWS AT SUSITNA STATION OF THE TWO OPERATIONAL WATANA AND DEVIL CANYON DAMS

Month	Watana Alone (cfs)	Watana/Devil Canyon (cfs)	% Change
OCT	32400	32200	<1
NOV	19200	19800	+3
DEC	17000	17600	+4
JAN	16100	17000	+6
FEB	14700	15900	+8
MAR	13500	14400	+7
APR	13300	13600	+2
MAY	57600	55900	-3
JUN	107400	105700	-2
JUL	117000	116300	<1
AUG	102300	101700	<1
SEPT	62600	63300	+1

TABLE E.3.30: IMPACT ISSUES AND PROPOSED MITIGATION FEATURES FOR ANTICIPATED FILLING AND OPERATIONAL IMPACTS TO AQUATIC HABITATS, SUSITNA HYDROELECTRIC PROJECTS

IMPACT ISSUE	OCCURRENCE				MITIGATION FEATURE			
	Watana Development		Devil Canyon Development		Watana Development		Devil Canyon Development	
	Filling	Operation	Filling	Operation	Filling	Operation	Filling	Operation
Passage of Adult Salmon	X	X		X	- Downstream release	- Downstream release		- Downstream release
Adverse Impacts to Slough Habitat	X	X		X	- Downstream relase - Slough modification - Replacement habitat through modification of side channels	- Downstream release - Slough modification - Replacement habitat through modification of side channels		- Downstream release - Slough modification - Replacement habitat through modification of side channels
Loss of Sidechannel and Mainstem Salmon Spawning Areas	X	X		X	- Replacement habitat through modification of side channels	- Replacement habitat through modification of side channels		- Replacement habitat through modification of side channels
Altered Thermal Regime	X	X		X		Multiple level outlet		Multiple level outlet
Gas Supersaturation	X	X			Fixed Core valves			Fixed core valves
Inundation of Tributary Habitat	X		X		Lake modification and restocking program		Lake modification stocking program	-
Outmigration of Juvenile Anadromous Fish	X	X		X	Downstream release	Downstream release		Downstream release

TABLE W1

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER SUSITNA RIVER BASIN* (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL, 1982)

Pteridophyta

Aspidiaceae

Dryopteris dilatata (Hoffm.) Gray	Shield fern	U	D	I
Dryopteris fragrans (L.) Schott	Fragrant shield fern	U		I
Gymnocarpium dryopteris (L.) Newm.	Oak fern	U	D	I

Athyriaceae

Athyrium filix-femina (L.) Roth	Lady fern	U	D	
Cystopteris fragilis (L.) Bernh.	Fragile fern	U		
Cystopteris montana (Lam.) Bernh.	Mountain fragile fern	U		
Matteuccia struthiopteris (L.) Todaro	Ostrich fern		D	I
Woodsia alpina (Bolton) S. F. Gray	Alpine woodsia	U		

Equisetaceae

Equisetum arvense L.	Meadow horsetail.	U		
Equisetum fluviatile L. ampl. Ehrh.	Swamp horsetail	U		
Equisetum palustre L.	Marsh horsetail		D	
Equisetum pratense L.	Meadow horsetail	U	D	
Equisetum silvaticum L.	Woodland horsetail	U		I
Equisetum variegatum Schleich.	Variegated scouring-rush	U	D	
Equisetum sp.	Horsetail			I

Isoetaceae

Isoetes muricata Dur.	Quillwort	U		

Lycopodiaceae

Lycopodium alpinum L.	Alpine clubmoss	U		
Lycopodium annotinum L.	Stiff clubmoss	U		
Lycopodium clavatum L.	Running clubmoss	U		
Lycopodium complanatum L.	Ground cedar	U		
Lycopodium selago L. ssp. selago	Fir clubmoss	U		

Thelypteridaceae

Thelypteris phegopteris (L.) Slosson	Long beech fern	U		

Gymnospermae

Cupressaceae

Juniperus communis L.	Common juniper	U		I

Pinaceae

Picea glauca (Moench) Voss	White spruce	U	D	I
Picea mariana (Mill.) Britt., Sterns & Pogg.	Black spruce	U	I	

Monocotyledoneae

Cyperaceae

Carex aquatilis Wahlenb.	Water sedge	U		
Carex bigelowii Torr.	Bigelow sedge	U		
Carex capillaris L.	Hairlike sedge	U		
Carex canescens L.	Silvery sedge		D	
Carex concinna R. Br.	Low northern sedge	U		

TABLE W1

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER SUSITNA RIVER BASIN* (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL, 1982) (Cont'd)

Carex filifolia Nutt.	Thread-leaf sedge	U		
Carex garberi Fern.	Sedge		D	
Carex limosa L.	Shore sedge	U		
Carex loliacea L.	Sedge	U		
Carex media R. Br. ex Richards	Sedge	U		
Carex membranacea Hook	Fragile sedge	U		
Carex podocarpa C. B. Clarke	Short-stalk sedge	U		
Carex rhynchophysa C. A. Mey	Sedge	U		
Carex saxatilis L.	Sedge		D	
Carex spp.	Sedge	U	D	I
Eleocharis sp.	Spike rush			I
Eriophorum angustifolium Honck.	Tall cottongrass	U		
Eriophorum scheuchzeri Hoppe	White cottongrass	U		
Eriophorum vaginatum L.	Tussock cottongrass	U	D	I
Eriophorum sp.	Cottongrass		D	I
Scirpus microcarpus Presl.	Small-fruit bullrush		D	
Trichophorum caespitosum (L.) Hartm.	Tufted clubrush	U		
Gramineae (Poaceae)				
Agropyron boreale (Turcz.) Drobov	Northern wheatgrass		D	
Agropyron caninum (L.) Beauv.	Wheatgrass		D	
Agropyron macrourum (Turcz.) Drobov	Wheatgrass		D	
Agropyron sp.	Wheatgrass	U		
Agrostis scabra Willd.	Tickle grass	U	D	
Agrostis sp.	Bent grass	U		
Alopecurus alpinus Sm.	Mountain foxtail	U		
Arctagrostis latifolia (R. Br.) Griseb.	Polargrass	U		
Beckmannia syzigachne (Steud.) Fern	Slough grass		D	
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint	U	D	I
Calamagrostis purpurascens R. Br.	Purple reedgrass	U		
Cinna latifolia (Trev.) Griseb. in Ledeb	Woodreed		D	
Danthonia intermedia Vasey	Timber oatgrass	U		
Deschampsia atropurpurea (Wahlenb.) Scheele**	Mountain hairgrass	U		
Deschampsia caespitosa (L.) Beauv.	Tufted hairgrass	U	D	
Festuca altaica Trin.	Fescue grass	U		
Festuca rubra L. Coll.	Red fescue	U		
Hierochloe alpina (Swartz) Roem. & Schult.	Alpine holygrass	U		
Hierochloe odorata (L.) Wahlenb.	Vanilla grass	U	D	
Phleum commutatum Gandoger	Timothy	U		
Poa alpina L.	Alpine bluegrass	U		
Poa arctica R. Br.	Arctic bluegrass	U		
Poa palustris L.	Bluegrass	U		
Trisetum spicatum (L.) Richter	Downy oatgrass	U	D	
Iridaceae				
Iris setosa Pellas	Wild iris	U		I
Juncaceae				
Juncus arcticus Willd.	Arctic rush	U	D	
Juncus castaneus Sm.	Chestnut rush	U		
Juncus drummondii E. Mey.	Drummond rush	U		
Juncus mertensianus Bong.	Mertens rush	U		
Juncus triglymis L.	Rush	U		
Luzula campestris (L.) DC. ex DC. & Lam.**	Woodrush	U		
Luzula confusa Lindeb.	Northern woodrush	U		
Luzula multiflora (Retz.) Lej.	Woodrush	U		
Luzula parviflora (Ehrh.) Desv.	Small-flowered woodrush	U		
Luzula tundricola Gorodk.	Tundra woodrush	U		
Luzula wahlenbergii Rupr.	Wahlenberg woodrush	U		

TABLE W1

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER SUSITNA RIVER BASIN* (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL. (1982) (Cont'd)

Liliaceae				
Lloydia serotina (L.) Rchb.	Alp lily	U		I
Streptopus amplexifolius (L.) DC.	Cucumber root	U	D	I
Tofieldia coccinea Richards	Northern asphodel	U		
Tofieldia pusilla (Michx.) Pers.	Scotch asphodel	U		I
Veratrum viride Ait.	False Helebore	U		I
Zygadenus elegans Pursh	Elegant death camas	U		I
Orchidaceae				
Listera cordata (L.) R. Br.	Twyblade			I
Platanthera convallariaefolia (Fisch.) Lindl.	Northern bog-orchis	U		
Platanthera dilatata (Pursh) Lindl.	White bog-orchis	U		
Platanthera hyperborea (L.) Lindl.	Northern bog-orchis	U		I
Potamogetomaceae				
Potamogeton epihydrous Raf.	Nuttall pondweed	U		
Potamogeton filiformis Pers.	Filiform pondweed	U		
Potamogeton gramineus L.	Pondweed	U		
Potamogeton perfoliatus L.	Clasping-leaf pondweed	U		
Potamogeton robbinsii Oakes	Robbins pondweed	U		
Sparganiaceae				
Sparganium angustifolium Michx.	Narrow-leaved burreed	U		
Dicotyledoneae				
Araliaceae				
Echinopanax horridum (Sm.) Decne. & Planch.	Devil's club	U	D	I
Betulaceae* **				
Alnus crispa (Ait.) Pursh	American green alder	U		I
Alnus sinuata (Reg.) Rydb.	Sitka alder	U	D	I
Alnus tenuifolia Nutt.	Thinleaf alder		D	
Alnus sp.	Alder			I
Betula glandulosa Michx.	Resin birch	U		I
Betula nana L.	Dwarf arctic birch	U	D	I
Betula occidentalis Hook.	Water birch	U		
Betula papyrifera Marsh.	Paper birch	U	D	I
Boraginaceae				
Mertensia paniculata (Ait.) G. Don	Tall bluebell	U	D	I
Myosotis alpestris F. W. Schmidt	Forget-me-not	U		
Callitrichaceae				
Callitriche hermaphroditica L.	Water starwort	U		
Callitriche verna L.	Vernal water starwort	U		
Campanulaceae				
Campanula lasiocarpa Cham.	Mountain harebell	U		I
Caprifoliaceae				
Linnaea borealis L.	Twin-flower	U		I
Sambuons callicarpa	Pacific red elder			I
Viburnum edule (Michx.) Raf.	High bush cranberry	U	D	I

TABLE W1

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER SUSITNA RIVER BASIN* (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL. 1982) (Cont'd)

Caryophyllaceae				
Minuartia obtusiloba (Rydb.) House	Alpine sandwort	U		
Moehringia laterifolia (L.) Fenzl	Grove Sandwort			I
Silene acaulis L.	Moss campion	U		
Stellaria crossifolia Ehrh.	Chickweed			I
Stellaria sp.	Starwort	U		
Wilhelmsia physodes (Fisch.) McNeill	Merckia	U		
Compositae (Asteraceae)				
Achillea borealis Bong.	Yarrow	U	D	
Achillea sibirica Ledeb	Siberian yarrow	U	D	
Antennaria alpina (L.) Gaertn.	Alpine pussytows	U		
Antennaria monocphala DC.	Pussytoes	U		
Antennaria rosea Greene	Pussytoes	U		
Arnica amplexicaulis Nutt. ssp. prima Maguire	Arnica	U		
Arnica chamissonis Less. (?)	Arnica		D	
Arnica frigida C. A. Mey.	Arnica	U		I
Arnica lessingii Greene	Arnica	U		
Artemisia alaskana Rydb.	Alaska wormwood	U		
Artemisia arctica Less.	Wormwood	U		I
Artemisia tilesii Ledeb.	Wormwood	U	D	I
Aster sibiricus L.	Siberian aster	U	D	I
Erigeron acris subsp. politus (L.) (E. Fries) Schinz & Keller	Fleabane	I		
Erigeron humuilis Graham	Fleabane daisy	U		
Erigeron lonchophyllous Hook.	Daisy		D	
Erigeron purpuratus Greene	Fleabane			I
Hieracium triste Willd	Wooly hawkweed	U		
Petasites frigidus (L.) Franch.	Arctic sweet coltsfoot	U		I
Petasites sagittatus (Banks) Gray	Arrowleaf sweet coltsfoot	U		
Petasites sp.	Sweet coltsfoot		D	I
Saussurea angustifolia (Willd.) DC.	Saussurea	U		I
Senecio atropurpureus (ledeb.) Fedtsch.	Ragwort	U		
Senecio lugens Richards.	Ragwort	U		I
Senecio sheldonensis Pors.	Sheldon groundsel	U		
Senecio triangularis Hook	Ragwort			I
Solidago multiradiata Ait.	Northern goldenrod	U	D	
Taraxacum sp.	Dandelion	U		
Cornaceae Seneaio sp	Ragwort			I
Cornus canadensis L.	Bunchberry	U	D	I
Crassulaceae				
Sedum rosea (L.) Scop.	Roseroot	U		I
Cruciferae (Brassicacea)				
Draba aurea Vahl	Draba			I
Cardamine bellidifolia L.	Alpine bittercress	U		
Cardamine pratensis L.	Cuckoo flower	U		
Cardamine umbellata Greene	Bittercress	U		
Draba nivalis Liljebl	Rockcress	U		
Draba stenoloba Ledeb.	Rockcress	U		
Parrya nudicaulis (L.) Regel	Parrya			I
Diapensiaceae				
Diapensia lapponica L.	Diapensia	U		I

TABLE W1

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER SUSITNA RIVER BASIN[a/] (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL. 1982) (Cont'd)

Droseraceae				
Drosera rotundifolia L.	Sundero			I
Elaeagnaceae				
Shepherdia canadensis (L.) Nutt.	Soapberry	U	D	I
Empetracene				
Empetrum nigrum L.	Crowberry	U		I
Ericaceae				
Andromeda polifolia L.	Bog rosemary	U		
Arctostaphylos alpina (L.) Spreng.	Alpine bearberry	U		I
Arctostaphylos rubra (Rehd. & Wilson) Fern.	Red-fruit bearberry	U		I
Arctostaphylos uva-ursi (L.) Spreng.	Bearberry	U		I
Cassiope tetragona (L.) D. Don	Four-angle mountain heather	U		I
Ledum decumbens (Ait.) Small***	Northern Labrador tea	U		I
Ledum groenlandicum Oeder	Labrador tea	U		I
Ledum sp.	Labrador tea		D	I
Loiseleuira procumbens (L.) Desv.	Alpine azalea	U		I
Menziesia ferrugivea Sm.	Menziesia			I
Oxycoccus microcarpus Turcz.	Swamp cranberry	U	D	
Rhododendron lapponicum (L.) Wahlenb.	Lapland rosebay	U		I
Vaccinium caespitosum Michx.	Dwarf blueberry	U		
Vaccinium uliginosum L.	Bog blueberry	U	D	I
Vaccinium vitis-idaea L.	Mountain cranberry	U		I
Vaccinium sp.	Blueberry			I
Fumariaceae				
Corydalis pauciflora (Steph.) Pers.	Few-flowered corydalis	U		I
Gentianaceae				
Gentiana glauca Pall.	Glaucous gentian	U		
Gentiana propinqua Richards.	Gentian	U		
Menyanthes trifoliata L.	Buckbean	U	D	I
Swertia perennis L.	Gentian	U		I
Geraniaceae				
Geranium erianthum DC.	Northern geranium	U		I
Haloragaceae				
Hippuris vulgaris L.	Common marestail	U		
Leguminosae (Fabaceae)				
Astragalus aboriginum Richards	Milk-vetch	U		
Astragalus alpinus L.**	Milk-vetch	U	D	
Astragalus umbellatus Bunge	Milk-vetch	U		
Hedysarum alpinum L.	Alpine sweet-vetch	U	D	I
Lupinus arcticus S. Wats.	Arctic lupine	U		I
Oxytropis campestris (L.) DC.	Field oxytrope		D	
Oxytropis huddelsonii Prosild	Huddelson oxytrope	U		
Oxytropis maydelliana Trautv.	Maydell oxytrope	U		
Oxytropis nigrescens (Pall.) Fisch.	Blackish oxytrope	U		I
Oxytropis viscida Nutt.	Viscid oxytrope	U		

TABLE W1

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER SUSITNA RIVER BASIN* (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL. 1982) (Cont'd)

Lentibulariaceae				
Pinguicula villosa L.	Hairy butterwort	U		
Utricularia vulgaris L.	Common bladderwort	U		
Myricaceae				
Myrica gale L.	Sweet gale	U	D	I
Nymphaceae				
Nuphar polysepalum Engelm.	Yellow pond lily	U		
Onagraceae				
Circaea alpina L.	Enchanter's nightshade		D	
Epilobium angustifolium L.	Fireweed	U	D	I
Epilobium latifolium L.	Dwarf fireweed	U	D	I
Epilobium palustre L.	Swamp willow-herb	U		
Orobanchaceae				
Boschniakia rossica (Cham. & Schlecht. Fedtsch.	Poque	U	D	I
Polemoniaceae				
Polemonium acutiflorum Willd.	Jacob's ladder	U	D	I
Polygonaceae				
Oxyria digyna (L.) Hill	Mountain sorrel	U		I
Polygonum bistorta L.	Meadow bistort	U		
Polygonum viviparum L.	Alpine bistort	U		I
Rumex arcticus Trautv.	Arctic dock	U		I
Rumex sp.	Dock	U		I
Portulacaceae				
Claytonia sarmentosa C. A. Mey.	Spring-beauty	U		I
Primulaceae				
Androsace chamaejasme Hult	Androsace			I
Dodecatheon frigidum Cham. & Schlecht.	Northern shooting star	U		I
Primula cuneifolia Ledeb	Wedge-leaf primrose	U		
Trientalis europaea L.	Arctic starflower	U	D	I
Pyrolaceae				
Moneses uniflora (L.) Gray	Single delight	U	D	
Pyrola asarifolia Michx.	Liverleaf wintergreen		D	
Pyrola grandiflora Radius	Large-flower wintergreen	U		
Pyrola minor L.	Lesser wintergreen	U		
Pyrola secunda L.	One-sided wintergreen	U	D	
Pyrola sp.	Wintergreen			I
Ranunculaceae				
Aconitum delphinifolium DC.	Monkshood	U		I
Actaea rubra (Ait.) Willd.	Baneberry		D	
Anemone narcissiflora L.	Anemone	U		I
Anemone parviflora Michx.	Northern anemone	U		I
Anemone richardsonii Hook	Anemone	U	D	I
Anemore sp.	Anemone			I
Caltha leptosepala DC.	Mountain marsh-marigold	U		I

TABLE W1

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER SUSITNA RIVER BASIN* (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL. 1982) (Cont'd)

Delphinium glaucum S. Wats	Larkspur			I
Ranunculus confervoides (E. Fries) E Fries	Water crowfoot	U		
Ranunculus macounii Britt. (may be *R. pacificus* or something similar)	Macoun buttercup		D	
Ranunculus nivalis L.	Snow buttercup	U		
Ranunculus occidentalis Nutt.	Western buttercup	U		
Ranunculus pygmaeus Wahlenb.	Pygmy buttercup	U		
Ranunculus sp.	Buttercup	U		I
Thalictrum alpinum L.	Arctic meadowrue	U		
Thalictrum sparsiflorum Turcz.	Few-flower meadowrue	U	D	I
Rosaceae				
Dryas drummondii Richards.	Drummond mountain-avens	U	D	I
Dryas integrifolia M. Vahl.	Dryas	U		I
Dryas octopetala L.	White mountain-avens	U		
Geum macrophyllum Wild.	Avens			I
Geum rossii (R. Br.) Ser.	Ross avens	U		I
Luetkea pectinata (Pursh) Ktze.	Luetkea	U		
Potentilla biflora Willd.	Two-flower cinquefoil	U		
Potentilla fruticosa L.	Shrubby cinquefoil	U		I
Potentilla hyparctica Malte	Arctic cinquefoil	U		
Potentilla palustris (L.) Scop.	Marsh cinquefoil	U	D	I
Rosa acicularis Lindl.	Prickly rose	U	D	I
Rubus arcticus L.	Nagoon berry	U	D	I
Rubus chamaemorus L.	Cloudberry	U		I
Rubus idaeus L.	Raspberry	U	D	I
Rubus pedatus Sm.	Five-leaf bramble	U		I
Rubus sp.	Raspberry			I
Sanguisorba stipulata Raf.	Sitka burnet	U		I
Sibbaldia procumbens L.	Sibbaldia	U		
Sorbus scopulina Greene	Western mountain ash	U		I
Spiraea beauverdiana Schneid.	Beauverd spirea	U	D	I
Rubiaceae				
Galium boreale L.	Northern bedstraw	U		I
Galium trifidum L.	Small bedstraw	U		
Galium triflorum Michx.	Sweet-scented bedstraw		D	
Salicaceae***				
Populus balsamifera L.	Balsam poplar	U	D	I
Populus tremuloides Michx.	Quaking aspen	U		I
Salix alaxensis (Anderss.) Cov	Feltleaf willow	U	D	
Salix arbusculoides Anderss.	Littletree willow	U	D	
Salix arctica Pall.	Arctic willow	U		
Salix barclayi Anderss.	Barclay willow	U		
Salix brachycarpa Nutt.	Barren-ground willow	U		
Salix fuscescens Anderss.	Alaska bog willow	U	D	
Salix glauca L.	Grayleaf willow	U		
Salix lanata L. subsp. *richardsonii* (Hook) A. Skwortz.	Richardson willow	U		
Salix monticola Bebb	Park willow	U		
Salix novae-angliae Anderss.	Tall blueberry willow	U	D	
Salix phlebophylla Anderss.	Skeletonleaf willow	U		
Salix planifolia Pursh ssp. planifolia	Planeleaf willow	U		
Salix planifolia Pursh ssp. pulchra (Cham.) Argus	Diamondleaf willow	U		
Salix polaris Wahlenb.	Polar willow	U		
Salix reticulata L.	Netleaf willow	U		
Salix rotundifolia Trautv.	Least willow	U		
Salix scouleriana Barratt	Scouler willow	U		
Salix sp.	Willow	U	D	I

TABLE W1

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER SUSITNA RIVER BASIN* (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL. 1982 (Cont'd)

Santalaceae				
Geocaulon lividum (Richards.) Fern.	Sandalwood	U		
Saxifragaceae				
Boykinia richardsonii (Hook.) Gray	Richardson boykinia	U		
Leptarrhena pyrolifolia (D. Don) Ser.	Leather-leaf saxifrage	U		
Parnassia palustris L.	Northern Grass-of-Parnassus	U		I
Parnassia kotzebuei Cham & Schlecht.	Kotzebue Grass-of Parnassus	U		I
Parnassia sp.	Grass of Parnassus			
Ribes hudsonianum Richards	Northern black currant			
Ribes laxiflorum Pursh (may be R. glandulosum)	Trailing black currant		D	
Ribes triste Pall.	Red currant	U	D	I
Saxifraga bronchialis L.	Spotted saxifrage	U		
Saxifraga davurica Willd.	Saxifrage	U		
Saxifraga foliolosa R. Br.	Foliose saxifrage	U		
Saxifraga hieracifolia Waldst. & Kit.	Hawkweed-leaf saxifrage	U		
Saxifraga lyallii Engler	Red-stem saxifrage	U		
Saxifraga oppositifolia L.	Purple mountain saxifrage	U		I
Saxifraga punctata L.	Brook saxifrage	U		
Saxifraga serpyllifolia Pursh	Thyme-leaf saxifrage	U		
Saxifraga tricuspidata Rottb.	Three-tooth saxifrage	U		I
Scrophulariaceae				
Castilleja caudata (Pennell) Rebr.	Pale Indian paintbrush	U		I
Mimulus gattatus DC.	Yellow monkey flower			I
Pedicularis capitata Adams	Capitate lousewort	U		
Pedicularis kanei Durand	Kane lousewort	U		I
Pedicularis labradorica Wirsing	Labrador lousewort	U		I
Pedicularis parviflora J. E. Sm. var. parviflora	Lousewort	U		
Pedicularis sudetica Willd.	Lousewort	U		
Pedicularis verticillata L.	Whorled lousewort	U		
Pedicularis sp.	Lousewort			I
Veronica Americana				I
Veronica wormskjoldii Roem. & Schult.	Alpine speedwell			I
Umbelliferae (Apiaceae)				
Angelica lucida L.	Wild celery	U		
Heracleum lanatum Michx.	Cow parsnip	U	D	I
Valerianaceae				
Valeriana capitata Pall.	Capitate valerian	U		I
Violaceae				
Viola epipsila Ledeb.	Marsh violet	U		I
Viola langsdorffi Fisch.	Violet	U		
Viola biflora L.	Violet			I
Viola sp.	Violet			I
Nonvascular Plant Species				
Lichens				
Cetraria cucullata (Bell.) Ach.		U		
Cetraria islandica (L.) Ach.		U		
Cetraria nivalis (L.) Ach.		U		
Cetraria richardsonii Hook.		U		
Cetraria spp.		U		
Cladonia alpetris (L.) Rabenh.		U		

TABLE W1

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER SUSITNA RIVER BASIN* (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL, 1982 (Cont'd)

	U	D
Cladonia mitis Sandst.	U	
Cladonia rangiferina (L.) Web.	U	
Cladonia spp.	U	
Dactylina arctica (Hook.) Nyl.	U	
Haematomma sp.	U	
Lobaria linita (Ach.) Rabh.		D
Nephroma spp.	U	
Peltigera spp.	U	
Rhizocarpon geographicum (L.) DC.	U	
Stereocaulon paschale (L.) Hoffm.	U	D
Thamnolia vermicularis (Sw.) Schaer.	U	
Umbilicaria sp.	U	
Mosses		
Climacium sp.	U	
Hypnum spp. and other feather mosses	U	
Paludella squarrosa (Hedw.) Brid.†	U	
Polytrichum spp.	U	D
Ptilium crista-castrensis (Hedw.) DeNot.	U	
Rhacomitrium spp.	U	D
Sphagnum spp.	U	D

* Vascular plant species nomenclature according to Hulten (1968) except where noted. Lichen nomenclature according to Thomson (1979). Moss nomenclature according to Conard (1979).

** Nomenclature according to Welsh (1974).

***Nomenclature according to Viereck and Little (1972).

† Nomenclature according to Crum (1976).

TABLE W2

VASCULAR PLANT SPECIES IN THE UPPER SUSITNA RIVER BASIN AND DOWNSTREAM AREAS WHICH ARE OUTSIDE THEIR RANGE AS REPORTED BY HULTEN (1968) AND (FROM MCKENDRICK ET AL, 1982)

Upper Basin Extensions:

Equisetum fluviatile	Swamp horsetail
Lycopodium selago ssp. *selago*	Fir clubmoss
Lycopodium complanatum	Ground cedar
*Picea mariana**	Black spruce
Carex filifolia	Thread-leaf sedge
Danthonia intermedia	Timber oatgrass
Luzula wahlenbergii	Wahlenberg woodrush
Veratrum viride	Helebore
*Listera cordata***	Heart-Leaved twinblade
Platanthera convallariaefolia	Northern bog-orchis
Platanthera hyperborea	Northern bog-orchis
Platanthera dilatata	White bog-orchis
Echinopanax horridum	Devil's club
Senecio sheldonensis	Sheldon groundsel
*Myrica gale**	Sweet gale
Ranunculus occidentalis	Western buttercup
Potentilla biflora	Two-flower cinquefoil
*Rubus idaeus**	Raspberry
Rubus pedatus	Five-leaf bramble
Pedicularis kanei kanei	Kane lousewort
Pedicularis parviflora	Lousewort
Potamogeton robbinsii	Robbins pondweed

Downstream Extensions:

Echinopanax horridum	Devil's club
*Rubus idaeus****	Raspberry
Scirpus microcarpus	Small-fruit bullrush
Galium triflorum	Sweet-scented bedstraw
Alnus tenuifolia	Thinleaf alder
Circaea alpina	Enchanter's nightshade
Actaea rubra	Baneberry
*Ribes hudsonianum****	Northern black currant
Arnica chamissonis	Arnica

* Viereck and Little (1972) include the upper Susitna River basin in the range of this species.

** This species was recorded by the third and small mammal survey group from the University of Alaska Museum.

*** Viereck and Little (1972) include downstream area in the range of this species.

TABLE W3

ENDANGERED AND THREATENED PLANT SPECIES* SOUGHT IN THE UPPER SUSITNA BASIN SURVEYS WITH NOTES ON THEIR HABITATS AND KNOWN LOCALITIES (FROM MCKENDRICK ET AL, 1982)

Species and Habitat	Unofficial Status**
Smelowskia pyriformis Drury & Rollins North America 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

* Species information and status from Murray (1980).

**All species are under review by the U.S. Fish & Wildlife Service for inclusion in the Endangered Species Act of 1973.

TABLE W4

HECTARES AND PERCENTAGE OF TOTAL AREA COVERED BY VEGETATIVE COMMUNITY TYPES IN THE WATANA RESERVOIR AREA (MODIFIED FROM MCKENDRICK ET AT, 1982, BASED ON MAPS AT A SCALE OF 1:250,000)

Vegetative Community	Hectares	Percent of Total Area
Forest	310,155	21.29
conifer	300,931	20.66
woodland spruce	185,608	12.74
open spruce	115,001	7.89
closed spruce	323	0.02
deciduous	1,290	0.09
open birch	968	0.07
closed birch	323	0.02
Mixed	7,933	0.54
open	7,817	0.54
closed	134	0.01
Tundra	323,612	22.21
wet sedge	4,839	0.33
mesic sedge	183,834	12.62
herbaceous alpine	807	0.06
mat and cushion	51,690	3.55
mat and cushion/sedge	82,442	5.66
Shrubland	595,519	40.88
tall shrub	93,379	6.75
low shrubs	497,140	34.13
birch	20,520	1.41
willow	10,645	0.73
mixed	465,975	31.99
Unvegetated	227,497	15.62
water	34,715	2.38
rock	103,063	7.07
snow and ice	89,720	6.16
Total vegetated area	1,229,286	84.38
Total area	1,456,783	100.00

TABLE W5

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA AND PLANT SPECIES IN OPEN CONIFER VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL, 1982)

Category		Average Cover** (percent)
Total vegetation		98
Overstory (>10 cm dbh)		24
Picea glauca	White spruce	24
Picea mariana	Black spruce	2
Understory (2.5 - 20 cm dbh)		10
Picea glauca	White spruce	3
Picea mariana	Black spruce	2
Shrub layer (>0.5 m tall, <2.5 cm dbh)		5
Picea glauca	White spruce	1
Picea mariana	Black spruce	3
Ground layer (<0.5 m tall)		94
Mosses, unidentified		11
Feather mosses	Feather moss	29
Ptilium spp.		13
Empetrum nigrum	Crowberry	6
Ledum decumbens	Northern Labrador tea	5
Vaccinium uliginosum	Bog Blueberry	7
Vaccinium vitis-idaea	Mountain cranberry	6
Equisetum arvense	Meadow horsetail	6
Equisetum silvaticum	Woodland horsetail	8
Linnaea borealis	Twinflower	8
Picea mariana	Black spruce	1
Calamagrostis canadensis	Bluejoint	14

* Number of areas sampled was 9.
**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W6

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN OPEN BLACK SPRUCE VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM McKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		96
Overstory (>10 cm dbh)		14
Picea glauca	White spruce	13
Picea mariana	Black spruce	5
Understory (2.5 - 10 cm dbh)		10
Picea glauca	White spruce	4
Picea mariana	Black spruce	5
Shrub layer (>0.5 m tall, <2.5 cm dbh)		7
Picea mariana	Black spruce	8
Saliz spp.	Willow	2
Ground layer (<0.5 m tall)		93
Mosses, unidentified		34
Feather mosses	Feather moss	30
Cladonia spp.		7
Empetrum nigrum	Crowberry	14
Ledum decumbens	Northern Labrador tea	14
Vaccinium uliginosum	Bog blueberry	10
Vaccinium vitis-idaea	Mountain cranberry	15
Equisetum silvaticum	Woodland horsetail	12
Salix spp.	Willow	7
Picea mariana	Black spruce	4

* Number of areas sampled was 3.
** Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W7: COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN OPEN WHITE SPRUCE VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		100
Overstory (>10 cm dbh)		35
Pica glauca	White spruce	35
Understory (2.5 - 10 cm dbh)		11
Picea glauca	White spruce	3
Alnus sinuata	Sitka alder	6
Shrub layer (>0.5 m tall, <2.5 cm dbh)		4
Picea mariana	White spruce	1
Alnus crispa	American green alder	4
Rosa acicularis	Prickly rose	3
Ground layer (<0.5 m tall)		94
Feather mosses	Feather moss	30
Ptilium spp.		24
Equisetum arvense	Meadow horsetail	11
Equisetum silvaticum	Woodland horsetail	6
Linnaea borealis	Twinflower	15
Betula glandulosa	Resin birch	6
Rosa acicularis	Prickly rose	5
Calamagrostis canadensis	Bluejoint	23

* Number of areas sampled was 5.

**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W8

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN WOODLAND CONIFER VEGETATION/HABITAT TYPE * IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL, 1982)

Category		Average Cover** (percent)
Total vegetation		99
Overstory (>10 cm dbh)		1
Pica glauca	White spruce	
Understory (2.5 - 10 cm dbh)		12
Picea mariana	Black spruce	11
Shrub layer (>0.5 m tall, <2.5 cm dbh)		17
Picea mariana	Black spruce	15
Ground layer (<0.5 m tall)		93
Feather mosses	Feather moss	5
Sphagnum spp.	Sphagnum moss	62
Empetrum nigrum	Crowberry	8
Ledum decumbens	Northern Labrador tea	5
Ledum groenlandicum	Labrador tea	5
Vaccinium uliginosum	Bog blueberry	23
Equisetum silvaticum	Woodland horsetail	10
Rubus arcticus	Nagoonberry	15
Rubus chamaemorus	Cloudberry	5
Picea mariana	Black spruce	3
Carex bigelowii	Bigelow sedge	7
Carex spp.	Sedge	6

* Number of areas sampled was 6.
**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W9

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN CLOSED BALSAM POPLAR FOREST VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		99
Overstory (>10 cm dbh)		80
Pica glauca	White spruce	1
Populus balsamifera	Balsam poplar	75
Understory (2.5 - 10 cm dbh)		5
Populus balsamifera	Balsam poplar	5
Shrub layer (>0.5 m tall, <2.5 cm dbh)		10
Populus balsamifera	Balsam poplar	5
Ground layer (<0.5 m tall)		85
Ptilium spp.		20
Polytrichum spp.		5
Empetrum nigrum	Crowberry	30
Ledum decumbens	Northern Labrador tea	40
Vaccinium uliginosum	Bog blueberry	40
Vaccinium vitis-idaea	Mountain cranberry	20
Cornus canadensis	Bunchberry	40
Populus balsamifera	Balsam poplar	1
Spiraea beauverdiana	Beauverd spiraea	5

* Number of areas sampled was 1.
**Includes only those species with at least 5 percent cover.

TABLE W10

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN CLOSED BIRCH DECIDUOUS FOREST VEGETATION/HABITAT TYPE* UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL, 1982)

Category		Average Cover** (percent)
Total vegetation		99
Overstory (>10 cm dbh)		73
Pica glauca	White spruce	8
Betula papyrifera	Paper birch	68
Understory (2.5 - 10 cm dbh)		9
Picea glauca	White spruce	5
Betula papyrifera	Paper birch	3
Shrub layer (>0.5 m tall, <2.5 cm dbh)		3
Picea glauca	White spruce	1
Betula papyrifera	Paper birch	3
Ground layer (<0.5 m tall)		95
Ptilium spp.		15
Polytrichum spp.		5
Vaccinium uliginosum	Bog blueberry	15
Vaccinium vitis-idaea	Mountain cranberry	5
Equisetum silvaticum	Woodland horsetail	10
Cornus canadensis	Bunchberry	16
Calamagrostis canadensis	Bluejoint	38
Gymnocarpium dryopteris	Oak-fern	20
Mertensia paniculata	Tall bluebell	10

* Number of areas sampled was 2.

** Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W11

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN CLOSED ASPEN DECIDUOUS VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		99
Overstory (>10 cm dbh)		80
Betula papyrifera	Paper birch	5
Populus tremuloides	Trembling aspen	80
Understory (2.5 - 10 cm dbh)		5
Betula papyrifera	Paper birch	5
Populus tremuloides	Trembling aspen	5
Shrub layer (>0.5 m tall, <2.5 cm dbh)		5
Picea glauca	White spruce	5
Betula papyrifera	Paper birch	5
Betula glandulosa	Resin birch	5
Rosa acicularis	Prickly rose	5
Salix spp.	Willow	5
Populus tremuloides	Trembling aspen	5
Ground layer (<0.5 m tall)		85
Ptilium spp.		5
Polytrichum spp.		5
Ledum decumbens	Northern Labrador tea	20
Vaccinium uliginosum	Bog blueberry	10
Linnaea borealis	Twinflower	5
Cornus canadensis	Bunchberry	80
Mertensia paniculata	Tall bluebell	5
Epilobium angustifolium	Fireweed	5
Geocaulon lividum	Sandalwood	5
Spiraea beauverdiana	Beauverd spiraea	5
Vaccinium vitis-idaea	Mountain cranberry	10
Betula nana	Dwarf arctic birch	5
Viburnum edulis	Highbush cranberry	5
Lycopodium annotinum	Stiff clubmoss	5
Lycopodium clavatum	Running clubmoss	5

* Number of areas sampled was 1.
**Includes only those species with at least 5 percent cover.

TABLE W12

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN CLOSED MIXED CONIFER DECIDUOUS FOREST VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		98
Overstory (>10 cm dbh)		60
Picea glauca	White spruce	33
Betula papyrifera	Paper birch	35
Understory (2.5 - 10 cm dbh)		8
Picea glauca	White spruce	3
Betula papyrifera	Paper birch	4
Shrub layer (>0.5 m tall, <2.5 cm dbh)		4
Picea glauca	White spruce	3
Ground layer (<0.5 m tall)		88
Ptilium spp.		40
Empetrum nigrum	Crowberry	3
Vaccinium vitis-idaea	Mountain cranberry	8
Equisetum silvaticum	Woodland horsetail	24
Cornus canadensis	Bunchberry	13
Rubus arcticus	Nagoonberry	7
Calamagrostis canadensis	Bluejoint	30

* Number of areas sampled was 3.

**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W13

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN OPEN MIXED CONIFER DECIDUOUS FOREST VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		100
Overstory (>10 cm dbh)		38
Picea glauca	White spruce	20
Betula papyrifera	Paper birch	12
Understory (2.5 - 10 cm dbh)		7
Picea glauca	White spruce	5
Betula papyrifera	Paper birch	1
Shrub layer (>0.5 m tall, <2.5 cm dbh)		17
Picea glauca	White spruce	2
Betula papyrifera	Paper birch	2
Salix novae-angliae	Tall blueberry willow	11
Ground layer (<0.5 m tall)		79
Feather mosses	Feather moss	18
Ptilium spp.		34
Empetrum nigrum	Crowberry	6
Ledum decumbens	Northern Labrador tea	6
Vaccinium uliginosum	Bog blueberry	16
Vaccinium vitis-idaea	Mountain cranberry	9
Equisetum silvaticum	Woodland horsetail	3
Cornus canadensis	Bunchberry	13
Picea glauca	White spruce	2
Calamagrostis canadensis	Bluejoint	11
Gymnocarpium dryopteris	Oak-fern	8

* Number of areas sampled was 8.
**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W14

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN WET SEDGE-GRASS TUNDRA VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL, 1982)

Category		Average Cover** (percent)
Total vegetation		99
Shrub layer (>0.5 m tall, <2.5 cm dbh)		13
Salix planifolia ssp. *pulchra*	Diamondleaf willow	8
Salix spp.	Willow	5
Ground layer (<0.5 m tall)		86
Mosses, unidentified		20
Sphagnum spp.	Sphagnum moss	22
Salix fuscescens	Aslaska bog willow	5
Calamagrostis canadensis	Bluejoint	14
Carex aquatilis	Water sedge	38
Carex bigelowii	Bigelow sedge	23

* Number of areas sampled was 3.

**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W15

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN MESIC SEDGE-GRASS TUNDRA VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL, 1982)

Category		Average Cover** (percent)
Total vegetation		65
Ground layer (<0.5 m tall)		65
Polytrichum spp.	Hairy-cap moss	5
Salix spp.	Willow	13
Carex bigelowii	Bigelow sedge	30
Carex spp.	Sedge	4

* Number of areas sampled was 2.

**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W16

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN CLOSED MAT AND CUSHION TUNDRA VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		78
Ground layer (<0.5 m tall)		78
Lichens, unidentified		14
Cladonia spp.		8
Empetrum nigrum	Crowberry	8
Ledum decumbens	Northern Labrador tea	7
Vaccinium uliginosum	Bog blueberry	8
Arctostaphylos spp.	Bearberry	7
Betula glandulosa	Resin birch	6
Betula nana	Dwarf arctic birch	10

* Number of areas sampled was 8.
** Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W17

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN CLOSED TALL ALDER VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		96
Understory (2.5 - 10 cm dbh)		57
Alnus sinuata	Sitka alder	25
Alnus crispa	American green alder	32
Shrub layer (>0.5 m tall, <2.5 cm dbh)		38
Alnus sinuata	Sitka alder	28
Alnus crispa	American green alder	10
Ribes spp.	Currant	8
Ground layer (<0.5 m tall)		62
Equisetum silvaticum	Woodland horsetail	31
Ribes spp.	Currant	8
Alnus sinuata	Sitka alder	7
Calamagrostis canadensis	Bluejoint	35

* Number of areas sampled was 3.
**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W18

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN CLOSED LOW SHRUB VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		93
Shrub layer (>0.5 m tall, <2.5 cm dbh)		42
Betula glandulosa	Resin birch	10
Salix planifolia ssp. *pulchra*	Diamondleaf willow	8
Ground layer (<0.5 m tall)		52
Mosses, unidentified		17
Feather mosses	Feather moss	6
Empetrum nigrum	Crowberry	7
Ledum decumbens	Northern Labrador tea	18
Ledum groenlandicum	Labrador tea	4
Vaccinium uliginosum	Bog blueberry	8
Vaccinium vitis-idaea	Mountain cranberry	8
Arctostaphylos rubra	Red-fruit bearberry	6
Betula glandulosa	Resin birch	34
Betula nana	Dwarf arctic birch	9

* Number of areas sampled was 10.
**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W19

COVER PERCENTAGES FOR TOTAL VEGETATION, VERTICAL STRATA, AND PLANT SPECIES IN OPEN LOW SHRUB VEGETATION/HABITAT TYPE* IN UPPER SUSITNA RIVER BASIN, SUMMER 1980 (FROM MCKENDRICK ET AL. 1982)

Category		Average Cover** (percent)
Total vegetation		100
Shrub layer (>0.5 m tall, <2.5 cm dbh)		17
Betula glandulosa	Resin birch	5
Ground layer (<0.5 m tall)		83
Feather mosses	Feather moss	13
Ledum groenlandicum	Labrador tea	5
Vaccinium uliginosum	Bog blueberry	15
Betula glandulosa	Resin birch	15
Carex aquatilis	Water sedge	43

* Number of areas sampled was 2.
**Includes only those species with at least 5 percent cover in any one area sampled.

TABLE W20

HECTARES AND PERCENTAGE OF TOTAL AREA COVERED BY VEGETATIVE COMMUNITY TYPES IN THE DEVIL'S CANYON RESERVOIR AREA (MODIFIED FROM MCKENDRICK ET AT, 1982, BASED ON MAPS AT A SCALE OF 1:250,000)

Vegetative Community	Hectares	Percent of Total Area
Forest	38,077	21.86
conifer	6,655	3.82
woodland spruce	2,783	1.60
open spruce	3,872	2.22
closed spruce	-	-
deciduous	-	-
open birch	-	-
closed birch	-	-
Mixed	31,422	18.04
open	15,570	8.94
closed	15,852	9.10
Tundra	71,073	40.80
wet sedge	-	-
mesic sedge	524	0.30
herbaceous alpine	-	-
mat and cushion	13,311	7.64
mat and cushion/sedge	57,238	32.85
Shrubland	49,171	28.22
tall shrub	30,656	17.60
low shrubs	18,515	10.63
birch	13,029	7.48
willow	-	-
mixed	5,486	3.15
Unvegetated	15,895	9.12
water	5,125	2.94
rock	10,649	6.11
snow and ice	121	0.07
Total vegetated area	158,321	90.88
Total area	174,216	100.00

TABLE W21

PERCENT COVER IN EARLY SUCCESSIONAL STANDS ON DOWNSTREAM FLOODPLAIN OF SUSITNA RIVER, SUMMER 1981 (FROM MCKENDRICK ET AL. 1982)

Category		Mean (percent)
Physical Features		
Water		+
Bare ground		53
Gravel, cobbles		2
Vegetation Categories		
Litter		13
Standing dead		+
Perennial grasses		1
Perennial forbs		25
Mosses		+
Lichens		+
Low shrubs		4
Tall shrubs		+
Trees		8
Total vegetation		38
Vegetation by Species or Genus		
Equisetum variegatum	Variegated horsetail	25
Populus balsamifera	Balsam poplar	8
Salix alaxensis	Feltleaf willow	4
Salix novae-angliae	Tall blueberry willow	1
Salix arbusculoides	Little tree willow	+
Salix sp.	Willow	+
Astragalus sp.	Milk-vetch	+
Hedysarum sp.	Sweet-vetch	+
Calamagrostis canadensis	Bluejoint	+
Eriophorum sp.	Cottongrass	+
Scirpus sp.	Bullrush	+
Alnus tenuifolia	Thinleaf alder	+
Alnus sinuata	Sitka alder	+
Artemisia telesii	Wormwood	+
Nephroma sp.	Nephroma	+

TABLE W22

PERCENT COVER IN IMMATURE BALSAM POPLAR STANDS ON DOWNSTREAM FLOODPLAIN, SUMMER 1981 (FROM MCKENDRICK ET AL. 1982)

Category		Mean (percent)
Physical Features		
Vegetation Categories		
Litter		95
Standing dead		+
Perennial grasses		23
Perennial forbs		9
Mosses		+
Low shrubs		6
Tall shrubs		48
Trees		62
Total vegetation		91
Vegetation by Species or Genus		
Populus balsamifera	Balsam poplar	62
Alnus tenuifolia	Thinleaf alder	40
Alnus sinuata	Sitka alder	8
Calamagrostis canadensis	Bluejoint	23
Viburnum edule	Highbush cranberry	3
Artemisia tilesii	Wormwood	3
Heracleum lanatum	Cow parsnip	1
Mertensia paniculata	Tall bluebell	1
Rosa acicularis	Prickly rose	3
Picea glauca	White spruce	+
Salix novae-angliae	Tall blueberry willow	+
Pyrola secunda	One-sided wintergreen	+
Pyrola sp.	Wintergreen	+
Rubus idaeus	Raspberry	+
Sanguisorba stipulata	Sitka burnet	+
Galium sp.	Bedstraw	+
Matteuccia struthiopteris	Ostrich fern	+
Streptopus amplexicaulis	Cucumber-root	+

TABLE W23

PERCENT COVER IN BIRCH-SPRUCE STANDS ON DOWNSTREAM FLOODPLAIN, SUMMER 1981 (FROM MCKENDRICK ET AL. 1982)

Category		Mean (percent)
Vegetation Categories		
Litter		100
Standing dead		+
Perennial grasses		18
Perennial forbs		44
Mosses		1
Low shrubs		40
Tall shrubs		14
Trees		52
Total vegetation		93
Vegetation by Species or Genus		
Betula papyrifera	Paper birch	42
Picea glauca	White spruce	12
Alnus tenuifolia	Thinleaf alder	10
Alnus sinuata	Sitka alder	5
Viburnum edule	Highbush cranberry	19
Ribes spp.	Currant	5
Rosa acicularis	Prickly rose	20
Calamagrostis canadensis	Bluejoint	18
Dryopteris dilatata	Spinulose shield-fern	7
Gymnocarpium sp.	Oak-fern	4
Echinopanax horridum	Devil's club	4
Cornus canadensis	Bunchberry	1
Mertensia paniculata	Tall bluebell	1
Rubus idaeus	Raspberry	3
Epilobium angustifolium	Fireweed	1
Epilobium latifolium	Dwarf fireweed	+
Salix novae-angliae	Tall blueberry willow	+
Rubus sp.	Bramble	+
Rubus arcticus	Nagoonberry	+
Trientalis europaea	Arctic starflower	+

TABLE W24

HECTARES AND PERCENT OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES WITHIN THE HEALY TO FAIRBANKS TRANSMISSION CORRIDOR (FROM MCKENDRICK ET AT, 1982)

Vegetative/Habitat Type*	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 confier-deciduous	12,502	11.2
Closed confier-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

*The Tanana Flat portion of the transmission corridor is an area of extremely complex mosaics of various vegetation types. As a result, various complexes were recognized.

TABLE W25

HECTARES AND PERCENT OF TOTAL AREA COVERED BY VEGETATION/ HABITAT TYPES WITHIN THE WILLOW TO COOK INLET TRANSMISSION CORRIDOR (FROM MCKENDRICK ET AL. 1982)

Vegetative/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 W26

HECTARES AND PERCENT OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES WITHIN THE DAM TO INTERTIE TRANSMISSION CORRIDOR (FROM MCKENDRICK ET AL. 1982)

Vegetative/Habitat Type*	Hectares	Percent of Total Area
Forest	34,388	36.3
Woodland spruce-black	3,028	3.2
Woodland spruce-white	4,957	5.2
Open spruce-black	2,527	2.7
Open spruce-white	4,284	4.5
Open birch	806	.9
Closed birch	1,749	1.8
Closed balsam poplar	449	.5
Open conifer-deciduous	5,119	5.4
Closed confier-deciduous	11,469	12.1
Tundra	24,975	26.3
Wet sedge-grass	314	.3
Sedge grass	3,670	3.9
Sedge shrub	5,870	6.2
Mat and cushion	15,121	15.9
Shrubland	31,548	33.3
Open tall shrub	4,717	5.0
Closed tall shrub	5,696	6.0
Birch shrub	10,909	11.5
Willow shrub	1,169	1.2
Mixed low shrub	9,057	9.6
Grassland	109	.1
Disturbed	10	.01
Unvegetated	3,778	4.0
Lake	608	.7
River	1,438	1.5
Rock	1,642	1.7
Total Area	94,808	100.0

TABLE W27

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	Dam and Spillways	Impoundment	Camp	Village	Airstrip	Borrow Areas A	D	E	F	H	I	Total	Percent of Upper Basin Total For That Type	Percent of 16 km* Area For That Type
Forest	34	10784				181	53	180	81	451	34	11798	3.4	8.3
Woodland spruce-black	8	3870				179	16			224		4297	3.1	6.8
Woodland spruce-white		397						71	69			537	3.1	4.0
Open spruce-black		2864								121	15	3000	4.0	10.6
Open spruce-while		769				2		62	11			844	4.0	8.0
Open birch	1	325										326	33.7	21.8
Closed birch	13	460					5					478	148.0**	20.5
Closed balsam poplar		3										3	***	0.5
Open conifer-deciduous	5	1337					32			106		1480	6.4	15.4
Closed conifer-deciduous	7	759						47	1		19	833	5.2	6.3
Tundra		84				70	8					162	0.1	0.1
Wet sedge-grass		84					8					92	1.9	2.6
Sedge-grass														
Sedge shrub														
Mat and cushion						70						70	0.1	0.1
Shrubland	46	1719	63	62	17	81	224		199	38		2449	0.4	1.4
Open tall shrub	6	227				1						234	0.4	1.5
Closed tall shrub	17	287				1	12					317		2.0
Birch shrub	1	443	34	35	13	4	88		195			813	2.4	1.9
Willow shrub		66							4	17		87	0.8	1.0
Mixed low shrub	22	651	29	27	4	75	124			21		953	0.2	1.0
Herbaceous		45										45		250.0
Grassland														
Disturbed														
Unvegetated	13	2104		8		1	2					2128	0.8	7.9
Rock	1	59					2					62	0.1	0.4
Snow and ice														
River	12	2007										2019	13.7	47.7
Lake		38		8		1						47	0.2	0.8
Total	93	14691	63	70	17	333	287	180	280	489	34	16537	1.0	3.6

* An area 16 km on either side of the Susitna River from Gold Creek to the mouth of the Maclaren River.

** 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.

***Areas of this type were too small to be mapped at the scale of which the upper Susitna River basin was mapped.

TABLE W28

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 AREAS WITHIN 16 KM OF THE SUSITNA RIVER

Vegetation/Habitat Type	Dam and Spillways	Impoundment	Camp	Village	Borrow Area K	Total	Percent of Upper Basin Total For That Type	Percent of 16 km* Area For That Type
Forest	16	2289	36	39	119	2 499	0.7	1.8
Woodland spruce-black		133				133	0.3	0.2
Woodland spruce-white		20				20	0.3	0.2
Open spruce-black	4	300			11	315	1.3	1.1
Open spruce-white		329				329	1.3	3.2
Open birch		57				57	5.9	3.8
Close birch	3	439				433	133.7**	18.6
Open balsam poplar		6				6	***	
Closed balsam poplar		8				8	***	1.4
Open conifer-deciduous	7	279				286	1.2	3.0
Closed conifer-deciduous	2	727	36	39	108	912	5.7	6.9
Tundra		11				11	0.0	0.0
Wet sedge-grass		11				11	0.2	0.3
Sedge grass								
Sedge shrub								
Mat and cushion								
Shrubland		70			18	88	0.0	0.1
Open tall shrub		2				2	0.0	0.0
Closed tall shrub		1				1	0.0	0.0
Birch shrub		49			18	67	0.2	0.1
Willow shrub		14				14	0.1	0.2
Mixed low-shrub		4				4	0.0	0.0
Herbaceous								
Grassland								
Disturbed								
Unvegetated	2	826			11	839	0.3	3.1
Rock		15				15	0.0	0.1
Snow and ice								
River	1	810				811	5.6	19.2
Lake	1	1			11	13	0.1	0.2
Total	18	3 196	36	39	148	3 437	0.2	0.7

* An area 16 km on either side of the Susitna River from Gold Creek to the mouth of the Maclaren River.

** 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.

***Balsam poplar stands were to small to be mapped at the scale of which the upper Susitna River basin was mapped.

TABLE W29

PROXIMITY TO THE SUSITNA RIVER OF RELOCATIONS OF 9 MALE (M) AND 29 FEMALE (F) MOOSE RADIO-COLLARED ALONG THE SUSITNA RIVER BETWEEN DEVIL CANYON AND THE DELTA ISLANDS, ALASKA, 1980-81 (from Modafferi [1982])

		Number		Distance of Relocations from River (mi)							
Location[1]	Sex	Individuals	Relocations	River	0-1	1-3	3-5	5-10	10-15	15-20	20+
Upstream											
	M	2[2]	74	3	36	29	6				
	F	10	222	21	82	90	22	6	0	1	
Downstream Westside	M	6[3]	162	13	10	55	21	43	0	19	1
	F	15	403	101	41	67	14	87	74	19	
Eastside	M	1[4]	45	0	0	2	1	0	9	11	22
	F	4[5]	166	5	4	17	32	77	22	9	

[1] Upstream - moose captured north of Talkeetna.
Downstream - moose captured south of Talkeetna.
Westside - captured moose that spent the breeding season to the west of the Susitna River.
Eastside - captured moose that spent the breeding season to the east of the Susitna River.

[2] One individual studied 1-1/2 years.

[3] One individual studied 1-1/2 years.

[4] Individual studied for 1-1/2 years.

[5] Three individuals studied for 1-1/2 years.

TABLE W30

SUMMARY OF MOOSE CENSUS DATA AND SUBSEQUENT POPULATION ESTIMATES FOR COUNT AREAS 7 AND 14 DERIVED FROM SURVEYS CONDUCTED ALONG THE SUSITNA RIVER FROM NOVEMBER 5 THROUGH NOVEMBER 8, 1980

(Table modified from Ballard et al. [1982])

Moose Density Stratum	Low	Medium	High
Number of sample areas censused	11	9	6
Total number of samples areas in each stratum	26	27	18
Area of each stratum (km^2)	864	920	663
Moose density per stratum	1.125	1.847	3.726
Population estimate per stratum	375	656	954
Total population estimate 90% CI = 1986 ± 371			
Sightability correction factor = 1.03			
Corrected population estimate = 2046 ± 382			

TABLE W31

DENSITY (MOOSE/KM OF RIVER) OF MOOSE OBSERVED ON 3 AERIAL CENSUSES IN 4 ZONES OF RIPARIAN HABITAT ALONG THE SUSITNA RIVER FROM COOK INLET TO DEVIL CANYON, ALASKA, 1981-82

(From Modafferi [1982 a, b])

	Aerial census number[b]					
River Zone[a]	1	2	3	4	5	6
I	0.45	0.23	0.10	0.09	0.31	0.09
II	0.53	0.63	0.17	0.57	0.83	0.60
III	2.26	2.94	2.06	3.66	2.55	0.88
IV	3.08	2.40	2.30	2.68	1.03	NA
All zones	1.50	1.41	1.11	1.72	1.20	0.47

[a] I = Devil Canyon to Talkeetna, 80 km.
II = Talkeetna to Montana Creek, 30 km.
III = Montana Creek to Yentna River, 65 km.
IV = Yentna River to Cook Inlet, 40 km.

[b] 1 = December 9 - 10, 1981.
2 = December 28, 1981 and January 4, 1982.
3 = February 2 and 6, 1982.
4 = March 1 - 2, 1982.
5 = March 23 - 24, 1982.
6 = April 12, 1982.

TABLE W32

SUMMARY OF MOOSE SEX AND AGE COMPOSITION DATA COLLECTED ANNUALLY IN CA 6 IN GAME MANAGEMENT UNIT 13 OF SOUTHCENTRAL ALASKA

(Table modified from Ballard et al. [1982])

Date	Total Males Per 100 Females	Small Moose % in Herd	Calves per 100 Females	Incidence of Twins Per 100 Females With Calf	Calf % in Herd	Total Sample
1955[a]	84.1	11.0	43.2	5.6	19.0	400
1956[a]	61.6	7.7	28.1	0.0	14.8	351
1957[a]	43.3	3.5	38.3	10.2	21.1	256
1958[a]	44.9	6.4	40.2	6.9	21.7	957
1959			NO DATA			
1960[a]	57.2	9.0	46.4	4.0	22.4	343
1961	70.1	12.5	48.4	16.0	22.2	424
1962	44.2	-	28.3	4.6	16.4	414
1963[a]	35.6	6.5	46.6	7.4	25.6	798
1964[a]	33.3	3.1	44.4	20.0	25.0	96
1965[a]	30.4	6.3	25.8	1.5	16.5	806
1966[a]	27.7	3.2	28.0	3.5	17.9	658
1967	29.7	3.4	28.8	0.8	18.1	681
1968	29.7	3.2	26.3	2.4	16.9	504
1969	35.7	7.8	33.5	2.8	19.3	384
1970	26.6	6.2	14.2	6.9	10.1	308
1971	30.0	2.8	22.8	3.9	14.9	362
1972	10.1	2.9	23.1	0.0	17.3	277
1973	20.7	5.2	19.0	2.3	13.6	324
1974	16.0	5.2	34.4	9.0	22.9	328
1975	17.6	5.7	18.5	5.6	13.6	279
1976	20.6	5.8	24.3	4.6	16.8	274
1977	16.7	3.7	33.8	13.2	22.4	352
1978	24.1	6.0	28.6	11.7	18.8	368
1979	14.6	2.2	25.3	9.3	18.1	326
1980	15.1	5.2	29.7	8.1	20.5	423
1981	26.5	9.6	38.6	5.1	23.4	530

Remarks: [a] Area boundary change - check maps 1969, Area No. 6.

TABLE W33

SUMMARY OF MOOSE SEX AND AGE COMPOSITION DATA COLLECTED ANNUALLY IN CA 7 IN GAME MANAGEMENT UNIT 13 OF SOUTHCENTRAL ALASKA

(Table modified from Ballard et al. [1982])

Date	Total Males Per 100 Females	Small Moose % In Herd	Calves per 100 Females	Incidence of Twins Per 100 Females With Calf	Calf % In Herd	Total Sample
1957			NO DATA			
1958			NO DATA			
1959			NO DATA			
1960			NO DATA			
1961			NO DATA			
1962			NO DATA			
1963[a]	47.7	3.3	38.5	0.0	20.7	121
1964[b]	39.7	6.3	31.4	2.8	18.4	207
1965[a]	59.8	7.8	16.2	0.0	9.2	412
1966	48.3	3.8	20.1	0.0	11.9	293
1967	41.0	4.4	20.6	2.5	12.8	642
1968			NO DATA			
1969			NO DATA			
1970	34.7	5.0	42.1	8.6	23.6	864
1971	26.3	5.3	33.2	7.1	20.8	624
1972	20.6	2.0	17.5	3.7	12.6	665
1973	21.9	6.0	16.3	2.9	11.8	890
1974	12.6	3.0	28.3	6.3	20.1	672
1975	10.0	3.4	15.9	4.8	12.7	695
1976	12.3	3.2	21.6	7.1	16.1	865
1977	10.8	3.0	28.7	6.0	20.6	954
1978	14.8	5.9	20.2	4.1	15.0	1030
1979	8.8	1.8	23.3	5.8	17.7	838
1980	13.3	5.6	25.1	1.1	17.9	946
1981	14.2	3.4	31.6	0.0	21.7	1284

Remarks: [a] Area boundary change - check maps 1969, Area No. 7.
[b] Early 1965 data used for 1964.

TABLE W33

SUMMARY OF MOOSE SEX AND AGE COMPOSITION DATA COLLECTED ANNUALLY IN CA 7 IN GAME MANAGEMENT UNIT 13 OF SOUTHCENTRAL ALASKA

(Table modified from Ballard et al. [1982])

Date	Total Males Per 100 Females	Small Moose % in Herd	Calves per 100 Females	Incidence of Twins Per 100 Females With Calf	Calf % in Herd	Total Sample
1957			N O D A T A			
1958			N O D A T A			
1959			N O D A T A			
1960			N O D A T A			
1961			N O D A T A			
1962			N O D A T A			
1963[a]	47.7	3.3	38.5	0.0	20.7	121
1964[b]	39.7	6.3	31.4	2.8	18.4	207
1965[a]	59.8	7.8	16.2	0.0	9.2	412
1966	48.3	3.8	20.1	0.0	11.9	293
1967	41.0	4.4	20.6	2.5	12.8	642
1968			N O D A T A			
1969			N O D A T A			
1970	34.7	5.0	42.1	8.6	23.6	864
1971	26.3	5.3	33.2	7.1	20.8	624
1972	20.6	2.0	17.5	3.7	12.6	665
1973	21.9	6.0	16.3	2.9	11.8	890
1974	12.6	3.0	28.3	6.3	20.1	672
1975	10.0	3.4	15.9	4.8	12.7	695
1976	12.3	3.2	21.6	7.1	16.1	865
1977	10.8	3.0	28.7	6.0	20.6	954
1978	14.8	5.9	20.2	4.1	15.0	1030
1979	8.8	1.8	23.3	5.8	17.7	838
1980	13.3	5.6	25.1	1.1	17.9	946
1981	14.2	3.4	31.6	0.0	21.7	1284

Remarks: [a] Area boundary change - check maps 1969, Area No. 7.
[b] Early 1965 data used for 1964.

TABLE W34

SUMMARY OF MOOSE SEX AND AGE COMPOSITION DATA COLLECTED ANNUALLY IN CA 14 IN GAME MANAGEMENT UNIT 13 OF SOUTHCENTRAL ALASKA

(Table modified from Ballard et al. [1982])

Date	Total Males Per 100 Females	Small Moose % in Herd	Calves per 100 Females	Incidence of Twins Per 100 Females With Calf	Calf % in Herd	Total Sample
1955[a]	105.6	10.5	73.2	10.6	26.0	200
1956			NO DATA			
1957	72.5	5.2	50.3	4.9	22.6	381
1958[a]	86.8	5.0	37.0	7.4	16.6	441
1959			NO DATA			
1960[a]	71.1	8.6	56.7	21.4	24.5	139
1961[a]	62.0	12.2	55.7	7.6	25.6	555
1962	56.3	10.1	23.8	1.8	13.2	416
1963			NO DATA			
1964			NO DATA			
1965	28.6	7.2	21.6	0.0	14.4	278
1966[a]	20.0	5.9	33.5	0.0	21.8	238
1967	39.0	3.9	34.1	2.9	19.7	355
1968[a]	9.4	2.8	36.5	3.8	25.0	108
1969	17.5	4.0	40.1	2.0	25.4	405
1970	19.4	2.2	44.4	2.1	25.9	185
1971	27.1	5.7	20.7	5.0	14.0	300
1972	21.4	6.2	25.5	0.0	17.4	288
1973	22.0	5.1	17.3	2.0	12.4	411
1974	15.4	3.4	35.2	3.7	23.4	500
1975	9.9	3.3	21.7	1.9	16.5	333
1976	9.2	3.6	19.9	3.0	15.4	447
1977			NO DATA			
1978	20.5	6.6	18.3	2.0	13.2	379
1979			NO DATA			
1980	13.7	7.4	16.2	3.8	12.5	447
1981			NO DATA			

Remarks: [a] Area boundary change - check maps.

TABLE W35

SUMMARY OF MOOSE SEX AND AGE COMPOSITION DATA OBTAINED DURING SURVEYS OF RIPARIAN COMMUNITIES ALONG THE LOWER SUSITNA RIVER

(Based on Modafferi [1982a])

		Incidence			
River Zone[a]	Total Males Per 100 Females	Calves Per 100 Females	Twins Per 100 Females With Calf	Calf % In Herd	Total Sample
I	40.0	40.0	0.0	22.2	36
II	37.5	62.5	25.0	31.3	16
III	10.9	45.7	13.5	30.6	147
IV	33.3	53.0	12.9	28.5	123
TOTAL	23.1	48.4	12.5	28.9	322

[a] I = Devil Canyon to Talkeetna.
II = Talkeetna to Montana Creek.
III = Montana Creek to Yentna River.
IV = Yentna River to Cook Inlet.

TABLE W36

PROPORTION OF RADIO-COLLARED CARIBOU SIGHTINGS IN EACH VEGETATION TYPE

(Data from Pitcher 1982a)

Habitat	Calving, Cows	Summer Bulls	Autumn Cows	Autumn Bulls	Rut, Winter, Cows	Spring Bulls	Total Cows	Total Bulls
Spruce forest	0.0	24.6	36.4	25.0	58.5	77.7	34.2	50.9
Tundra-herbaceous	72.5	37.9	29.1	20.8	11.6	9.3	36.0	19.4
Shrubland	26.7	37.9	16.4	41.7	24.3	9.3	23.9	24.1
Bare substrate	0.8	3.3	18.2	12.5	5.5	3.7	5.9	5.6
Total sightings	120	30	55	24	164	54	339	108

TABLE W37

NELCHINA CARIBOU HERD POPULATION ESTIMATES
(Fall estimates for years after 1962)

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 W38

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] Preliminay data.

TABLE W39

COMPILATION OF HIGHEST YEARLY COUNTS COMPLETED IN WATANA HILLS SHEEP TREND COUNT AREA

Year	Legal Rams*	Lambs	Total	% Legal Rams	% Lambs	Surveyor
1950	--	--	0	--	--	Scott
1967	--	--	230	--	--	Nichols
1968	--	--	183	--	26.6	Nichols, August
1973	10	40	176	5.6	22.7	McIlroy, August
1974	6	18	76	7.9	23.7	Harkness, April
1976	4	30	130	3.1	23.0	Eide, August
1977	4	33	152	2.6	21.7	Spraker, July 11
1978	5	34	189	2.6	18.0	Eide, July 23
1980	9	42	174	5.1	24.1	Tobey, July 22
1981	2	43	209	>1.0	20.6	Westlund, July 28

*A legal ram is defined as having a 3/4 curl or greater horn. Beginning in 1979 a legal ram is defined as having a 7/8 curl or greater horn.

TABLE W40

NUMBER AND AGE-SEX CLASSIFICATION OF SHEEP OBSERVED AT JAY CREEK MINERAL LICKS FROM MAY 6 THROUGH JUNE 24, 1981

Date	Time	Location	Sheep	Ewes	Yearlings	Lambs	Rams
5/06	-	West side[a]	5				
5/08	-	West side	15	2	2		
5/09	a.m.	West side	4				
5/13	1645	West side	2				
5/14	0900	West side	4				
5/18	1355	West side	4	1	1		6
5/21	-	West side	8				
5/22	1700	West side	8	1	1		6
5/23	1145	East side	9	2	1		6
5/24	1840	West side	9	1	2		6-7
5/25	1152	East side[b]	14	1	1		12
5/26	1808	-	0				
5/27	2225	-	0				
5/30	-	East side	5				
6/02	-	-	0				
6/03	1405	Upstream E.[c]	1				1
6/03	1408	Upstream W.	9				9
6/04	1926	-	0				0
6/05	1900	East side	9				9
6/06	2146	West side	9				
6/07	2025	East side	9				
6/08	2115	East side	10				
6/09	-	West side	7	7			
6/10	0955	West side	4	2	2		
6/11	-	West side	4	3		1	
6/12	1939	Upstream	10				
6/13	1154	East side	1	1			
6/13	1154	Upstream W.	7	4		3	
6/14	0933	-	0				
6/15	1509	West side	4	4			
6/15	1509	Upstream	3	2		1	
6/16	1102	Upstream W.	4	3		1	
6/17	1155	Upstream E.	1	1			
6/19	1000	Upstream	1	4			1
6/19	1000	West side	1	1			
6/21	1545	West side	14				
6/24	0847	West side	7				7

[a] Bluff on western bank of lower Jay Creek.

[b] Directly across Jay Creek from above site.

[c] Two miles upstream from above site.

TABLE W41

NUMBER OF AERIAL BROWN BEAR OBSERVATIONS BY MONTH IN EACH OF 5 MAJOR HABITAT CATEGORIES

(From Miller and McAllister [1982])

Habitat	May	June	July	August	September	October/ April	All Months
Spruce	44	50	17	16	9	5	141
% of Months	31.2	35.5	12.1	11.3	6.4	3.5	(25.0)
% of Habitats	31.0	29.6	19.3	17.6	25.0	13.2	-
Riparian	16	26	22	20	4	1	89
% of Months	18.0	29.2	24.7	22.5	4.5	1.1	(15.8)
% of Habitats	11.3	15.4	25.0	22.0	11.1	2.6	-
Shrubland	39	75	46	52	21	5	238
% of Months	16.4	31.5	19.3	21.8	8.8	2.1	(42.2)
% of Habitats	27.5	44.4	52.3	57.1	58.3	13.2	-
Tundra	12	14	1	1	0	0	28
% of Months	42.9	50.0	3.6	3.6	0	0	(5.0)
% of Habitats	8.5	8.3	1.1	1.1	0	0	-
Other	31	4	2	2	2	27	68
% of Months	45.6	5.9	2.9	2.9	2.9	39.7	(12.1)
% of Habitats	21.8	2.4	2.3	2.2	5.6	71.1	-
All Habitats	142 (25.2)	169 (30.0)	88 (15.6)	91 (16.1)	36 (6.4)	38 (6.7)	564 (100.0)

TABLE W42

COMPARISON OF REPORTED HOME RANGE SIZES OF BROWN/GRIZZLY BEARS IN NORTH AMERICA

(Adapted from Reynolds, 1980)

Area	Sex	Sample Size	Mean Home Range (km^2)	Source
Kodiak Island, AK	M	7	24	Burns 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, 1976
	F	12	73	
Western Montana	M	3	513	Rockwell et al, 1978
	F	1	104	
Nelchina Basin	M	14	790	This study (1978 and 1980 results only)
	F	19	316	
Northwestern Alaska	M	8	1350	Reynolds, 1980
	F	18	344	

TABLE W43: DENSITIES OF SELECTED NORTH AMERICAN BROWN BEAR POPULATIONS

(From Miller and McAllister [1982]).

mi^2/Bear	km^2/Bear	Location	Source
0.6	1.6	Kodiak Island, AK	Troyer and Hensel, 1964
6.0[a]	15.5	Alaska Peninsula, AK	Unpublished data (Glenn pers. comm.)
8.2	21.2	Glacier National Park, Montana	Martinka, 1974[b]
11.0	28.5	Glacier National Park, BC	Mundy and Flook, 1973[b]
9-11	23-27	SW Yukon Territory	Pearson, 1975
16-24	41-62	Upper Susitna River, 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] Data refer to an 1,800 mi^2 intensively studied area of the central Alaska Peninsula.

[b] Taken from Pearson, 1975.

[c] Mean is for the entire National Petroleum Reserve, Alaska; the range represents values for different habitat types in this reserve. The highest density occurred in an intensively studied experimental area.

TABLE W44

AVERAGE AGE AND SEX RATIOS OF BROWN BEAR POPULATIONS IN THE UPPER SUSITNA AND NELCHINA RIVER BASINS

(From Miller and McAllister 1982)

Subpopulations	Males: Average Spring Age (Years)	Males: (Range)	Males: n	Females: Average Spring Age (Years)	Females: (Range)	Females: n	Average Both Sexes (Years)	Sex Ratio % 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
Upper Susitna Basin (1980-1981): all captures	7.7	(3.5-14.5)	14	7.9	(3.5-13.5)	15	7.8	48
Radio-collared bears (1980-1981) with ≥ 5 captures	6.0	(3.5-10.5)	4	8.6	(3.5-13.5)	13	8.0	24[a]

[a] Because adult male bears lost their collars more easily than adult females, this ratio underestimated the percentage of males.

TABLE W45

LITTER SIZES OF VARIOUS NORTH AMERICAN BROWN BEAR POPULATIONS

(From Miller and McAllister (1982)

Source	Area	Average Litter Size (No. of Litters Observed) Age of Litter 0.5	1.5	0.5-1.5
Pearson 1975	Southwestern Yukon Territory	1.7(11)	1.5(11)	1.6(22)
Martinka 1974	Glacier National Park, Montana	1.7(35)	1.8(30)	1.7(65)
This Study	Nelchina Basin, Alaska	2.3(9)	1.6(16)	1.7(10)
Reynolds 1976	Eastern Brooks Range, Alaska	1.8(13)	2.0(7)	1.9(20)
Reynolds 1980*	Western Brooks Range, Alaska	2.0(33)	1.9(21)	2.0(54)
Mundy 1963	Glacier National Park, B.C.	1.9(81)	1.8(45)	1.9(126)
Klein 1958	Southeastern Alaska	2.2(25)	1.9(35)	2.0(60)
Glenn et al. 1976	McNeil River, Alaska	2.5(41)	1.8(69)	2.1(110)
Glenn 1976 & updated	Black Lake, Alaska Peninsula	2.1(19)	2.1(51)	2.1(70)
Hensel et al. 1969	Kodiak Island, Alaska	2.2(98)	2.0(103)	2.1(201)
Craighead et al. 1976	Yellowstone National Park	2.2(68)	-	-

*Calculations from data presented in Table 3 of Reynolds (1980)

TABLE W46

REPRODUCTIVE RATES OF NORTH AMERICAN BROWN BEAR POPULATIONS

(From Miller and McAllister [1982])

Area	Mean Age at 1st Production to Maximum Age of Breeding	Potential Reproduction Life ÷ Reproductive Interval		Litter Size		Potential Production of Cubs	$\bar{x}$ Reproductive Rate (No. cubs/adult female/year)
Yellowstone Park (Craighead et al. 1976)	6.3 - 24.8	18.5 years / 3.40	x	2.24	=	12.2	0.66
Alaska Peninsula (Glenn et al. 1976)**	6.3 - 24.8	18.5 years / 3.77	x	2.50	=	12.3	0.66
Eastern Brooks Range (Reynolds 1976)**	0.1 - 24.8	14.7 years / 4.24	x	1.78	=	6.2	0.42
Western Brooks Range (Reynolds 1980)	8.4 - 24.8	16.4 years / 4.03	x	2.03	=	8.3	0.50
Nelchina Basin (This study)	5.2 - 24.8	19.6 years / 3.3	x	2.3	=	13.7	0.70
Nelchina Basin (This study)	5.2 - 14.4***	9.2 years / 3.3	x	2.3	=	6.4	0.70

* This potential may be close to actual in lightly hunted populations in Yellowstone and the Brooks Range, it probably over estimates productivity of heavily hunted population (Alaska Peninsula).

** Reynold's (1980) analysis of data presented by others.

***Maximum age based on age of 30 females ($\geq$12 years) in the sport harvest 1970-1980.

TABLE W47

SUMMARY OF BROWN BEAR HARVEST FROM ALASKA'S GAME MANAGEMENT UNIT 13, 1973-1980

(From Miller and McAllister [1982])

Year	Total Sport Take	Average Age (N)			% Total Harvest Taken in Fall[a]			% of Total Take By Non-Residents
		Males	Females	Both	Males	Females	Both	
1973	44	6.9(25)	7.3(15)	7.1(40)	100	100	100	59
1974	72	6.3(39)	7.3(28)	6.7(67)	100	100	100	47
1975	80	7.2(40)	7.7(31)	7.4(71)	100	100	100	46
1976	59	6.8(28)	5.0(25)	5.9(53)	100	100	100	39
1977	38	6.1(28)	7.1(6)	6.3(34)	100	100	100	32
1978	63	6.1(32)	6.5(24)	6.2(56)	100	100	100	44
1979	73	6.5(34)	8.1(28)	7.2(62)	100	100	100	42
1980	84	5.0(39)	5.8(31)	5.4(70)	79	85	82	30
73-80	513	6.2(265)	6.8(188)	6.5(453)	96	97	42	
Fall Only -		6.3(255)	6.9(183)	6.5(438)				
Spring Only -		7.7(10)	6.2(5)	7.2(15)				

[a] Only fall seasons prior to 1980.

TABLE W48

NUMBER OF AERIAL BLACK BEAR OBSERVATIONS BY MONTH IN EACH OF 5 HABITAT CATEGORIES

(From Miller and McAllister [1982])

Habitat	May	June	July	August	September	October-April	All Months
SPRUCE	82	95	54	68	44	15	358
% by Months	22.9	26.5	15.1	19.0	12.3	4.2	(39.4)
% by Habitat	50.3	46.3	35.8	31.8	30.8	46.9	
RIPARIAN	23	33	23	18	23	1	121
% by Months	19.0	27.3	19.0	14.9	19.0	.8	(13.3)
% by Habitat	14.1	16.1	15.2	8.4	16.1	3.1	
SHRUBLAND	50	70	69	119	71	9	388
% by Months	12.9	18.0	17.8	30.7	18.3	2.3	(42.7)
% by Habitat	30.7	34.1	45.7	55.6	49.7	28.1	
TUNDRA	3	3	3	6	2	0	17
% by Months	17.6	17.6	17.6	35.3	11.8	0	(1.9)
% by Habitat	1.8	1.5	2.0	2.8	1.4	0	
OTHER	5	4	2	3	3	7	24
% by Months	20.8	16.7	8.3	12.5	12.5	29.2	(2.6)
% by Habitat	3.1	2.0	1.3	1.4	2.1	21.9	
TOTALS	163 (18.0)	205 (22.6)	151 (16.6)	214 (23.6)	143 (15.7)	32 (3.5)	908 (100.0)

TABLE W49

SUMMARY OF REPORTED BLACK BEAR HARVESTS FROM ALASKA'S GAME MANAGEMENT UNIT 13, 1973-1980

(From Miller and McAllister [1982])

Year	Total Sport Take	Average Age (n)[a]			% Males			% Total Harvest Taken in Fall			A[d]	B[d]	C[d]
		Males	Females	Both	Spring	Fall	Both	Males	Females	Both			
1973	70	5.9(39)	5.2(20)	5.6	NA	63	63	100	100	100	49	14	-
1974	48	5.7(26)	7.8(14)	6.4	86	64	67	81	93	85	21	25	-
1975	67				75	75	75	67	67	67	19	36	-
1976	63	5.2(5)			63	70	67	63	55	62	21	26	55
1977[b]	58	5.1(26)	4.8(12)	5.0	81	64	69	66	82	71	19	26	52
1978[c]	70	5.4(13)			80	63	68	64	81	69	20	7	64
1979[c]	70				68	50	55	64	79	70	11	18	73
1980	85				77	74	75	67	71	69	24	32	67
73-80	531	5.6(121)	5.9(58)	5.7	74	65	68	71	79	74	23	184	63
Fall Only	-	5.5(88)	5.9(49)	5.6									
Spring Only	-	5.7(33)	6.3(9)	5.8									

[a] Mean age given only when n $\geq$ 5.
[b] Only fall bears aged.
[c] Only spring bears aged.
[d] A % of total take by non-residents.
B Number taken by hunters reporting aircraft as primary source of transportation.
C % of total where meat was salvaged for food.

TABLE W50

COMPARISONS OF FOOD REMAINS IN WOLF SCATS COLLECT AT DEN AND RENDEZVOUS SITES IN 1980 AND 1981 FROM THE EASTERN SUSITNA BASIN AND ADJACENT AREAS

(From Ballard et al. 1982)

Food Items	1980 727 Scats		1981 290 Scats	
	No. Items	% Occurrences	No. 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 W51

ESTIMATE OF NUMBERS OF WOLVES BY INDIVIDUAL PACK INHABITING THE SUSITNA HYDROELECTRIC STUDY AREA IN SPRING AND FALL 1980 AND 1981

(From Ballard et al. 1982)

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 W52

NUMBER OF SAMPLE UNITS CONTAINING INDICATED LEVEL OF BEAVER ACTIVITY DURING SUMMER 1982 DOWNSTREAM SURVEY

(See text for explanation)

	None No Sign Seen	Low Tracks, Cuttings	Mod. Dams, Trails	High Dens, Lodges	
Main Channel	22	-	-	-	
Side Channel	22	5	1	4	UPPER SECTION
Slough	2	3	1	5	n = 38
Clearwater	-	2	2	3	
Main Channel	4	-	-	-	
Side Channel	1	1	6	3	MIDDLE SECTION
Slough	-	1	3	1	n = 11
Clearwater	-	-	-	4	
Main Chan.	1	-	-	-	
Side Chan.	1	-	3	9	LOWER SECTION
Slough	1	-	1	3	n = 8
Clearwater	*				

* Lower Section contained no clearwater habitat in sample units surveyed.

TABLE W53

Aerial counts of beaver structures along 15.2 km of lower Deadman Creek immediately downstream from Deadman Lake, and a marshy section of upper Deadman Creek from its mouth at Deadman Lake 3.2 km upstream from the lake.

Location	Catches	Lodges		Dams	
		Active	Inactive	Active	Inactive
Lower Deadman Creek	8	9[1]	5	3	4
Upper Deadman Creek	5	5	0	0	0
TOTAL	13	14	5	3	4

[1]Two apparently active lodges were observed within 30 meters of each other and only one food cache was noted between the lodges. Possibly both of these lodges had been active during summer, but only one would remain active through winter.

TABLE W54

RESULTS OF SURVEYS FOR MUSKRAT PUSHUPS UPSTREAM FROM GOLD CREEK DURING SPRING 1980 (From Gipson et al 1982)

Lake Number	Elevation MSL (m)	No Pushups	Location of Lakes: Quarter Section	Section	Range	Township
001	267	2	SW	31	1W	32N
			SE	31	1W	32N
002	472	4	SE	30	1W	32N
			SW	29	1W	32N
003	526	14	NE	30	1W	32N
			NW	29	1W	32N
004	640	0	NE	20	1W	32N
			NW	21	1W	32N
			SE	20	1W	32N
005	500	26	SE	15	1W	32N
			SW	14	1W	32N
			SE	14	1W	32N
			NW	23	1W	32N
006	495	0	NW	23	1W	32N
			NE	23	1W	32N
007	480	0	NW	24	1W	32N
			SW	24	1W	32N
			SE	23	1W	32N
			NE	23	1W	32N
008	463	0	SW	6	1E	31N
009	463	0	SE	6	1E	31N
010	442	0	SW	32	1E	32N
011	472	0	SE	32	1E	32N
012	419	0	SE	32	1E	32N
013	542	0	SW	4	1E	32N
			SE	4	1E	32N
014	724	0	NW	28	1E	32N
015	724	0	NE	21	1E	32N
			NW	22	1E	32N
			SW	22	1E	32N
			NW	27	1E	32N
			SE	21	1E	32N
016	712	0	SW	16	1E	32N
			SE	16	1E	32N
			SW	15	1E	32N
			NW	22	1E	32N
			NE	21	1E	32N
017	754	0	NE	22	1E	32N
			NW	23	1E	32N
018	572	0	NW	35	1E	32N
019	503	0	SW	35	1E	32N
			NW	2	1E	31N
020	541	0	SE	35	1E	32N
			NE	2	1E	31N
021	724	0	NW	36	1E	32N
022	724	0	NW	36	1E	32N
023	686	0	SW	24	1E	32N
			SE	24	1E	32N
			SW	19	2E	32N
			NW	30	2E	32N
			NE	25	1E	32N
			NW	25	1E	32N
024	724	0	NE	19	2E	32N
			NW	20	2E	32N
025	722	0	NW	20	2E	32N
			NE	20	2E	32N
			SE	20	2E	32N
			SW	20	2E	32N

TABLE W54

RESULTS OF SURVEYS FOR MUSKRAT PUSHUPS UPSTREAM FROM GOLD CREEK DURING SPRING 1980 (From Gipson et al 1982) (Cont'd)

Lake Number	Elevation MSL (m)	No Pushups	Location of Lakes			
			Quarter Section	Section	Range	Township
026	709	0	SW	21	2E	32N
027	533	0	NW	27	2E	32N
			NE	27	2E	32N
			SE	27	2E	32N
			SW	27	2E	32N
028	754	0	NE	7	4E	31N
029	716	0	SW	8	4E	31N
030	602	0	NW	17	4E	31N
031	602	0	NE	17	4E	31N
032	693	1	NW	5	5E	31N
			SW	5	5E	31N
033	693	0	SW	5	5E	31N
034	716	0	SW	4	5E	31N
			SE	5	5E	31N
035	680	0	SW	9	5E	31N
			SE	9	5E	31N
			NE	16	5E	31N
			NW	16	5E	31N
			NE	17	5E	31N
			NW	17	5E	31N
			NE	18	5E	31N
			SE	7	5E	31N
			SW	8	5E	31N
			SE	8	5E	31N
036	678	8	SW	10	5E	31N
			SE	9	5E	31N
037	693	0	SE	3	5E	31N
			SW	3	5E	31N
			SE	10	5E	31N
			SW	10	5E	31N
			NE	9	5E	31N
038	643	0	SE	11	5E	31N
			SW	11	5E	31N
			NW	14	5E	31N
			NE	15	5E	31N
			SW	15	5E	31N
			NW	15	5E	31N
			SW	10	5E	31N
039	709	0	NW	3	5E	31N
040	683	0	SW	21	5E	32N
041	678	1	NW	21	5E	32N
042	683	0	NE	21	5E	32N
043	689	1	NE	21	5E	32N
			NW	22	5E	32N
			SE	21	5E	32N
			NE	21	5E	32N
044	693	0	SW	15	5E	32N
			NW	22	5E	32N
045	683	0	SE	16	5E	32N
			NE	21	5E	32N
046	693	0	SE	15	5E	32N
			SW	45	5E	32N
047	683	7	NW	15	5E	32N
			NE	16	5E	32N
048	739	6	NW	10	5E	32N
049	716	0	NW	14	5E	32N
			SW	14	5E	32N
050	716	0	NW	14	5E	32N
051	716	0	NW	14	5E	32N

TABLE W54

RESULTS OF SURVEYS FOR MUSKRAT PUSHUPS UPSTREAM FROM GOLD CREEK DURING SPRING 1980 (From Gipson et al 1982) (Cont'd)

Lake Number	Elevation MSL (m)	No Pushups	Location of Lakes: Quarter Section	Section	Range	Township
052	716	0	NW	14	5E	32N
			NE	14	5E	32N
053	716	0	NE	14	5E	32N
054	716	0	SE	14	5E	32N
055	716	0	NE	14	5E	32N
			SE	14	5E	32N
056	716	0	NE	14	5E	32N
			NW	13	5E	32N
057	693	0	SW	35	5E	32N
058	708	0	NE	53	5E	32N
059	693	32	NE	13	5E	32N
			NW	18	5E	31N
			SW	18	5E	31N
			SE	13	5E	31N
			SW	13	5E	31N
			SE	14	5E	31N
			NE	14	5E	31N
			NE	13	5E	31N
060	692	0	SW	5	6E	31N
			SE	5	6E	31N
			NE	8	6E	31N
			SE	7	6E	31N
			SW	7	6E	31N
			NE	7	6E	31N
			NW	8	6E	31N
061	678	3	SW	4	6E	31N
			SE	5	6E	31N
062	678	0	NW	2	6E	31N
063	709	0	SE	19	6E	32N
064	724	0	NW	19	6E	32N
			NE	24	6E	32N
065	747	3	SW	18	6E	32N
066	716	0	NE	18	6E	32N
			NW	18	6E	32N
067	716	24	SW	7	6E	32N
			SE	7	6E	32N
			SW	8	6E	32N
			SE	8	6E	32N
			NE	17	6E	32N
			NW	17	6E	32N
			NE	18	6E	32N
068	692	15	SE	17	6E	32N
			SW	16	6E	32N
			NW	21	6E	32N
			NE	20	6E	32N
069	693	14	SE	11	6E	32N
070	709	8	NW	12	6E	32N
071	533	5	SE	24	6E	32N
072	503	2	NW	31	7E	32N
073	610	0	SW	29	7E	32N
074	625	2	NW	29	7E	32N
			NE	29	7E	32N
			SE	29	7E	32N
075	625	0	SE	29	7E	32N
			NE	32	7E	32N
076	625	2	SW	28	7E	32N
077	625	0	SE	29	7E	32N
078	625	0	SE	29	7E	32N
079	960	0	SE	23	7E	31N
080	838	0	SE	6	8E	31N

TABLE W54

RESULTS OF SURVEYS FOR MUSKRAT PUSHUPS UPSTREAM FROM GOLD CREEK DURING SPRING 1980 (From Gipson et al 1982) (Cont'd)

Lake Number	Elevation MSL (m)	No Pushups	Location of Lakes: Quarter Section	Section	Range	Township
081	823	0	SE	6	8E	31N
			SW	5	8E	31N
082	564	2	SW	8	8E	31N
083	770	0	SW	33	8E	32N
			NE	33	8E	32N
084	770	0	NW	3	8E	31N
085	808	0	SW	2	8E	31N
			SE	2	8E	31N
086	808	0	SE	2	8E	31N
087	808	0	SE	2	8E	31N
088	741	1	SE	7	9E	31N
089	866	25	SE	25	11E	30N
			SW	30	11E	30N
			NW	31	11E	30N
			NE	36	11E	30N
090	870	2	SE	30	11E	30N
			NW	31	11E	30N
091	869	0	NW	31	11E	30N
092	777	1	SW	5	11E	29N
			NW	8	11E	29N
093	777	0	NW	8	11E	29N
			NE	8	11E	29N
			SE	8	11E	29N
			SW	8	11E	29N
094	780	0	SE	5	11E	29N
			NE	8	11E	29N
095	777	0	SW	4	11E	29N
096	777	0	NW	9	11E	29N
097	777	0	NW	9	11E	29N
098	777	0	NW	9	11E	29N
			SW	9	11E	29N
099	777	0	SE	8	11E	29N
			SW	9	11E	29N
100	853	1	NE	26	10E	30N
101	853	0	NE	26	10E	30N
			NW	25	10E	30N
102	853	0	SW	24	10E	30N
103	853	0	SW	23	3E	30N
			NW	26	3E	30N

TABLE W55

NUMBERS OF FURBEARER TRACKS SEEN DURING AERIAL TRANSECTS IN THE UPPER SUSITNA BASIN, AUTUMN 1980

(From Gipson et al. 1982)

Transect[a] Number	Marten	Fox	Short-tailed Weasel	Mink	Otter	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
Totals	1353	213	746	34	30	2376

[a] See Figure S for transect locations.

TABLE W56

NUMBER OF TRACKS OF OTTER AND MINK OBSERVED AT NORTH AND SOUTH SIDES OF 37 SUSITNA RIVER CHECK POINTS, NOVEMBER 10-12, 1980[a]

(From Gipson et al. 1982)

Checkpoint Numbers	North		South	
	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
Totals	20	16	27	38

[a] See Figure S for locations of river check points.

TABLE W57

RESULTS OF MARTEN SCAT ANALYSES BY SEASON, BASED UPON PERCENT FREQUENCY OF OCCURRENCE

(from Gipson et al. [1982])

	Autumn 1980	Winter 1980-81	Spring 1981	Autumn 1981	Unknown Season	Total
Unknown Mammal	0.0	0.7	3.9	0.7	0.0	1.2
Microtine	83.3	85.6	82.7	98.7	85.7	88.8
Shrew	16.7	2.7	2.9	0.0	1.3	2.4
Sciurid	4.2	9.6	15.4	0.0	3.9	6.8
Ungulate	16.7	0.0	1.9	1.4	6.5	2.6
Snowshoe Hare	0.0	1.4	0.0	0.0	3.9	1.0
Muskrat	0.0	3.4	2.9	0.0	0.0	1.6
Bird	4.2	17.1	12.5	3.4	5.2	9.6
Berry	41.7	39.7	29.8	1.4	19.5	23.3
Fish	0.0	0.7	1.0	0.0	1.3	0.6
Human Foods	0.0	0.0	0.0	0.0	7.8	1.2
Total Scats	24.0	146.0	104.0	148.0	77.0	499.0
Food Items/Scat	1.7	1.7	1.6	1.1	1.4	1.5

TABLE W58

TRACKS OF RED FOXES ENCOUNTERED DURING FALL 1980 AERIAL TRANSECT SURVEYS

(From Gipson et al. 1982)

Elevation (m)	Number of Fox Tracks	
	North side Susitna	South side Susitna
516 - 547		1
548 - 581	2	4
582 - 613	5	-
614 - 645	1	-
646 - 677	-	-
678 - 709	-	-
710 - 741	20	2
742 - 774	9	6
775 - 806	10	18
807 - 838	-	2
839 - 870	12	47
871 - 902	5	1
903 - 935	-	38
936 - 967	5	1
968 - 1000	7	2
1001 - 1032	-	1
1033 - 1064	-	2
1065 - 1096	3	11
1097 - 1129	-	15
Total	79	151
Transects 1 - 11	67	51

TABLE W59: LOCATION AND STATUS OF RAPTOR AND RAVEN NEST SITES IN THE UPPER SUSITNA BASIN, ALASKA

Species	Nesting Location No.	Corresponding U of A Museum No. (Kessel at el, 1982, B. Cooper pers. comm., 1982)	Status[a]				USGS Talkeetna Mountains 15 ft x 30 ft Quad No.	Location			Estimated[e] Elevation m (ft)
			1974[b]	1980[c]	1981[c]	1982[d]		Township	Range	Section	
Golden Eagle	GE-1	V, C, ii	-	x	x	NC	C-1	T30N	R11E	7	716-731 (2,350-2,400)
	GE-2	D, T, gg	-	x	x	NC	D-2	T31N	R9E	17	610-655 (2,000-2,150)
	GE-3	E, kk, ll	-	x	x	NC	D-2	T31N	R8E	1	715 (2,400)[f]
	GE-4	qq	-	-	0	x	D-2	T31N	R8E	15, 22	564 (1,850)
	GE-5	F	-	x	0	NC	D-2	T31N	R8E	9, 10	549 (1,800)
	GE-6	-	0	-	-	NC	D-2	T31N	R8E	8, 9	(579 ((1,900)
	GE-7	R	-	-	x	NC	D-3	T31N	R7E	14	945 (3,100)[f]
	GE-8	G	-	x	0	NC	D-3	T32N	R6E	28	518 (1,600-1,700)
	GE-9	ff	-	-	0	NC	D-3	T32N	R6E	29	518 (1,600-1,700)
	GE-10	-	-	-	0	NC	D-4	T33N	R5W	28	1,189 (3,900)
	GE-11	dd	-	-	0	NC	D-4	T32N	R4E	25	490-518 (1,600-1,700)
	GE-12	-	0	-	-	NC	D-4	T31N	R3E	15, 14	(549? ((1,800?)
	GE-13	Z	-	0	0	NC	D-4	T31N	R3E	17, 18	427-442 (1,400-1,450)

TABLE W59: LOCATION AND STATUS OF RAPTOR AND RAVEN NEST SITES IN THE UPPER SUSITNA BASIN, ALASKA (Cont'd)

Species	Nesting Location No.	Corresponding U of A Museum No. (Kessel at el, 1982, B. Cooper pers. comm., 1982	Status[a]				USGS Talkeetna Mountains 15 ft x 30 ft Quad No.	Location			Estimated[e] Elevation m (ft)
			1974[b]	1980[c]	1981[c]	1982[d]		Township	Range	Section	
Golden Eagle (contd)	GE-14	-	0	-	-	NC	D-4	T31N	R3E	12	427-457? (1,400-1,500?)
	GE-15	X, Y	-	-	0	NC	D-5	T32N	R2E	22, 23	518-579 (1,700-1,900
	GE-16	I	-	x	x	NC	D-5	T32N	R2E	27	470-485 (1,540-1,590)
	GE-17	pp	-	-	0	NC	D-5	T31N	R2E	17	610-625 (2,000-2,050)
	GE-18	M	-	-	x	NC	D-5	T32N	R1E	32	335 (1,100)
Bald Eagle	BE-1	-	0	-	-	NC	C-1	T31N	R12E	28, 33	686-694 (2,250-2,275)
	BE-2	B	-	x	x	NC	C-1	T29N	R11E	9, 10	663-671 (2,175-2,210)
	BE-3	hh	x	-	0	NC	C-2	T30N	R10E	16	579 (1,900)
	BE-4	S	x	-	x	NC	D-2	T31N	R8E	11	540-549 (1,775-1,800)
	BE-5	A	x	x	0	NC	D-3	T31N	R7E	2	497-503 (1,630-1,650)
	BE-6	K	-	x	x	NC	D-3	T33N	R5E	34	760 (2,500)
	BE-7	N	-	-	x	NC	C-4	T30N	R3E	1	564-572 (1,850-1,875)
	BE-8	L	0	x	x	NC	D-6	T31N	R2W	9, 10	230 (750)

TABLE W59: LOCATION AND STATUS OF RAPTOR AND RAVEN NEST SITES IN THE UPPER SUSITNA BASIN, ALASKA (Cont'd)

Species	Nesting Location No.	Corresponding U of A Museum No. (Kessel at el, 1982, B. Cooper pers. comm., 1982)	Status[a] 1974[b]	1980[c]	1981[c]	1982[d]	USGS Talkeetna Mountains 15 ft x 30 ft Quad No.	Location Township	Range	Section	Estimated[e] Elevation m (ft)
Gyrfalcon	GYR-1	U	x?	-	x	NC	C-2	T30N	R10E	11	686 (2,250)
	GYR-2	H	x	x	0	NC	D-5	T31N	R2E	17, 18	587 (1,925)
	GYR-3	-	x	-	-	NC	D-5	T31N	R1E	5	579-610? (1,900-2,000?)
Goshawk	GOS-1	-	-	-	x	x	D-2	T31N	R8E	10, 15	518 (1,700)
	GOS-2	-	?	-	-	NC	D-4	T31N	R4E	10	442 (1,450)
	GOS-3	o	-	-	x	NC	D-5	T31N	R1E	4	549 (1,800)
Raven	R-1	-	0	-	-	NC	C-1	T30N	R11E	7, 8	717? (2,350?)
	R-2	-	x	-	-	NC	C-2	T30N	R10E	11	671? (2,200?)
	R-3	jj	x	-	0	NC	C-2	T30N	R10E	11	641 (2,100)
	R-4	-	x	-	-	NC	C-2	T30N	R10E	7, 8	610-778 (2,000-2,550)
	R-5	-	x	-	-	NC	D-2	T31N	R8E	12	641 (2,100)
	R-6	-	0	-	-	NC	D-2	T31N	R8E	15	610 (2,000)
	R-7	-	x	-	-	NC	D-3	T31N	R8E	7	534-549 (1,750-1,800)

TABLE W59: LOCATION AND STATUS OF RAPTOR AND RAVEN NEST SITES IN THE UPPER SUSITNA BASIN, ALASKA (Cont'd)

Species	Nesting Location No.	Corresponding U of A Museum No. (Kessel at el, 1982, B. Cooper pers. comm., 1982)	Status[a] 1974[b]	1980[c]	1981[c]	1982[d]	USGS Talkeetna Mountains 15 ft x 30 ft Quad No.	Location Township	Range	Section	Estimated[e] Elevation m (ft)
Raven	R-8	-	x	-	-	NC	D-3	T32N	R7E	33	519 (1,700)
	R-9	-	x	-	-	NC	D-3	T32N	R6E	25	488 (1,600)
	R-10	-	x	0	-	NC	D-3	T32N	R6E	28	488 (1,600)
	R-11	-	0	-	-	NC	D-3	T32N	R5E	26, 35	564 (1,850)
	R-12	Q	-	-	x	NC	D-3	T32N	R5E	23, 26	625 (2,050)
	R-13	P, ee	-	-	x	NC	D-4	T32N	R5E	20	549 (1,800)
	R-14	mm, nn, cc	-	-	0	NC	D-4	T31N	R4E	14	549-580 (1,800-1,900)
	R-15	O, aa, bb	-	-	x	NC	D-4	T31N	R4E	15	519-580 (1,700-1,900)
	R-16	-	0	-	-	NC	D-4	T31N	R3E	18	442 (1,450)
	R-17	-	0	-	-	NC	D-4	T31N	R3E	13	442 (1,450)
	R-18	-	0	-	-	NC	D-5	T32N	R2E	36	427 (1,400)
	R-19	J	x	x	-	NC	D-5	T32N	R2E	27	458 (1,500)
	R20	W	-	-	0	NC	D-5	T32N	R2E	33	366 (1,200)

TABLE W59: LOCATION AND STATUS OF RAPTOR AND RAVEN NEST SITES IN THE UPPER SUSITNA BASIN, ALASKA (Cont'd)

Species	Nesting Location No.	Corresponding U of A Museum No. (Kessel at el, 1982, B. Cooper pers. comm., 1982)	Status[a] 1974[b]	1980[c]	1981[c]	1982[d]	USGS Talkeetna Mountains 15 ft x 30 ft Quad No.	Location Township	Range	Section	Estimated[e] Elevation m (ft)
Raven (Contd)	R-21	-	0	-	-	NL	D-5	T32N	R1E	32	427 (1,400)

[a]Status unknown, x = possibly active, x = active, 0 = inactive, - = pot reported (1974) or not located (1980 - 1981) (although suitable habitat was present in most cases), NC = not checked.
[b]Data from White (1974).
[c]Data from Kessel, et al, (1982), B. Kessel and B. Cooper (unpubl. data).
[d]Data from Kessel and Cooper (unpubl. data).
[e]Differences occur between elevations given here and those reported by Kessel, et al, (1982). Original estimates were obtained by attempting to locate nests as accurately as possible on USGS 1:63 360 maps with contour intervals of 100' (majority) or 50' (Talkeetna Mtns C-1), but it was often difficult to precisely locate nests and to locate them relative to tightly spaced contour intervals (Cooper, pers. comm. 1982). All elevations have been reviewed and some revisions were made; however, in some cases estimates given here may contain errors of as much as +100'. All elevations must be considerd approximate (unless otherwise noted) until the majority are rechecked with an altimeter (handhold or helicopter).
[f]Elevation checked with helicopter altimeter on October 11, 1982.

TABLE W60

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 (unpublished data) and Brown (1974)

TABLE W61

DATA ON BALD EAGLE NESTS ALONG THE SUSITNA RIVER, BETWEEN DEVIL CANYON AND COOK INLET. NESTS IN 1980 WERE OBSERVED IN APRIL BY U.S. FISH AND WILDLIFE SERVICES; 1981 NESTS WERE LOCATED ON 26 JUNE BY TERRESTRIAL ENVIRONMENTAL SPECIALISTS, INC.; THE 1982 NESTS WERE RESULTS OF UNIVERSITY OF ALASKA MUSEUM SURVEYS. ALL 1982 NESTS WERE LOCATED IN LARGE, OLD COTTONWOOD TREES.

Year and Status 80	81	82	No. Chicks 1982		Locality	Nest Height (m)	Tree Height (m)	Broken Topped ?	Tree dead or alive	Distance from river (m)	Elevation (m/ft)
N	A	A	1	62°47'N 149°38'W:	North bank of Susitna River 1 km upstream from confluence with Indian River	23	23	Yes	live	4	244 (800)
N	A	I	0	62°40'N 149°55'W:	Island in Susitna River 4 km downstream from Sherman	21	21	Yes	dead	250	182 (600)
N	A	A	2	62°20'N 150°10'W:	Confluence of Chulitna and Susitna rivers	25	33	No	dead	200	107 (350)
-	-	A	2	62°21'N 150°03'W:	South bank of Talkeetna River 3 km upstream from confluence with Susitna River	27	30	No	live	3	116 (380)
-	-	A	1	62°19'N 150°08'W:	West bank of Susitna River opposite Talkeetna	30	33	No	live	10	107 (350)
N	A	A	>1	62°13'N 150°06'W:	East bank of Susitna River 4.5 km upstream from Parks Highway Bridge	22	33	No	live	5	91 (300)
N	-	A	-	62°10'N 150°10'W:	East bank of Susitna River 2 km downstream from Parks Highway Bridge	-	-	-	-	-	91 (300)
-	A	A	-	62°01'N 150°06'W:	Island in Susitna River near Sheep Creek Slough	-	-	-	-	-	76 (250)
N	-	A	-	61°49'N 150°10'W:	Island in Susitna River west of Kashwitna Lake	12	23	No	live	30	30 (100)
N	-	A	>1	61°47'N 150°10'W:	Island in Susitna River opposite mouth of Willow Creek	23	30	No	live	10	30 (100)
N	-	A	1	61°46'N 150°13'W:	Island in Susitna River 2 km west of mouth of Willow Creek	30	34	No	dead	90	24 (80)
-	-	A	2	61°45'N 150°15'W:	Northwest corner of Delta Islands	30	30	Yes	live	40	24 (80)
N	A	A	>1	61°43'N 150°19'W:	West bank of Susitna River .5 km upstream from mouth of Kroto Creek	28	28	Yes	live	100	30 (100
N	-	I	0	61°43'N 150°17'W:	East bank of Susitna River opposite mouth of Kroto Creek	22	30	No	live	20	27 (90)
N	-	A	>1	61°40'N 150°19'W:	East bank of Susitna River opposite Kroto Slough	23	27	Yes	live	5	30 (100)
N	-	I	0	61°39'N 150°20'W:	Island in Susitna River near Kroto Slough	20	27	No	live	100	24 (80)
N	-	I	0	61°39'N 150°21'W:	Island in Susitna River near Kroto Slough	27	30	No	live	5	24 (80)
-	-	A	-	61°37'N 150°23'W:	Island in Susitna River 5 km upstream from Yentna River mouth	23	30	No	live	100	20 (60)
-	-	A	-	61°35'N 150°25'W:	Island at confluence of Yentna and Susitna rivers	-	-	-	-	-	17 (50)
-	-	A	>1	61°28'N 150°30'W:	East bank of Susitna River east of Flat Horn Lake	23	27	Yes	live	5	10 (30)
-	-	I	0	61°28'N 150°32'W:	West bank of Susitna River east of Flat Horn Lake	23	25	Yes	live	3	10 (30)
-	-	A	-	61°24'N 150°30'W:	South end of Bell Island	-	-	-	-	-	7 (20)
-	-	I	0	61°22'N 150°36'W:	Northern end of Big Island	20	34	No	live	1	3 (10)
-	-	I	0	61°22'N 150°37'W:	West bank of Susitna River west of Big Island	18	23	No	live	2	3 (10)
-	-	I	0	61°20'N 150°38'W:	West side of Big Island	20	23	Yes	dead	20	3 (10)
-	-	I	0	61°20'N 150°28'W:	West side of Big Island	20	20	Yes	dead	20	3 (10)
-	-	I	0	61°25'N 150°28'W:	East bank of Susitna River near Maid Lake	-	-	Yes	-	-	3 (10)
-	-	I	0	61°22'N 150°31'W:	Island in the Susitna River west of Beaver Lake	-	-	Yes	-	-	3 (10)
N	-	-	-	61°22'N 150°01'W:	Confluence of the Chunilna and Talkeetna rivers	-	-	-	-	-	137 (450)
N	-	-	-	62°20'N 150°05'W:	Island 1 km up to Talkeetna River	-	-	-	-	-	107 (350)
N	-	-	-	62°17'N 150°08'W:	Island in Susitna River 3 km downstream from Talkeetna	-	-	-	-	-	107 (350)
N	-	-	-	62°16'N 150°09'W:	West bank of Susitna River 6 km downstream from Talkeetna	-	-	-	-	-	107 (350)
-	A	-	-	61°59'N 150°07'W:	Island in Susitna River near mouth of Sheep Creek	-	-	-	-	-	60 (200)
N	-	-	-	61°54'N 150°07'W:	East bank of Susitna River near mouth of 196 Mile Creek	-	-	-	-	-	45 (150)
N	-	-	-	61°46'N 150°13'W:	North end of Delta Islands	-	-	-	-	-	30 (100)
-	A	-	-	61°28'N 150°32'W:	West bank of Susitna River west of Bell Island	-	-	-	-	-	7 (20)
-	A	-	-	61°27'N 150°30'W:	Island in Susitna River east of Bell Island	-	-	-	-	-	7 (20)
N	-	-	-	61°57'N 150°06'W:	Island in Susitna River 1 km upstream from Caswell Creek mouth	-	-	-	-	-	55 (180)

Key: N = nest, A = active nest, I = inactive nest, - = no information

TABLE W62

SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON LAKES SURVEYED IN SPRING, SUMMER AND FALL IN THE UPPER SUSITNA BASIN

(Based on Kessel et al. 1982)

	Fall[1]		Spring[1]	Summer[1] 1981	
Species	1980	1981	1981	Adults	Broods
Common loon	8	9	4	22	3
Arctic loon			5	2	0
Red-throated			2	8	
Loon spp.	5		7		
Red-necked grebe	17	16	4	7	1
Horned grebe	35		2	5	5
Whistling swan		42	8		
Trumpeter swan		30	21	16	1
Swan spp.	104	101			
Canada goose	21	50			
Mallard	438	467	296	10	1
Pintail	201	32	257	7	2
Blue-winged teal	1				
Green-winged teal	125	16	152	2	1
Northern shoveler	28		40	7	1
American wigeon	721	152	198	8	6
Canvasback			1		
Redhead			28		
Scaup, greater and lesser	1854	786	616	70	5
Ring-necked duck	14				
Goldeneye, common and Barrow's	471	247	89	6	1
Bufflehead	396	118	12		
Oldsquaw	57	54	86	47	11
White-winged scoter	11	82	16	81	0
Surf scoter	18	29	39	33	2
Black scoter	105	10	43	26	11
Scoter spp.	134	162	86	6	1
Common merganser		3	7		
Red-breasted merganser			2	1	1
Merganser spp.	161	133	25	1	
New gull				83	7
Bonapart's gull				5	0
Arctic tern				48	0
Total birds	4925	2539	2046	461	60
Total wetland area surveyed (km^2)	141.73	79.78	60.76	20.5	20.5
Density (birds/km^2 of wetlands)	34.1	31.8	81.0	22.5	2.9

1

TABLE W63

AVERAGE DENSITY OF WATERBIRDS IN LAKES IN THE UPPER SUSITNA BASIN IN FALL 1980 AND SPRING AND SUMMER 1981

(Data from Kessel, pers. comm.)

Lake/Lake Group	Average Density (birds/km^2) Fall	Spring	Summer Adults	Summer Broods
MacLaren R - Tyron R	89.1	29.02	NS*	NS
Tyrone R - Ashetna R	NS	28.48	49.5	2.9
Clarence Lake area	64.84	36.67	21.9	3.8
Watana Lake	76.60	17.06	6.4	0.0
Lower Watana Creek area	NS	NS	NS	NS
Fog Lakes	16.5	11.65	18.3	3.8
Lower Deadman creek area	17.92	88.0	21.3	6.4
Big Lake	2.17	NS	NS	NS
Deadman Lake	41.30	21.09	NS	NS
Upper Deadman Creek area	23.81	NS	NS	NS
Lower Devil - Lower Portage Creek	NS	4.97	12.0	4.0
Murder Lake	260.00	342.00	153.3	6.7
Stephen Lake	43.94	28.08	24.5	0.6
Stephen Lake area	37.1	17.83	12.8	1.7
Lower Portage Creek area	NS	17.26	NS	NS
Swimming Bear Lake	NS	8.19	57.9	7.0

*NS = Not surveyed

TABLE W64

SEASONAL POPULATION STATISTICS FOR THE MORE IMPORTANT OF SURVEYED WATERBODIES OF THE UPPER SUSITNA RIVER BASIN, 1980-81. INCLUDED ARE WATERBODIES THAT WERE AMONG THE SIX HIGHEST IMPORTANCE VALUE RATINGS IN AT LEAST ONE SEASON.

		Fall 1980**			Fall 1981**			Spring 1981††			Summer 1981			
Waterbody	Size (km^2)	Mean No. Birds	Mean Density (no/km^2)	Mean No. Species	Mean No. Birds	Mean Density (no/km^2)	Mean No. Species	Mean No. Birds	Mean Density (no/km^2)	Mean No. Species	No. Adults	Density of Adults	No. Species	No. Broods
Murder Lake	0.15	39.0	260.0	4.3	38.0	253.3	3.0	51.3	342.2	5.0	23	153.3	5	1
Stephan Lake	3.55	156.0	43.9	9.5	168.5	47.5	5.0	99.7	28.1	7.3	87	24.5	9	2
WB 140 (Tyone R - Ashetna R group)	0.90	53.5	59.4	5.0	30.5	33.9	2.5	48.3†	53.7†	3.7†	75	83.3	11	4
WB 131 (MacLaren R - Tyone R group)	1.04	212.8	204.6	6.5	123.0	118.3	5.0	54.7†	52.6†	3.7†	-	-	-	-
WB 145 (Clarence Lake area group)	1.60	103.8	64.8	7.0	42.5	26.6	4.5	58.7	36.7	7.0	35	21.9	8	6
WB 059 (Fog Lake group)	1.44	72.8	50.5	6.5	55.0	38.2	3.0	21.3	14.8	4.7	54	37.5	11	5
Watana Lake (Lower Deadman)	1.25	95.8	76.6	3.8	34.5	27.6	2.0	21.3†	17.1†	3.0†	8	6.4	3	0
Pistol Lake (Lower Deadman Creek group)	0.76	19.0*	17.9*	4.0*	4.0†	5.3	1.5†	85.0	111.8	6.0	15	19.7	8	5
WB 032 (Fog Lake group)	0.07	-	-	-	-	-	-	-	-	-	8	114.3	4	6
Swimming Bear Lake	0.57	-	-	-	11.5	20.2	0.5	4.7†	8.2†	0.7†	33	57.9	5	4

* Combines WB 064-067
**11, 16, 20 and 26 September 1980; 15 and 26 September 1981
† 100 percent frozen on at least one survey
††3, 10 and 26 May 1981
\- Not surveyed

TABLE W65

– MEAN NUMBER OF TERRITORIES OF EACH BIRD SPECIES ON 10-HA CENSUS PLOT, UPPER SUSITNA RIVER BASIN, ALASKA, IN 1981 AND 1982 (+ = SMALL PORTION OF A BREEDING TERRITORY ON CENSUS PLOT, COUNTED AS 0.1 IN DENSITY AND DIVERSITY CALCULATIONS; V = VISITOR TO PLOT)

(Based on Kessel et al, 1982, and Kessel pers. comm.)

	HABITAT[1]											
Species	Mat and Cushion Tundra	Dwarf-Low Birch Shrub	Medium Birch Shrub	Low-Medium Willow Shrub	Tall Alder Shrub	Balsam Poplar Forest	Paper Birch Forest	White Spruce-Paper Birch (Mixed) Forest I	White Spruce-Paper Birch (Mixed) Forest II	Open White Spruce Forest	White Spruce Woodland	Black Spruce Woodland
Pintail	–	–	–	–	–	–	–	–	–	V	–	–
Goshawk	–	–	–	–	V	–	–	–	V	+	–	–
Marsh Hawk	–	–	V	–	–	–	–	–	–	–	–	V
Spruce Grouse	–	–	–	–	V	V	V	0.5	0.8	+	V	V
Ruffed Grouse	–	–	–	–	–	–	–	–	–	+	–	–
Willow Ptarmigan	–	0.3	–	V	–	–	–	–	–	–	–	V
Rock Ptarmigan	–	0.4	–	–	–	–	–	–	–	–	–	–
White-Tailed Ptarmigan	+	–	–	–	–	–	–	–	–	–	–	–
American Golden Plover	0.3	–	–	–	–	–	–	–	–	–	–	–
Whimbrel	–	–	–	–	–	–	–	–	–	–	+	–
Greater Yellowlegs	–	–	–	–	–	–	–	–	–	–	0.3	–
Common Snipe	–	V	V	+	–	–	–	–	–	–	0.3	0.5
Long-Billed Dowitcher	–	V	–	–	–	–	–	–	–	–	–	–
Baird's Sandpiper	1.4	V	–	–	–	–	–	–	–	–	–	–
Long-Tailed Jaeger	–	V	–	–	–	–	–	–	–	–	–	–
Great Horned Owl	–	–	–	–	–	V	–	–	–	–	–	–
Hawk Owl	–	–	–	–	–	–	–	–	–	–	V	–
Short-Eared Owl	–	V	–	V	–	–	–	–	–	–	–	–

TABLE W65

- MEAN NUMBER OF TERRITORIES OF EACH BIRD SPECIES ON 10-HA CENSUS PLOT, UPPER SUSITNA RIVER BASIN, ALASKA, IN 1981 AND 1982
(+ = SMALL PORTION OF A BREEDING TERRITORY ON CENSUS PLOT, COUNTED AS 0.1 IN DENSITY AND DIVERSITY CALCULATIONS; V = VISITOR TO PLOT) (Cont'd)

(Based on Kessel et al, 1982, and Kessel pers. comm.)

	HABITAT[1]											
Species	Mat and Cushion Tundra	Dwarf-Low Birch Shrub	Medium Birch Shrub	Low-Medium Willow Shrub	Tall Alder Shrub	Balsam Poplar Forest	Paper Birch Forest	White Spruce-Paper Birch (Mixed) Forest I	White Spruce-Paper Birch (Mixed) Forest II	Open White Spruce Forest	White Spruce Woodland	Black Spruce Woodland
Common Flicker	-	-	-	-	-	-	-	-	V	V	-	-
Hairy Woodpecker	-	-	-	-	-	1.0	-	-	0.5	-	-	-
Downy Woodpecker	-	-	-	-	-	0.3	-	-	-	-	-	-
Northern Three-Toed Woodpecker	-	-	-	-	-	-	-	-	V	0.8	V	V
Alder Flycatcher	-	-	-	-	-	0.5	-	-	-	-	-	-
Olive-Sided Flycatcher	-	-	-	-	-	-	-	-	V	+	-	-
Horned Lark	0.5	0.2	-	-	-	-	-	-	-	-	-	-
Tree Swallow	-	-	V	V	-	V	-	-	-	V	-	-
Violet-Green Swallow	-	-	-	-	-	-	-	-	-	V	-	-
Gray Jay	-	-	-	-	0.5	-	V	0.7	0.8	0.8	+	V
Black-Belled Magpie	-	-	-	-	V	-	-	-	-	-	-	-
Common Raven	V	-	-	-	-	-	-	-	-	-	-	V
Black-Capped Chickadee	-	-	-	-	-	1.9	V	V	V	-	-	-
Boreal Chickadee	-	-	-	-	-	-	V	1.4	1.5	V	V	0.5
Brown Creeper	-	-	-	-	-	1.1	-	-	1.0	-	-	-
American Robin	-	-	-	-	0.3	+	V	-	-	+	0.3	0.7
Varied Thrush	-	-	-	+	1.0	6.8	2.8	2.3	2.2	2.0	V	V
Hermit Thrush	-	-	-	-	2.0	V	5.1	1.9	V	-	-	-

TABLE W65

- MEAN NUMBER OF TERRITORIES OF EACH BIRD SPECIES ON 10-HA CENSUS PLOT, UPPER SUSITNA RIVER BASIN, ALASKA, IN 1981 AND 1982 (+ = SMALL PORTION OF A BREEDING TERRITORY ON CENSUS PLOT, COUNTED AS 0.1 IN DENSITY AND DIVERSITY CALCULATIONS; V = VISITOR TO PLOT) (Cont'd)

(Based on Kessel et al, 1982, and Kessel pers. comm.)

	HABITAT[1]											
Species	Mat and Cushion Tundra	Dwarf-Low Birch Shrub	Medium Birch Shrub	Low-Medium Willow Shrub	Tall Alder Shrub	Balsam Poplar Forest	Paper Birch Forest	White Spruce-Paper Birch (Mixed) Forest I	White Spruce-Paper Birch (Mixed) Forest II	Open White Spruce Forest	White Spruce Woodland	Black Spruce Woodland
Swainson's Thrush	-	-	-	-	+	4.7	3.3	4.8	7.0	3.5	V	V
Gray-Cheeked Thrush	-	-	-	-	-	3.4	V	V	-	V	2.6	2.5
Wheatear	V	-	-	-	-	-	-	-	-	-	1.0	-
Arctic Warbler	-	-	4.9	3.3	-	-	-	-	-	-	2.4	-
Ruby-Crowned Kinglet	-	-	-	-	-	V	V	3.1	2.4	4.2	1.2	2.9
Water Pipit	1.3	-	-	-	-	-	-	-	-	-	-	-
Bohemian Waxwing	-	-	-	-	-	-	-	-	-	-	-	V
Orange-Crowned Warbler	-	-	-	-	0.4	-	V	-	+	V	-	V
Yellow-Rumped Warbler	-	-	-	-	0.4	4.5	6.9	5.9	7.7	2.0	0.4	2.2
Blackpoll Warbler	-	-	-	-	-	3.5	3.5	1.3	0.3	+	1.0	1.2
Northern Waterthrush	-	-	-	-	-	4.2	+	1.9	+	V	-	-
Wilson's Warbler	-	-	5.8	6.6	1.8	2.0	2.9	3.8	0.2	V	6.6	-
Rusty Blackbird	-	-	-	-	-	-	-	-	-	-	-	V
Common Redpoll	V	V	V	0.7	V	1.3	1.0	1.0	1.5	0.5	0.3	0.8
Pine Grosbeak	-	-	-	-	-	-	V	-	V	V	-	-
Pine Siskin	-	-	-	-	-	-	V	-	-	V	-	-
White-Winged Crossbill	-	-	-	-	V	V	-	V	V	V	V	V
Savannah Sparrow	1.0	7.1	3.1	9.3	-	-	-	-	0.5	V	1.3	0.4

TABLE W65

- MEAN NUMBER OF TERRITORIES OF EACH BIRD SPECIES ON 10-HA CENSUS PLOT, UPPER SUSITNA RIVER BASIN, ALASKA, IN 1981 AND 1982 (+ = SMALL PORTION OF A BREEDING TERRITORY ON CENSUS PLOT, COUNTED AS 0.1 IN DENSITY AND DIVERSITY CALCULATIONS; V = VISITOR TO PLOT) (Cont'd)

(Based on Kessel et al, 1982, and Kessel pers. comm.)

	HABITAT[1]											
Species	Mat and Cushion Tundra	Dwarf-Low Birch Shrub	Medium Birch Shrub	Low-Medium Willow Shrub	Tall Alder Shrub	Balsam Poplar Forest	Paper Birch Forest	White Spruce-Paper Birch (Mixed) Forest I	White Spruce-Paper Birch (Mixed) Forest II	Open White Spruce Forest	White Spruce Woodland	Black Spruce Woodland
Dark-Eyed Junco	-	-	-	-	2.6	0.9	2.9	3.4	4.8	3.0	1.0	1.7
Tree Sparrow	-	2.7	9.8	11.3	0.8	-	-	-	-	-	5.8	2.1
White-Crowned Sparrow	-	0.2	3.1	3.6	+	2.5	-	-	-	-	5.5	2.3
Golden-Crowned Sparrow	-	-	-	0.4	-	-	-	-	-	-	-	-
Fox Sparrow	-	V	-	V	2.4	4.3	1.5	2.5	V	-	2.8	3.2
Lincoln's Sparrow	-	-	-	V	-	-	-	-	-	-	-	V
Lapland Longspur	1.0	0.7	-	-	-	-	-	-	-	-	-	-
Snow Bunting	0.1	-	-	-	-	-	-	-	-	-	-	-

[1]Habitat designations have been modified from Kessel et al (1982) by Kessel (pers. comm.) to coincide with habitat types described in Section 3.

TABLE W66

MEAN AVIAN HABITAT OCCUPANCY LEVELS, UPPER SUSITNA RIVER BASIN, BREEDING SEASON, 1981 AND 1982

(Based on Kessel et al, 1982 and Kessel, pers. comm.)

Avian Census Plot	No. species (No. breeding Species	Density (No. territories/ 10 ha)	Biomass[1] (Grams/ 10 ha)	Species Diversity (H')
Balsam Poplar Forest	19 (14.5)	43.0	2658	2.425
White Spruce-Paper Birch Mixed Forest II	18.5 (13)	30.6	1455	2.080
White Spruce-Paper Birch Mixed Forest I	15 (12.5)	34.1	1491	2.348
Paper Birch Forest[a]	14.5 (9.5)	29.8	1437	2.035
White Spruce Woodland	19 (12.5)	63.0	1297	2.120
Black Spruce Woodland	18 (12)	20.8	1019	2.280
Open White Spruce Forest	20.5 (10.5)	16.9	944	1.835
Tall Shrub	14 (9.5)	12.2	735	2.035
Low-Medium Willow Shrub	11 (7.5)	35.4	1140	1.680
Medium Birch Shrub	9 (5)	26.6	789	1.489
Dwarf-Low Birch Shrub[2]	11 (6)	11.5	408	1.100
Mat-cushion Tundra[2]	9 (65)	5.5	367	1.695

[1] Does not include grouse and ptarmigan
[2] Based on 25-ha plots; other plots were 10 ha

TABLE W67

RELATIVE ABUNDANCE OF BIRDS BY HABITAT AND VEGETATION SUCCESSION STAGE, LOWER SUSITNA RIVER FLOODPLAIN, 10-21 JUNE 1982. FIGURES ARE THE NUMBER OF BIRDS RECORDED PER 100 MINUTES IN EACH HABITAT

	Early Successional Stands			Mid-Successional Stands				Late Successional Stands		
Species	Alluvia	Dwarf & Low Shrub	Medium Shrub	Tall Willow Shrub	Tall Alder Shrub	Mixed Tall Shrub	Tall Alder-Immature Cottonwood	Cottonwood Forest	Mixed Paper Birch-Cottonwood-White Spruce Forest	Mixed Paper Birch-White Spruce Forest
Goldeneye sp.								0.3		
Semipalmated Plover	--------2.1---------------									
Spotted Sandpiper	--------13.0--------------									
Herring Gull	*									
Arctic Tern	--------4.2---------------									
Downy Woodpecker								0.3		
Hairy Woodpecker			1.5		0.9	0.6	1.4	0.6		
N. Three-toed Woodpecker										0.6
Alder Flycatcher				13.3	9.1	7.0	0.5	2.0	1.7	2.1
Black-capped Chickadee					0.4			2.5	1.7	
Brown Creeper										0.3
Varied Thrush					0.9	0.6	1.0	5.4	1.7	2.1
Gray-cheeked Thrush					4.6	8.2	2.9	7.1	8.3	1.7
Swainson's Thrush					0.4			3.7	5.0	7.4
American Robin				3.3	1.4			2.8	3.3	0.6
Ruby-crowned Kinglet									1.7	2.4
Bohemian Waxwing								1.1		0.3
Orange-crowned Warbler						1.9			3.3	
Yellow Warbler				3.3	1.8	1.9	7.3	0.3		
Yellow-rumped Warbler					3.2	1.3	3.9	6.2	18.3	13.3
Blackpoll Warbler				6.7	3.2	9.5	2.4	6.5	6.7	5.3
Northern Waterthrush			1.5		7.3	12.0	2.9	12.5	10.0	3.3
Wilson's Warbler						1.9		0.8	3.3	0.3
Common Redpoll					0.9	5.7		0.6		2.1
Fox Sparrow			1.5	3.3	4.1	1.9		4.3	3.3	1.5
White-crowned Sparrow			13.8		2.3	1.3	0.5	2.5	1.7	1.2
Dark-eyed Junco						0.6		1.7	1.7	2.1
Total number of species	4	+	4	5	14	14	9	19	15	17
		8			17				22	
No. minutes of censuses/habitat	127	+	65	30	219	158	206	352	60	338
		192			613				750	
Relative abundance/habitat	19.3	+	18.5	30.0	40.6	54.4	22.8	61.1	71.7	46.5
		25.5			37.5				51.5	

*Herring Gulls excluded from relative abundance calculations because of their clumped distribution in high-density breeding colonies.

TABLE W68

COMPARISON OF BREEDING BIRD DENSITIES, 1981 AND 1982, UPPER SUSITNA RIVER IN ALASKA

(Based on Kessel, pers. comm.)

Avian Census Plot	No. Breeding Species		Diversity (H')		Density (No. territories/ 10 ha)		
	1981	1982	1981	1982	1981	1982	Change[2] (%)
Balsam Poplar Forest	16	13	2.55	2.30	60.9	25.0	-58.9
White Spruce-Paper Birch (mixed) Forest II	13	13	2.07	2.09	34.6	26.6	-23.1
White Spruce-Paper Birch (mixed) Forest I	14	11	2.47	2.26	41.8	26.4	-36.8
Paper Birch Forest	10	9	2.05	2.02	38.1	21.4	-43.8
White Spruce Woodland	16	9	2.29	1.95	43.8	19.2	-56.2
Black Spruce Woodland	13	11	2.43	2.13	24.8	16.8	-32.3
Open White Spruce Forest	8	13	1.83	1.84	15.7	18.1	+15.3
Tall Shrub	10	9	2.05	2.02	12.5	11.8	-5.6
Low-Medium Willow Shrub	6	9	1.56	1.80	45.4	25.4	-44.1
Medium Birch Shrub	5	5	1.48	1.49	32.5	20.7	-36.3
Dwarf-Low Birch Shrub[1]	7	6	1.29	0.91	11.9	11.6	0
Mat-cushion Tundra[1]	10	7	1.73	1.66	4.8	6.2	+23.1

1 Based on 25-ha plot; other plots were 10 ha.
2 Overall number of territories on 150 ha of censused plots decreased 37.5 percent.

TABLE W69

- NUMBER OF SMALL MAMMALS CAPTURED PER 100 TRAP NIGHTS DURING FOUR SAMPLING PERIDS BETWEEN AUGUST 1980 AND AUGUST 1982, UPPER SUSITNA RIVER BASIN (Number of Captures are Given in Parentheses.)

(from S. O. MacDonald, pers. comm.)

Species	Captures per 100 Trap Nights (No. of Captures) Fall 1980	Spring 1981	Fall 1981	Fall 1982	Number of Captures All Trapping Periods	Percent of Total
Sorex cinereus	9.12 (361)	0.93 (39)	11.36 (847)	0.56 (42)	(1289)	34.6
S. monticolus	2.42 (96)	0	0.64 (48)	0.03 (2)	(146)	3.9
S. arcticus	2.98 (118)	0.07 (3)	2.31 (172)	0.13 (10)	(303)	8.1
S. hoyi	0.13 (5)	0	0.07 (5)	0	(10)	0.3
Clethrionomys rutilus	8.41 (333)	2.23 (93)	10.95 (816)	2.89 (216)	(1458)	39.1
Microtus pennsylvanicus	0.33 (13)	0	0.74 (55)	0.47 (35)	(103)	2.8
M. occonomus	0.61 (24)	0.05 (2)	2.12 (158)	0.53 (40)	(224)	6.0
M. miurus	0	0	0.91 (68)	1.07 (80)	(148)	4.0
Lemmus sibiricus	0	0.02 (1)	0.23 (17)	0.15 (11)	(29)	0.8
Synaptomys borealis	0	0	0.05 (4)	0.15 (11)	(15)	0.4
Total captures	24.00 (950)	3.30 (138)	29.38 (2 190)	5.98 (447)	(3725)	100.0
Number of trap nights	3960	4176	7455	7470		

TABLE W70

- STANDARDIZED HABITAT NICHE BREADTH VALUES FOR TEN SMALL MAMMAL SPECIES SAMPLED BY SNAP AND PITFALL TRAPPING AT 43 SITES, UPPER SUSITNA RIVER BASSIN, FALL 1981 (Niche Breadth Measures were Calculated Using Formula Employed by Krebvs and Wingate 1976)

(from Kessel et al 1982)

Species (d_1)	Standardized Habitat Niche Breadth Value[a]
Masked shrew (464.7)	0.60
Northern red-backed vole (454.8)	0.59
Dusky shrew (28.3)	0.45
Arctic shrew (96.3)	0.38
Brown lemming (10.2)	0.21
Tundra vole (87.7)	0.17
Northern bog lemming (2.2)	0.09
Meadow vole (43.8)	0.08
Pygmy shrew (2.8)	0.08
Singing vole (42.7)	0.05

[a]High values of B indicate that a species habitat niche includes a wide range of habitats whereas low values indicate that a species occurs in very few habitat types.

TABLE W71

LOSS OF EIGHT COVER TYPES COMMONLY USED BY MOOSE, IN RELATION TO THEIR AVAILABILITY. THE PROPORTIONATE SEASONAL USE OF EACH TYPE BY RADIO-COLLARED MOOSE IS ALSO SHOWN.

<table>
<tr><th rowspan="3">Forest Cover Type</th><th colspan="2">WATANA</th><th rowspan="3">Proportionate Loss[a]</th><th colspan="2">DEVIL CANYON</th><th rowspan="3">Proportionate Loss</th><th colspan="3">Proportion of Relocations[b]</th><th rowspan="3">N</th></tr>
<tr><th colspan="2">Area Affected (ha)</th><th colspan="2">Area Affected (ha)</th><th rowspan="2">Spring</th><th rowspan="2">Summer-Fall</th><th rowspan="2">Winter</th></tr>
<tr><th>Impoundment</th><th>Construction</th><th>Impoundment</th><th>Construction</th></tr>
<tr><td>Moderate to dense spruce forest</td><td>4267</td><td>567</td><td>0.03</td><td>153</td><td>0</td><td>0.06</td><td>0.56[c]</td><td>0.43</td><td>0.40</td><td>791</td></tr>
<tr><td>Sparse spruce forest</td><td>3633</td><td>75</td><td>0.03</td><td>629</td><td>15</td><td>0.17</td><td>0.29[c]</td><td>0.28</td><td>0.30</td><td>504</td></tr>
<tr><td>Birch forest</td><td>785</td><td>19</td><td>0.62</td><td>487</td><td>3</td><td>-[d]</td><td><0.01</td><td><0.01</td><td><0.01</td><td>7</td></tr>
<tr><td>Mixed forest</td><td>2099</td><td>207</td><td>0.29</td><td>1506</td><td>162</td><td>0.04</td><td>-[d]</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Tall shrub</td><td>514</td><td>37</td><td><0.01</td><td>3</td><td>0</td><td><0.01</td><td rowspan="4">0.14</td><td rowspan="4">0.29</td><td rowspan="4">0.29</td><td rowspan="4">445</td></tr>
<tr><td>Birch shrub</td><td>443</td><td>288</td><td>0.04</td><td>49</td><td>18</td><td><0.01</td></tr>
<tr><td>Willow - low shrub</td><td>717</td><td>283</td><td><0.01</td><td>18</td><td>0</td><td><0.01</td></tr>
<tr><td>Tundra</td><td>84</td><td>78</td><td><0.01</td><td>11</td><td>0</td><td><0.01</td></tr>
</table>

[a] Proportionate loss is expressed as the amount of the cover type lost (ha) in relation to its total coverage (ha) in the respective watershed. (See Section 3.3 - Botanical Resources for a description of the watershed and area estimates of the forest cover types.)

[b] Proportion of moose relocations in that habitat during April-May, June-October, and November-March, respectively.

[c] Ballard et al. (1982) included mixed forest communities in their spruce forest classifications and therefore moose use in mixed forest cover types cannot be separately estimated.

[d] Vegetation in areas beyond the impoundment and construction zones was mapped at a scale too small to adequately assess the availability of this cover type.

TABLE W72

NUMBER OF LAKES WITH MUSKRAT PUSHUPS IN SPRING 1980 OCCURRING WITHIN BORROW AREAS AND IMPOUNDMENTS

	Lakes Sampled	With Pushups	Pushups
Watana			
Borrow Areas	20	5	16
Impoundment	9	5	13
Devil Canyon			
Borrow Areas	5	0	0
Impoundment	0	0	0

TABLE W73

GENERAL TYPES OF IMPACTS TO RAPTORS

(From Roseneau et al, 1981)

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
- may strike wires, fences, etc.
- 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, petrochemicals, 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

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.

Habitat Loss

Abandonment of area due to destruction of nest, perch or important hunting habitat

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TABLE W74

NUMBER OF KNOWN RAPTOR OR RAVEN NEST SITES IN THE UPPER SUSITNA RIVER BASIN, ALASKA, THAT WOULD BE INUNDATED BY THE WATANA AND DEVIL CANYON RESERVOIRS, OR THAT MAY BE AFFECTED BY DEVELOPMENT OF ASSOCIATED ACCESS ROUTES AND TRANSMISSION ROUTES

			WATANA							
			Nests That Will be Flooded or Destroyed by Impoundment Borrow Sites and Campsites			Nests That May be Affected by Access and Transmission Routes			Total Nests That May be Affected by Overall Project	
Species	Total No. of Recently Active Nesting Locations (1980 - 1982)	Total No. of Inactive Nesting Locations	Recently Active Nesting Locations	Inactive Nesting Locations	(Percent of Total)	Recently Active Nesting Locations	Inactive Nesting Locations	(Percent of Total)	Total No.	(Percent of Total)
Cliff-nesting locations										
Golden Eagle	9	7[a]	4[b]	2[c]	(38)	0	[1][d]	[6]	6	(38)
Bald Eagle[e]	1	0	1	0	(100)	0	0	(0)	1	(100)
Gyrfalcon	2[f]	1	0	0	(0)	0	0	(0)	0	(0)
Common Raven	4	17[h]	1	8[i] - 9[j]	(43 - 48)	1	0	(5)	10 - 11[j]	(48 - 52)
Total cliff-nesting locations	16	25	6	9 - 10	(37 - 39)	1	1	(5)	17 - 18	(41 - 44)
Tree-nesting locations										
Bald Eagle[e]	5	2	3[k]	0	(43)	1	0	(14)	4	(57)
Goshawk	2	1	1	1[L]	(66)	0	0	(0)	2	(66)
Total tree-nesting locations	7	3	4	0	(40)	1	0	(10)	5	(50)

[a]Does not include two nesting locations reported by White (1974), but not relocated in 1980 - 1981--these two locations (GE-6 and GE-12) may have been mislocated on White's original map, and may represent two of the total seven confirmed inactive golden eagle nesting locations rather than representing two additional nesting locations.

[b]Includes one nesting location (GE-8) that will be inundated, and that is also approximately 0.1 km north of Borrow Site J.

[c]Includes one nesting location (GE-9) that will be inundated, and that is also approximately 0.1 km north of Borrow Site J, and one location (GE-11) within Borrow Site E (see Table W75).

[d]Repeats location GE-11, and thus not included in total number and percentage of total.

[e]Combined cliff and tree-nesting locations for bald eagles are 6, 2, 4, 0, (50), 1, 0, (13), 5, (63), 0, 0, (0), 1, 0, (13), 1, (13), 4, (50), 2, (25), 6 and (75), respectively.

[f]Includes one nesting location occupied by gyrfalcons in 1974 (White, 1974), and occupied in 1980 by an unknown species (probably gyrfalcons).

[g]Includes one gyrfalcon nesting location where young were found in 1974 (White, 1974) that was not relocated in 1980 - 1981.

[h]Includes six confirmed active and six unconfirmed active raven nests reported in 1974 (White, 1974).

[i]Includes three raven nesting locations that will be inundated, and that are also within 0.5 km of Borrow Site J (see note b above).

[j]Includes one raven nesting location reported by White (1974) that may be as low as about 2,000 ft, or as high as about 2,550 ft (and thus not inundated).

[k]Includes one bald eagle nesting location (BE-2) that is very near maximum operating level (2,185 ft)--this location is assumed lost as a result of shoreline erosion.

[L]This nesting location is only 0.2 km from Borrow Site I and is likely to be affected by Watana development, but it will also be inundated at a later date by the Devil Canyon reservoir if Devil Canyon development occurs.

TABLE W74 - Page 2

NUMBER OF KNOWN RAPTOR OR RAVEN NEST SITES IN THE UPPER SUSITNA RIVER BASIN, ALASKA, THAT WOULD BE INUNDATED BY THE WATANA AND DEVIL CANYON RESERVOIRS, OR THAT MAY BE AFFECTED BY DEVELOPMENT OF ASSOCIATED ACCESS ROUTES AND TRANSMISSION ROUTES

			DEVIL CANYON							
			Nests That Will be Flooded or Destroyed by Impoundment Borrow Sites and Campsites			Nests That May be Affected by Access and Transmission Routes			Total Nests That May be Affected by Overall Project	
Species	Total No. of Recently Active Nesting Locations (1980 - 1982)	Total No. of Inactive Nesting Locations	Recently Active Nesting Locations	Inactive Nesting Locations	(Percent of Total)	Recently Active Nesting Locations	Inactive Nesting Locations	(Percent of Total)	Total No.	(Percent of Total)
Cliff-nesting locations										
Golden Eagle	9	7[a]	0	1 - 2	(6 - 12)	1	0	(6)	2 - 3	(12 - 18)
Bald Eagle[e]	1	0	0	0	(0)	0	0	(0)	0	(0)
Gyrfalcon	2[f]	1	0	1	(33)	1	1[g]	(33 - 66)	2[g]	(33 - 66)
Common Raven	4	17[h]	0	4	(19)	0	0	(0)	4	(19)
Total cliff-nesting locations	16	25	0	5	(12)	2	1	(7)	8	(20)
Tree-nesting locations										
Bald Eagle[e]	5	2	0	0	(0)	1	0	(14)	1	(14)
Goshawk	2	1	0	0[L]	(0)[L]	0	0	(0)[L]	0[L]	(0)[L]
Total tree-nesting locations	7	3	1	0	(10)	1	0	(10)	2	(20)

Species	Total No. of Recently Active Nesting Locations (1980 - 1982)	Total No. of Inactive Nesting Locations	Total Nests That Would be Flooded by Watana and Devil Canyon or Affected by Impoundment Borrow Sites: Total No.	(Percent of Total)	Total Nests That May be Affected by Watana and Devil Canyon Access and Transmission Routes: Total No.	(Percent of Total)	Total Nests That May be Potentially Affected by Watana and Devil Canyon Projects: Total No.	(Percent of Total)
Cliff-nesting locations								
Golden Eagle	9	7[a]	7 - 8[a]	(44 - 50)	[2][d]	(12)	8 - 9[a]	(51 - 56)
Bald Eagle[e]	1	0	1	(100)	0	(0)	1	(100)
Gyrfalcon	2[f]	1	1	(33)	2[g]	(33 - 66)	2[g]	(33 - 66)
Common Raven	4	17[h]	13 - 14[j]	(62 - 67)	1	(5)	14 - 15[j]	(67 - 72)
Total cliff-nesting locations	16	25	21 - 22	(51 - 54)	5	(12)	26 - 27	(63 - 66)
Tree-nesting locations								
Bald Eagle[e]	5	2	3	(43)	2	(29)	5	(71)
Goshawk	2	1	2	(66)	0	(0)	2	(66)
Total tree-nesting locations	7	3	5	(50)	2	(20)	7	(70)

TABLE W75

RAPTOR AND RAVEN NESTING LOCATIONS IN THE UPPER SUSITNA BASIN, ALASKA, THAT MAY BE AFFECTED BY THE SUSITNA HYDROELECTRIC PROJECT DEVELOPMENT

Nesting Location Number	Estimated[a] Elevation [m (ft)]	Project Action	Potential Effects
GE-2	610 - 655 (2 000 - 2 150)	Filling Watana Reservoir	Inundation
GE-4	564 (1 850)	Filling Watana Reservoir	Inundation
GE-5	549 (1 800)	Filling Watana Reservoir	Inundation
[GE-6]	[<579 (<1 900)]	[Filling Watana Reservoir]	[Inundation; however, GE-6 may correspond to nearby GE-5. The elevation of this nesting location is unclear. White (1974) marked this nesting location at a place where suitable nesting habitat does not appear to occur.]
GE-8	490 - 518 (1 600 - 1 700)	Watana Borrow Site J	Watana Borrow Site J is located within 0.1 km of GE-8 and considerable disturbance may result from material excavation during construction of the dam and prior to inundation as the reservoir is filled.
		Filling Watana Reservoir	Inundation (see potential effect of Watana Borrow Site J)
GE-9	490 - 518 (1 600 - 1 700)	Watana Borrow Site J	Watana Borrow Site J is located within 0.1 km of GE-9 and considerable disturbance may result from material excavation prior to the filling of the reservoir and flooding of this nesting location.
		Filling Watana Reservoir	Inundation

TABLE W76

RAPTOR AND RAVEN NESTING LOCATIONS IN THE UPPER SUSITNA BASIN, ALASKA, THAT MAY BE AFFECTED BY THE SUSITNA HYDROELECTRIC PROJECT DEVELOPMENT (Cont'd)

Nesting Location Number	Estimated[a] Elevation [m (ft)]	Project Action	Potential Effects
GE-10	1 189 (3 900)	Watana Borrow Site F	Minimal disturbance is anticipated although GE-10 lies within 1.2 km of Watana Borrow Site F. The elevation and location of the nest on the opposite side of Tsusena Butte from the borrow site will probably minimize any direct influence that excavation and/or transport of materials may have.
		Denali-Watana Access Road	Minimal disturbance is anticipated since the road lies 1.9 km to the northeast.
GE-11	490 - 518 (1 600 - 1 700)	Watana Borrow Site E	Nesting location will be physically destroyed as it lies within Watana Borrow Site E.
		Transmission Corridor	Some disturbance may result from activities associated with the installation and maintenance of the power transmission line about 0.1 km from GE-11.
[GE-12]	[<549? (<1 800?)]	[Filling Devil Canyon Reservoir]	[Inundation; however, GE-12 may correspond to nearby GE-13. White (1974) marked this nesting location at a place where suitable nesting habitat does not appear to occur.]
GE-13	427 - 442 (1 400 - 1 450)	Filling Devil Canyon Reservoir	Inundation

TABLE W76

RAPTOR AND RAVEN NESTING LOCATIONS IN THE UPPER SUSITNA BASIN, ALASKA, THAT MAY BE AFFECTED BY THE SUSITNA HYDROELECTRIC PROJECT DEVELOPMENT (Cont'd)

Nesting Location Number	Estimated[a] Elevation [m (ft)]	Project Action	Potential Effects
GE-14	427 - 457? (1 400 - 1 500?)	Transmission Corridor	The power transmission line is routed about 0.4 km from GE-14 and some disturbance may result from activities associated with its installation and maintenance.
		Filling Devil Canyon Reservoir	Possible inundation. The elevation of this nest site is unclear. White (1974) marked this nesting location at a place where suitable nesting habitat does not appear to occur. GE-14 may have been located on one of two small cliff areas 1.4 or 2.0 km further downstream.
GE-17	610 - 625 (2 000 - 2 050)	Transmission Corridor	Minimal disturbance is expected since the corridor is 1.5 km north of GE-17.
GE-18	335 (1 100)	Watana-Devil Canyon Access Road and Bridge	The access road route is 0.2 km from and near the top of the cliff on which GE-18 is located and the access road bridge crosses the river 0.9 km downstream from the nest location. Considerable disturbance may result from these nearby construction activities.
		Devil Canyon Dam Construction	The Devil Canyon damsite is 0.9 km upstream from GE-18 and the construction and maintenance may result in considerable disturbance.

TABLE W76

RAPTOR AND RAVEN NESTING LOCATIONS IN THE UPPER SUSITNA BASIN, ALASKA, THAT MAY BE AFFECTED BY THE SUSITNA HYDROELECTRIC PROJECT DEVELOPMENT (Cont'd)

Nesting Location Number	Estimated[a] Elevation [m (ft)]	Project Action	Potential Effects
BE-2	663 - 671 (2 175 - 2 200)	Filling Watana Reservoir	Possible inundation. BE-2 lies near the limit of the impoundment flooding and the estimated elevation span of this nesting location extends slightly above and below the 2,185-ft maximum operating level of the Watana reservoir.
BE-3	579 (1 900)	Filling Watana Reservoir	Inundation
BE-4	540 - 549 (1 775 - 1 800)	Filling Watana Reservoir	Inundation
BE-5	497 - 503 (1 630 - 1 650)	Filling Watana Reservoir	Inundation
BE-6	760 (2 500)	Denali-Watana Access Road and Borrow Pits	This nesting location lies within one of the access road borrow pits and directly in the path of the access road which will result in the destruction of this nesting location.
BE-8	230 (750)	Devil Canyon Railroad	Devil Canyon railroad is 0.5 km from this nesting location and construction and operation activities may result in considerable disturbance.
GYR-2	587 (1 925)	Transmission Corridor	The power transmission line route lies 0.5 km to the north of GYR-2 and some disturbance may result from installation and maintenance-related activities.

TABLE W76

RAPTOR AND RAVEN NESTING LOCATIONS IN THE UPPER SUSITNA BASIN, ALASKA, THAT MAY BE AFFECTED BY THE SUSITNA HYDROELECTRIC PROJECT DEVELOPMENT (Cont'd)

Nesting Location Number	Estimated[a] Elevation [m (ft)]	Project Action	Potential Effects
GYR-3	579 - 610? (1 900 - 2 000?)	Devil Canyon Quarry Site K	GYR-3 may lie within this quarry site and material excavation could result in the destruction of this nesting location.
		Transmission Corridor	The power transmission corridor lies about 0.6 km to the south of GYR-3 and some disturbance may result from the installation and maintenance activities associated with the power lines.
GOS-1	518 (1 700)	Filling Watana Reservoir	Inundation
GOS-2	442 (1 450)	Watana Borrow Site I	This material site is 0.2 km to the west of GOS-2 and considerable disturbance may result from excavation and transport of materials from this site prior to filling the reservoir and flooding of the nesting location.
		Filling Devil Canyon Reservoir	Inundation (see potential effect of Watana Borrow Site I)
GOS-3	549 (1 800)	Watana-Devil Canyon Access Road Borrow Pit	The borrow pit for the access road is 1.0 km west of GOS-3 but minimal disturbance is anticipated.
		Transmission Corridor	The transmission corridor lies 1.1 km south of GOS-3 but minimal disturbance is anticipated.

TABLE W76

RAPTOR AND RAVEN NESTING LOCATIONS IN THE UPPER SUSITNA BASIN, ALASKA, THAT MAY BE AFFECTED BY THE SUSITNA HYDROELECTRIC PROJECT DEVELOPMENT (Cont'd)

Nesting Location Number	Estimated[a] Elevation [m (ft)]	Project Action	Potential Effects
R-3	641 (2 100)	Filling Watana Reservoir	Inundation
R-4	610 - 778 (2 000 - 2 550)	Filling Watana Reservoir	Possible inundation. The elevation of R-4 is unclear. White (1974) marked the general location of R-4 in the vicinity of two small cliff areas on the north bank of the Susitna River. The nest was not found in 1980 or 1981 but is estimated to be within the indicated elevations and potentially flooded by the 2,002-ft maximum flood level of the Watana reservoir.
R-5	641 (2 100)	Filling Watana Reservoir	Inundation
R-6	610 (2 000)	Filling Watana Reservoir	Inundation
R-7	534 - 549 (1 750 - 1 800)	Filling Watana Reservoir	Inundation
R-8	519 (1 700)	Filling Watana Reservoir	Inundation
R-9	488 (1 600)	Watana Borrow Site J	Material excavation from Watana Borrow Site J for dam construction will occur within the river basin as close as 0.2 km to R-9. Considerable disturbance may result from these activities prior to the filling of the reservoir and eventual flooding of this nesting location.
		Filling Watana Reservoir	Inundation (see potential effect of Watana Borrow Site J)

TABLE W76

RAPTOR AND RAVEN NESTING LOCATIONS IN THE UPPER SUSITNA BASIN, ALASKA, THAT MAY BE AFFECTED BY THE SUSITNA HYDROELECTRIC PROJECT DEVELOPMENT (Cont'd)

Nesting Location Number	Estimated[a] Elevation [m (ft)]	Project Action	Potential Effects
R-10	488 (1 600)	Watana Borrow Site J	Watana Borrow Site J is 0.1 km from R-10 and considerable disturbance may result from excavation and transport of materials from this material site prior to the filling of the reservoir and eventual flooding of this nesting location.
		Filling Watana Reservoir	Inundation (see potential effect of Watana Borrow Site J)
R-11	564 (1 850)	Watana Borrow Site J	Watana Borrow Site J is 0.1 km from R-11 and considerable disturbance may result from excavation and transport of materials from this material site prior to the filling of Watana reservoir and eventual flooding of this nesting location.
		Filling Watana Reservoir	Inundation (see potential effect of Watana Borrow Site J)
R-12	625 (2 050)	Watana Camp	The camp is 1.4 km west of R-12. Minimal disturbance is anticipated as a result of construction or use of the camp.
		Denali-Watana Access Road	The access road is 1.9 km west of R-12. Little or no disturbance is anticipated as a result of the proximity of the access road.
		Filling Watana Reservoir	Inundation

TABLE W76

RAPTOR AND RAVEN NESTING LOCATIONS IN THE UPPER SUSITNA BASIN, ALASKA, THAT MAY BE AFFECTED BY THE SUSITNA HYDROELECTRIC PROJECT DEVELOPMENT (Cont'd)

Nesting Location Number	Estimated[a] Elevation [m (ft)]	Project Action	Potential Effects
R-13	549 (1 800)	Watana Camp) Denali-Watana Access Road and Borrow Pit) Watana Damsite)	R-13 lies within 1.9 to 2.8 km of the camp, access road borrow pit and Watana damsite; however, little disturbance is anticipated.
R-14	549 - 580 (1 800 - 1 900)	Watana Borrow Site H	This borrow site is 0.8 km from R-14 and some disturbance may result from excavation and transportation of materials from this site.
R-15	519 - 580 (1 700 - 1 900)	Watana Borrow Site H	This borrow site is 0.2 km from R-15 and considerable disturbance may result from excavation and transportation of materials from this site.
R-16	442 (1 450)	Filling Devil Canyon Reservoir	Inundation
R-17	442 (1 450)	Filling Devil Canyon Reservoir	Inundation
R-18	427 (1 400)	Filling Devil Canyon Reservoir	Inundation
R-20	366 (1 200)	Filling Devil Canyon Reservoir	Inundation
R-21	427 (1 400)	Devil Canyon Dam Construction	The damsite is 0.7 km upstream from R-21 and considerable disturbance may result from construction-related activities associated with the dam.

TABLE W76

RAPTOR AND RAVEN NESTING LOCATIONS IN THE UPPER SUSITNA BASIN, ALASKA, THAT MAY BE AFFECTED BY THE SUSITNA HYDROELECTRIC PROJECT DEVELOPMENT (Cont'd)

Nesting Location Number	Estimated[a] Elevation [m (ft)]	Project Action	Potential Effects
		Watana-Devil Canyon Access Road	This road is 0.2 km from R-21 and lies near the top of the cliff on which R-21 was indicated by White (1974). Considerable disturbance may result from the construction and/or use of this road.

[a] Differences occur between elevations given here and those reported by Kessel et al (1982). Original estimates were obtained by attempting to locate nests as accurately as possible on USGS 1:63 360 maps with contour intervals if 100 ft (majority) or 50 ft (Talkeetna Mountains C-1), but it was often difficult to precisely locate nests and to locate them relative to tightly-spaced contour intervals (Cooper pers. comm., 1982). All elevations have been reviewed and some revisions were made; however, in some cases, estimates given here may contain errors of as much as 100 ft. All elevations must be considered approximate (unless otherwise noted) until the majority are rechecked with an altimeter (hand-held or helicopter).

TABLE W77

LINEAR DISTANCES OF CLIFFS IN VICINITY OF PROPOSED IMPOUNDMENTS, AND DISTANCES THAT WOULD BE INUNDATED, SUSITNA HYDROELECTRIC PROJECT

	Type of Cliff[1]	Length Inundated (km)	Length Remaining >15 m Above Waterline (km)
Watana Reservoir			
	A	15.1	0.9
	B	5.1	0.0
	C	1.6	0.3
Devil Canyon Reservoir			
	A	27.4	24.9
	B	8.3	7.9
	C	2.4	1.6

[1] Cliffs were ranked as follows.
A - "Good potential raptor cliffs" (solid subsrate generally, currently used by nesting raptors).
B - Fair or moderate potential for nesting (less solid and less massive subsrates generally, not currently used by nesting raptors.
C - Poor potential for nesting, less desirable, loose soil or gravel cutbanks, or very low rock, not currently used, nor likely to be used by nesting raptors.

TABLE W78

FACTORS THAT AFFECT THE SENSITIVITY OF RAPTORS TO DISTURBANCES

(From Roseneau et al, 1981)

Characteristics of the Disturbance

- type of disturbance
- severity (speed, loudness, suddenness, persistence, etc.)
- frequency of occurrence

Characteristics of the Bird

- the individual (individual differences in response)
- sex
- age
- 'mood' (a factor of recent activities, weather)
- territorial status (breeder, territorial non-breeder, or non-territorial floater)
- stage of annual life cycle (winter, migration, courtship, egg-laying, rearing young, etc.)
- occurrence of other disturbances or natural stresses at the same time
- previous experience with this type of disturbance (habituation may occur)

Topography

- nearness of disturbance to raptor or nest
- relative elevations (is nest or raptor above or below the disturbance? by what distance?)
- presence of screening features (trees, intervening hill)
- direction faced by nest relative to sun, wind, disturbance
- type of nest (exposed ledge, overhung ledge, cave)
- distance of nest above foot of cliff and below lip of cliff (i.e., 'security' of nest)

Time of Day

Weather at Time of Disturbance

Potential Predators Nearby

Type of Prey Utilized by the Bird (species, location, abundance)

TABLE W78a

PROPORTIONATE HABITAT LOSS FOR BIRDS

Habitat Type	Area Affected (ha)					
	Watana Impoundment	Watana Construction	Percent of Upper Susitna Basin[1]	Devil Canyon Impoundment	Devil Canyon Construction	Percent of Upper Basin[2] (Watana and Devil Canyon
Woodland spruce forest	4 267	567	2.6	153	0	2.7
Open spruce forest	3 633	75	3.1	629	15	3.7
Birch forest	785	19	62.3	487	3	100.0
Mixed forest	2 099	207	5.8	1 006	162	8.8
Tall shrub	514	37	0.4	3	0	0.4
Birch shrub	443	290	2.2	49	18	2.4
Willow and mixed low shrub	717	323	0.2	18	0	0.2
Sedge tundra habitat	84	8	<0.1	11	0	<0.1
Mat and cushion tundra	0	70	0.1	0	0	0.1

[1]Percent loss is expressed as proportion lost over proportion of total availability of that habitat.
[2]Some stands of birch forest in the upper basin will be unaffected, but are too small to be mapped as a separate cover.

TABLE W79

INFLUENCE OF TIMING OF DISTURBANCE ON THE POSSIBLE EFFECTS ON RAPTORS

(From Roseneau et al, 1981)

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 phase	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

TABLE W79a

ESTIMATED NUMBER OF BREEDING PAIRS OF SMALL AND MEDIUM-SIZED UPLAND BIRDS THAT WILL BE ELIMINATED BY THE SUSITNA HYDROELECTRIC PROJECT[1]

(Based on Kessel et al, 1982, and Kessel pers. comm.)

Species	Watana Impoundment 1981	Watana Impoundment 1982	Watana Construction 1981	Watana Construction 1982	Watana Total 1981	Watana Total 1982	Devil Canyon Impoundment 1981	Devil Canyon Impoundment 1982	Devil Canyon Construction 1981	Devil Canyon Construction 1982	Devil Canyon Total 1981	Devil Canyon Total 1982	Access 1981	Access 1982	Grand Total 1981	Grand Total 1982
Goshawk		36		2		38		6		<1		6		1		45
Spruce grouse	209	96	22	8	231	104	101	36		5	101	411	39	10	371	155
Ruffed grouse	36		2		38		6		19		25			1	63	1
Willow ptarmigan	11	9	9	5	20	14		<1	1	<1	1		4	1	25	15
Rock ptarmigan	16		13		29				1		1		5		35	
White-tailed ptarmigan			1		1										1	
Lesser golden plover				4		4								1		1
Greater yellowlegs	4	4	1	1	5	5		<1				<1			5	5
Common snipe	407	27	50	10	457	37	14	1			14	1	1	2	472	40
Baird's sandpiper			6	14	6	14							2	2	8	16
Hairy woodpecker	105	<1	11		116	<1	52	1	10		62	1	22	3	200	4
Downy woodpecker							1	1			1	1	1	1	2	2
N. 3-toed woodpecker	395	182	24	11	419	193	78	31	4	1	82	32	13	4	514	229
Alder flycatcher							1				1		3		4	
Olive-sided flycatcher		36		2		38		6		<1		6		1		45
Horned lark		7	2	10	2	17		1		<1		1	1	4	3	22
Gray jay	473	914	37	30	510	944	113	122	11	18	124	140	34	38	668	1 122
Black-capped chickadee		1				1	3	3			3	3	5	5	8	9
Boreal chickadee	669	313	72	33	741	346	270	151	26	29	296	180	53	58	1 090	584
Brown creeper	105	104	11	11	116	115	149	50	10	10	159	60	24	20	299	195
American robin	26	390	30	41	56	431	8	18			8	18	4	3	68	452
Varied thrush	2 014	867	137	63	2 151	930	646	316	61	31	707	347	176	78	3 034	1 355
Hermit thrush	988	407	61	14	1 049	421	489	196	38	1	527	197	100	13	1 676	631
Swainson's thrush	2 921	2 487	219	185	3 140	2 672	952	762	135	94	1 087	856	307	212	4 534	3 740
Gray-cheeked thrush	1 123	1 020	161	125	1 284	1 145	235	40			235	40	16	11	1 535	1 196
Arctic warbler	475	405	244	217	719	622	24	22	4	5	28	27	63	59	810	708
Ruby-crowned kinglet	3 554	2 934	317	256	3 871	3 190	535	617	48	70	583	687	118	161	4 572	4 038
Water pipit			4	14	4	14							1	5	5	19
Orange-crowned warbler		51		4		55		5		1		6		2		63
Yellow-rumped warbler	3 907	3 196	342	260	4 249	3 456	1 440	918	168	103	1 608	1 021	374	224	6 231	4 701

TABLE W79a

ESTIMATED NUMBER OF BREEDING PAIRS OF SMALL AND MEDIUM-SIZED UPLAND BIRDS THAT WILL BE ELIMINATED BY THE SUSITNA HYDROELECTRIC PROJECT[1] (Cont'd)

(Based on Kessel et al, 1982, and Kessel pers. comm.)

Species	Watana Impoundment 1981	Watana Impoundment 1982	Watana Construction 1981	Watana Construction 1982	Watana Total 1981	Watana Total 1982	Devil Canyon Impoundment 1981	Devil Canyon Impoundment 1982	Devil Canyon Construction 1981	Devil Canyon Construction 1982	Devil Canyon Total 1981	Devil Canyon Total 1982	Access 1981	Access 1982	Grand Total 1981	Grand Total 1982
Blackpoll warbler	1 207	666	125	51	1 332	717	336	207	23	9	359	216	66	23	1 757	956
Northern waterthrush	271	147	27	15	298	162	139	74	24	13	163	87	64	33	525	282
Wilson's warbler	2 006	1 124	646	280	2 652	1 404	450	291	48	35	498	326	240	117	3 390	1 847
Common redpoll	1 194	557	157	43	1 351	600	370	70	50	2	420	72	119	8	1 890	680
Savannah sparrow	1 486	849	473	438	1 959	1 287	60	92	8	20	68	112	155	148	2 182	1 547
Dark-eyed junco	2 970	3 004	435	233	3 405	3 237	736	793	85	81	821	874	214	194	4 440	4 305
Tree sparrow	2 789	1 507	977	560	3 766	2 067	130	67	13	10	143	77	230	136	4 139	2 280
White-crowned sparrow	1 602	1 241	403	295	2 005	1 536	69	49	4	2	73	51	76	43	2 154	1 630
Golden-crowned sparrow		57		26		83		1				1		6		90
Fox sparrow	1 621	2 064	201	229	1 822	2 293	197	306	19	29	216	335	68	76	2 106	2 704
Lapland longspur	18	11	22	16	40	27	2	1	1	<1	3	1	8	6	51	34
Snow bunting			1		1								1		2	
TOTAL	32 602	24 713	5 243	3 506	37 845	28 219	7 606	5 254	811	569	8 417	5 823	2 607	1 710	48 869	35 752

[1]Estimates were made by extrapolating by habitat the number of breeding pairs per census plot to the area affected by various project components.

TABLE W80

ESTIMATED PERCENTAGE LOSS OF BREEDING PAIRS OF SMALL- AND MEDIUM-SIZED UPLAND BIRDS FROM VARIOUS ASPECTS OF THE SUSITNA HYDROELECTRIC PROJECT[1]

Species	Watana Impoundment	Watana Construction Zone	Watana Total	Devil Canyon Impoundment	Devil Canyon Construction Zone	Access Route	Total
Goshawk	3.0	0.2	3.2	0.5	<0.1	0.6	4.3
Spruce grouse	5.3	0.6	5.9	2.6		1.0	9.5
Ruffed grouse	3.0	0.1	3.1	0.5	1.6		5.2
Willow ptarmigan	1.3	1.0	2.3		0.1	0.5	2.9
Rock ptarmigan	1.4	1.1	2.5		0.1	0.4	3.0
White-tailed ptarmigan							
Lesser golden plover		0.1	0.1			<0.1	0.1
Greater yellowlegs	0.4	0.1	0.5			<0.1	0.5
Common snipe	2.2	0.3	2.5	0.1		<0.1	2.6
Baird's sandpiper		0.1	0.1				0.1
Hairy woodpecker	5.3	0.6	5.9	2.6	0.5	1.1	10.1
Downy woodpecker							
N. 3-toed woodpecker	3.2	0.2	3.4	0.6	<0.1	0.1	4.1
Alder flycatcher							
Olive-sided flycatcher	3.0	0.2	3.2	0.5	<0.1		3.7
Horned lark		0.1	0.1			0.1	0.2
Gray jay	1.7	0.1	1.8	0.4	<0.1	0.1	2.3
Black-capped chickadee							
Boreal chickadee	4.5	0.5	5.0	1.8	0.2	0.4	7.4
Brown creeper	5.3	0.6	5.9	7.8	0.5	1.2	19.9
American robin	0.2	0.2	0.4	<0.1		<0.1	0.5
Varied thrush	3.1	0.2	3.3	1.0	0.1	0.2	4.6
Hermit thrush	2.7	0.2	2.9	1.3	0.1	0.3	4.6
Swainson's thrush	4.7	0.3	5.0	1.5	0.2	0.5	7.2
Gray-cheeked thrush	1.9	0.3	2.2	0.4		<0.1	2.6
Arctic warbler	0.2	0.1	0.3	<0.1	<0.1	<0.1	0.4
Ruby-crowned kinglet	3.4	0.3	3.7	0.5	<0.1	0.1	4.3
Water pipit		0.1	0.1			<0.1	0.1
Orange-crowned warbler	0.5	<0.1	0.5		<0.1	<0.1	0.6
Yellow-rumped warbler	5.0	0.4	5.4	1.9	0.2	0.5	8.0

TABLE W80

ESTIMATED PERCENTAGE LOSS OF BREEDING PAIRS OF SMALL- AND MEDIUM-SIZED UPLAND BIRDS FROM VARIOUS ASPECTS OF THE SUSITNA HYDROELECTRIC PROJECT[1] (Cont'd)

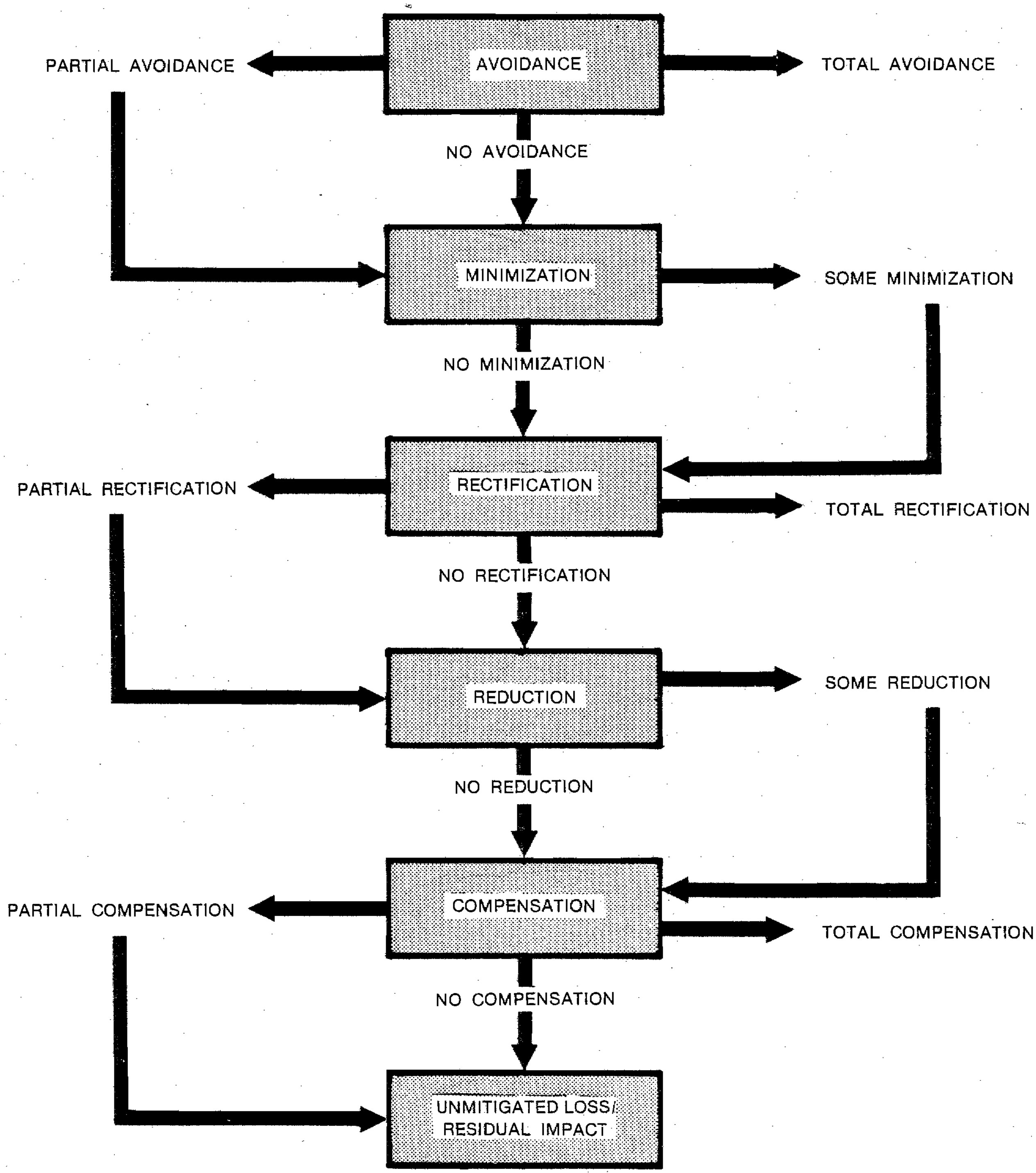
	Watana			Devil's Canyon			
Species	Impoundment	Construction Zone	Total	Impoundment	Construction Zone	Access Route	Total
Blackpoll warbler	3.2	0.3	3.5	1.0	0.1	0.2	4.8
Northern waterthrush	5.5	0.5	6.0	2.8	0.5	1.3	11.6
Wilson's warbler	0.4	0.1	0.5	<0.1	<0.1	<0.1	0.6
Common redpoll	1.2	0.1	1.3	0.4	0.1	0.1	1.9
Savannah sparrow	0.2	<0.1	0.2	<0.1	<0.1	<0.1	0.4
Dark-eyed junco	2.5	0.4	2.9	0.6	0.1	0.2	3.8
Tree sparrow	0.3	0.1	0.4	<0.1	<0.1	<0.1	0.5
White-crowned sparrow	1.7	0.4	2.1	0.1	<0.1	<0.1	2.3
Golden-crowned sparrow	<0.1	<0.1	<0.1		<0.1	<0.1	0.2
Fox sparrow	6.6	0.8	7.4	0.8	0.1	0.3	8.6
Lapland longspur	0.2	0.3	0.5	<0.1	<0.1	0.1	0.7
Snow bunting		0.1	0.1			0.1	0.1

[1] Bird populations in the upper Susitna basin were estimated by extrapolating the breeding bird densities from census plots, by habitat, to the upper basin. The values in the body of this table are the estimated numbers of breeding pairs affected by each project activity (from Table Bird Impacts 2) divided by the estimated number of pairs of that species in the upper basin, expressed as a percent.

TABLE W81: THE SUCCESS OF ARTIFICIAL NESTING STRUCTURES INSTALLED ON POWER POLES AND TRANSMISSION TOWERS (EXCERPTED FROM OLENDORFF ET AL. 1981).

Reference	Location	Type and No. of Structures	*No. Occupied (and species)
Illinois Power Co. 1972	ILlinois	1 Wooden Nestbox	1 (Kestrel)
Sietke (In Saurola 1978)	East Germany	30 Iron Platforms on Poles	Almost All Used Each Year (Ospreys)
Stahlecker 1975, 1979	Colorado	12 Wooden Platforms 1975 25 Nestboxes 1976 25 Nestboxes 1977 25 Nestboxes	None 12 (Kestrel) 19 (Kestrel) 24 (Kestrel)
Nelson 1978, 1979a, 1980b	Idaho	6 Wooden Platforms (2 to 4 Years Each)	4 (Golden Eagle) 1 (Red-tailed Hawk) 1 (Osprey) **1 (Bald Eagle)
Nelson 1980a, 1980b	Idaho Oregon	40 Steel Platforms on Towers	Too Early for Results
Bridges 1980	North Dakota	20 Wooden or Wire Mesh Platforms	Too Early for Results
Lee 1980	Oregon, Washington, Montana	1977 4 Wooden/ Fiberglass Platforms 1978 5 Wooden/ Fiberglass Platforms 1979 5 Wooden/ Fiberglass Platforms	1 (Red-tailed Hawk) 1 (Osprey) 1 (Osprey) 1 (Osprey)

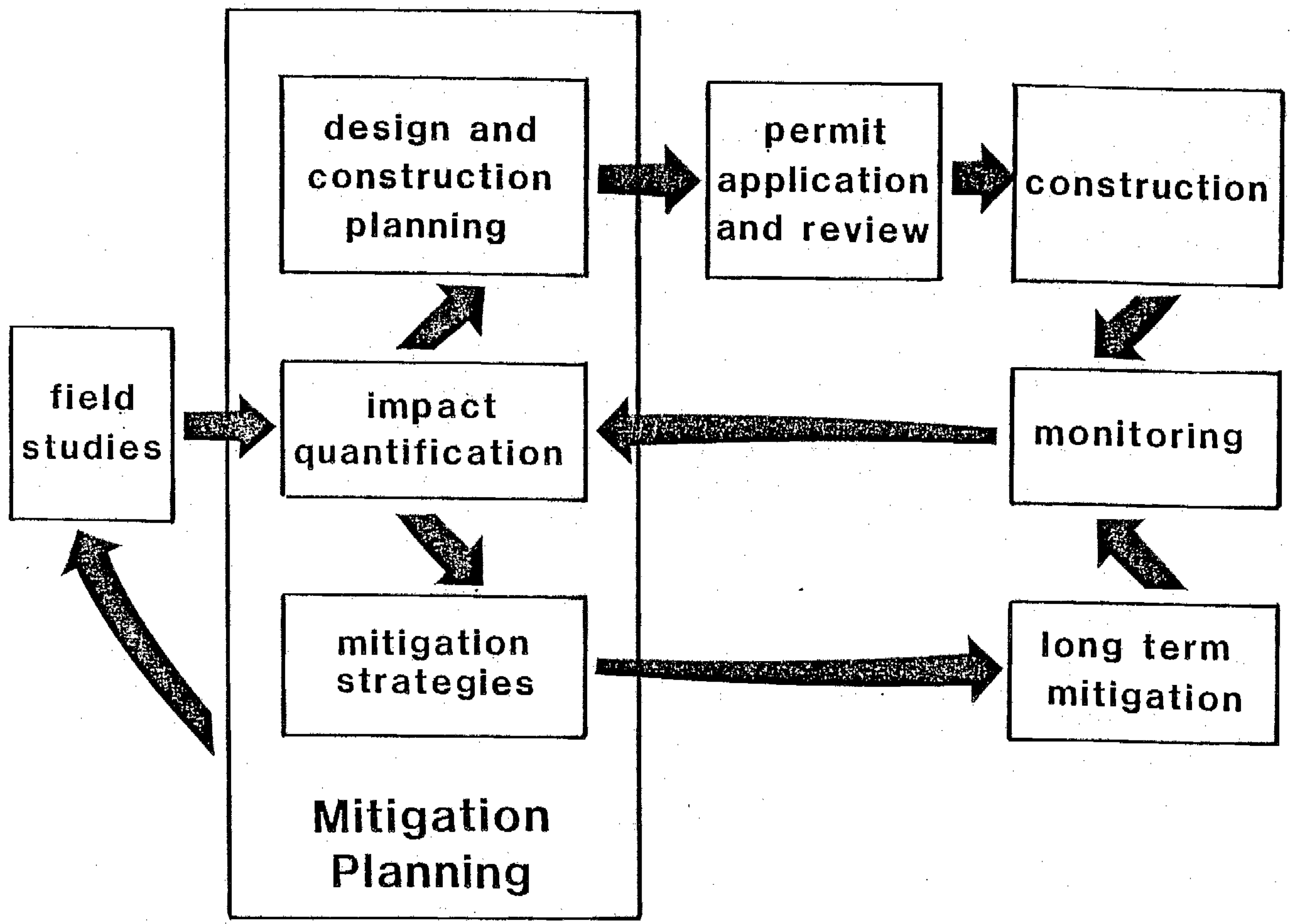
*Minimum number of times used in time periods specified.
**A pair occupied a platform early one season, but did not nest successfully.



OPTION ANALYSIS

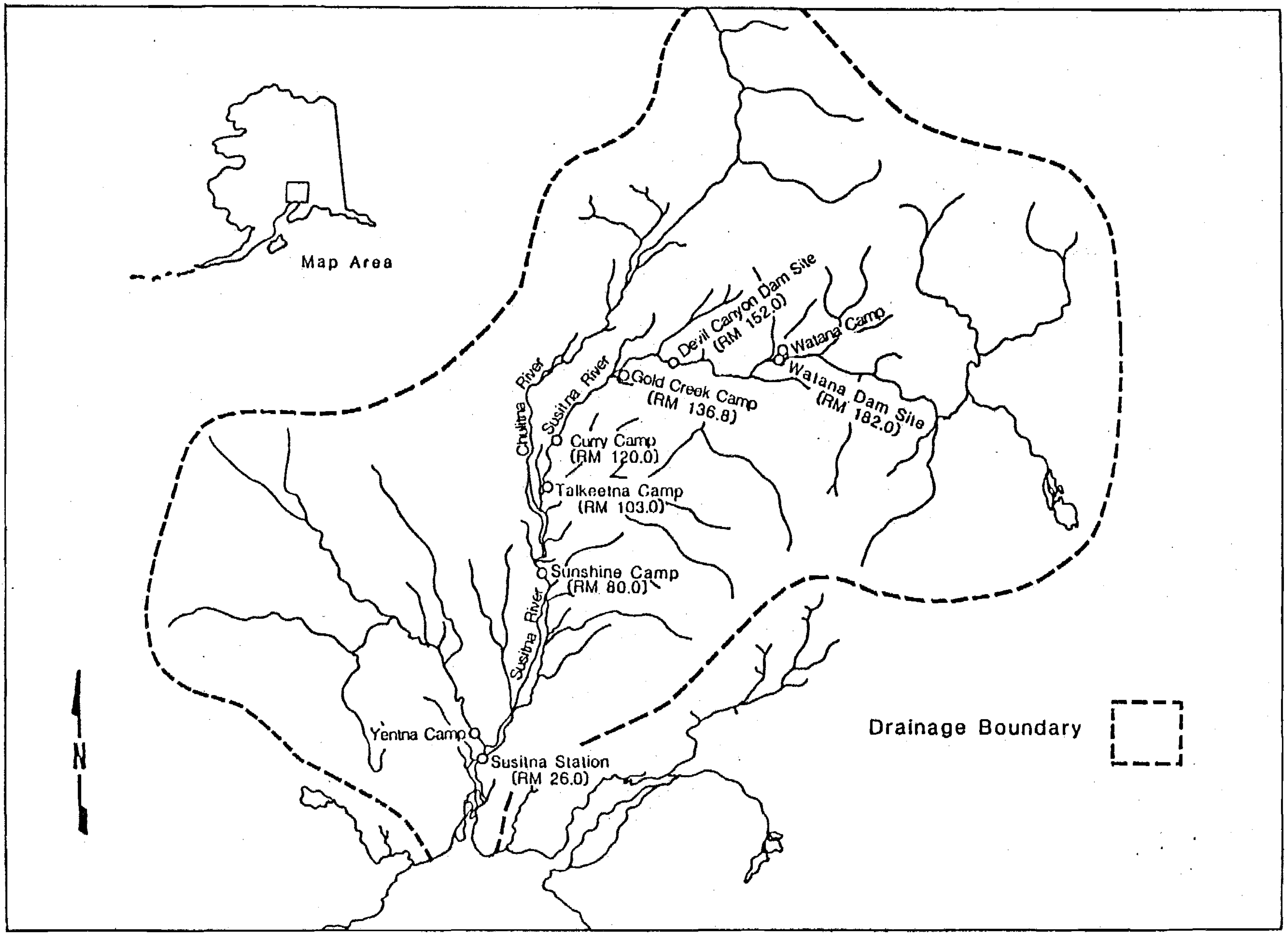
(PREPARED BY TES)

FIGURE E.3.1



RELATIONSHIP OF FIELD STUDIES AND MONITORING TO IMPACT ASSESSMENT AND MITIGATION PLANNING

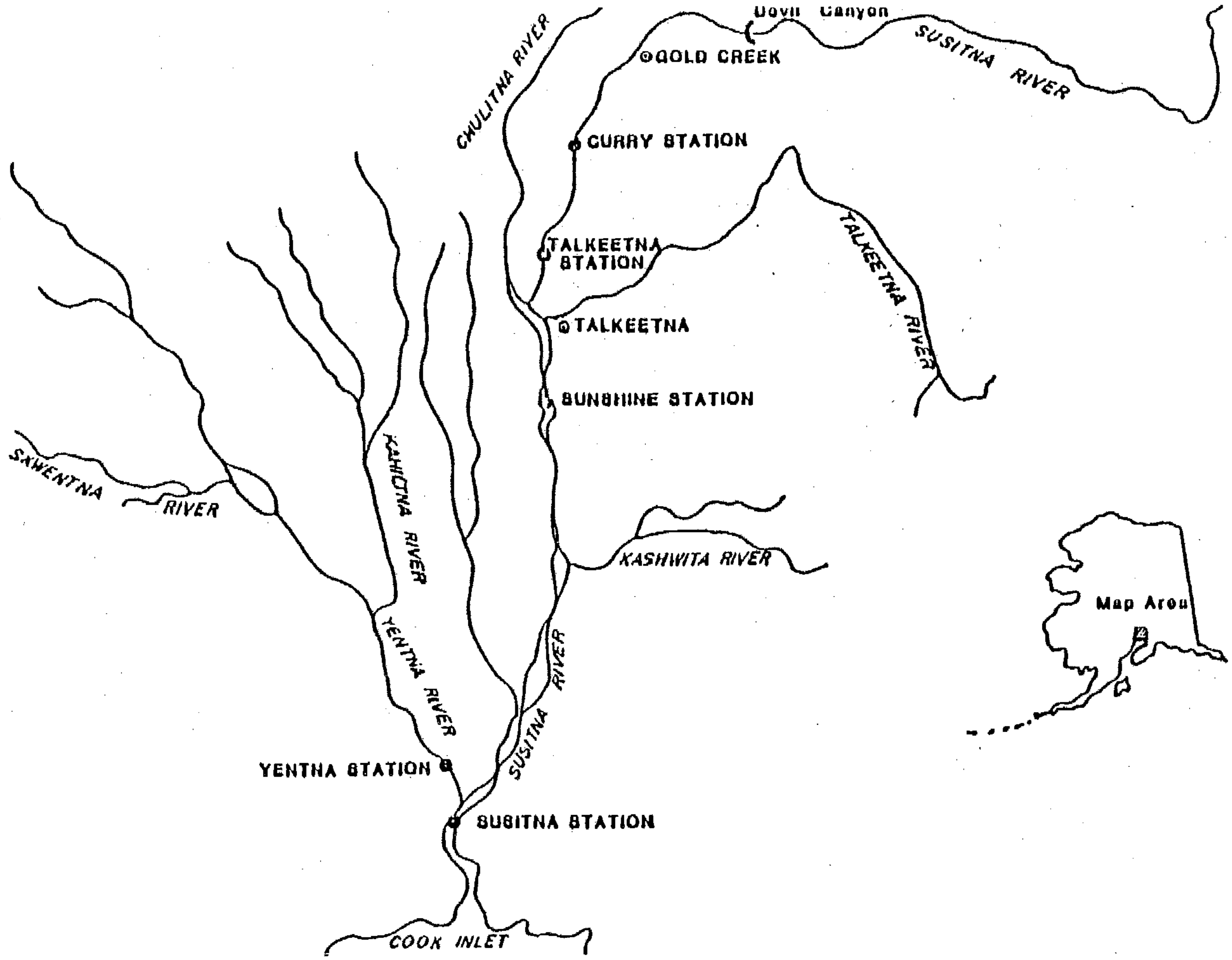
FIGURE E.3.2



SUSITNA RIVER DRAINAGE BASIN

FIGURE E 3.3

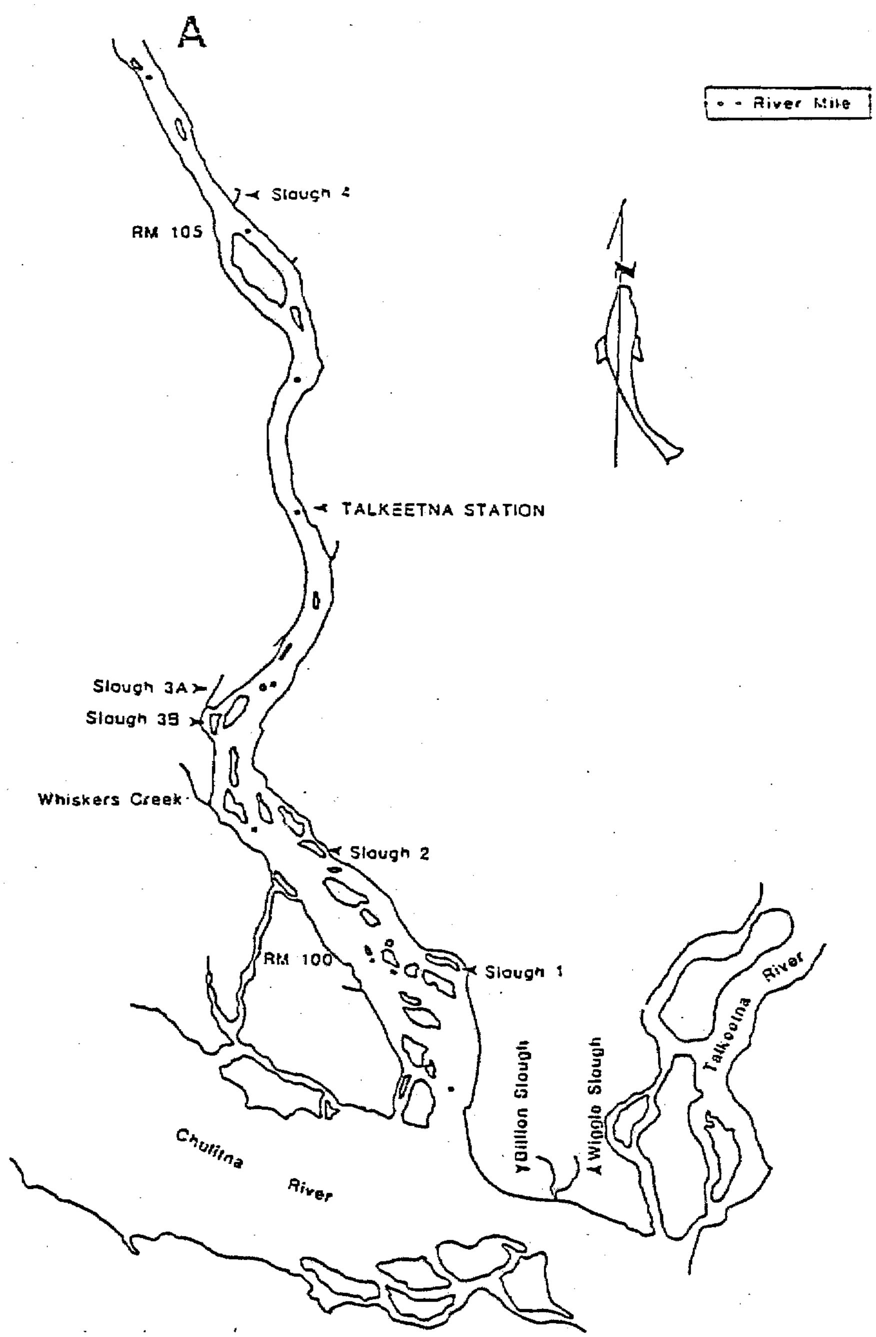
SOURCE: ADF & G 1981



SUSITNA BASIN WITH FIELD STATIONS AND MAJOR GLACIAL STREAMS DEFINED, ADULT ANADROMOUS INVESTIGATIONS, SU HYDRO STUDIES, 1981.

FIGURE E 3.4

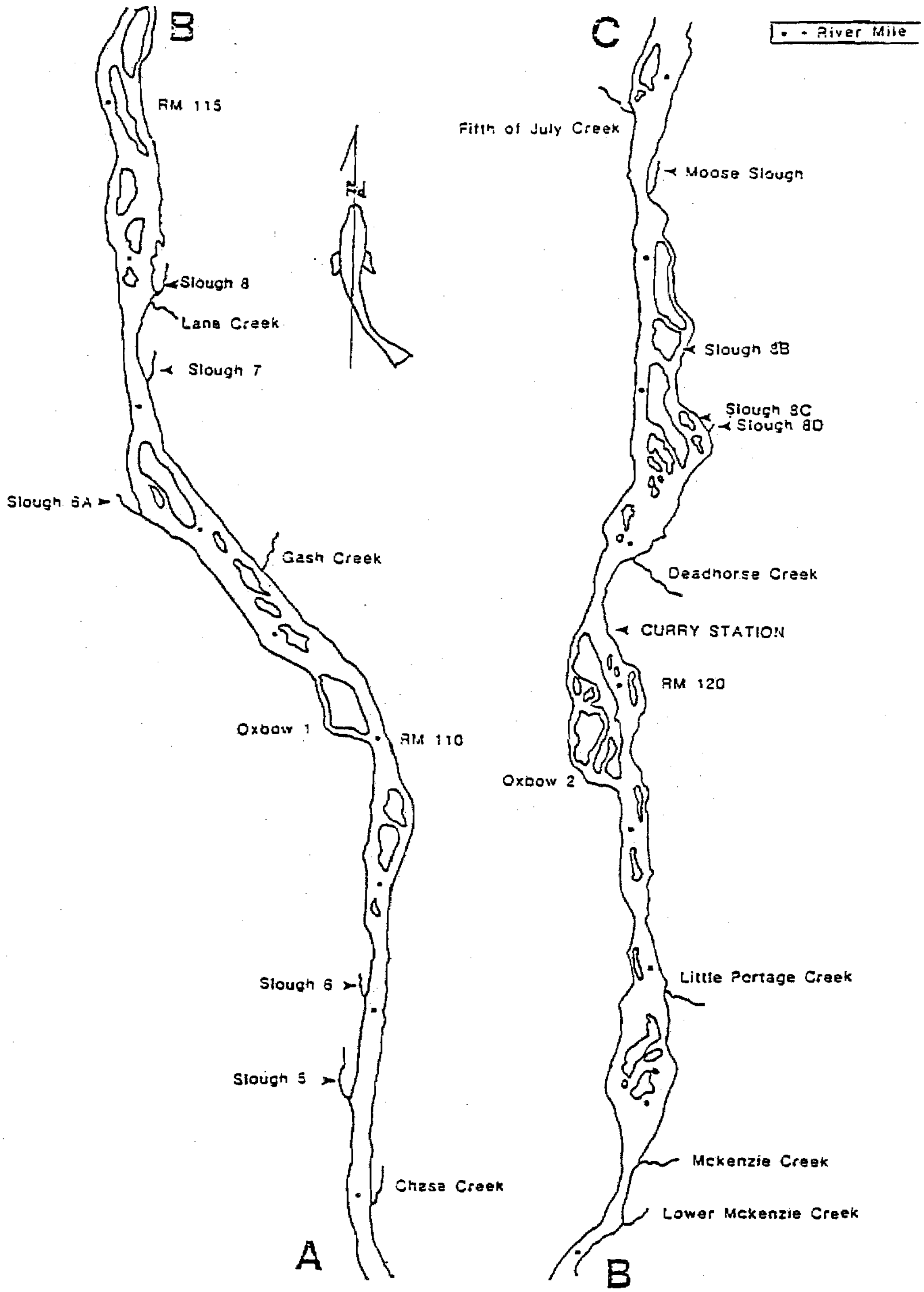
SOURCE ADF AND G 1981 b



SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES OF THE SUSITNA RIVER FROM THE CONFLUENCE OF THE CHULITNA AND TALKEETNA RIVERS TO DEVIL CANYON, ADULT ANADROMOUS, SU HYDRO STUDIES, 1981.

SOURCE: ADF&G 1981b

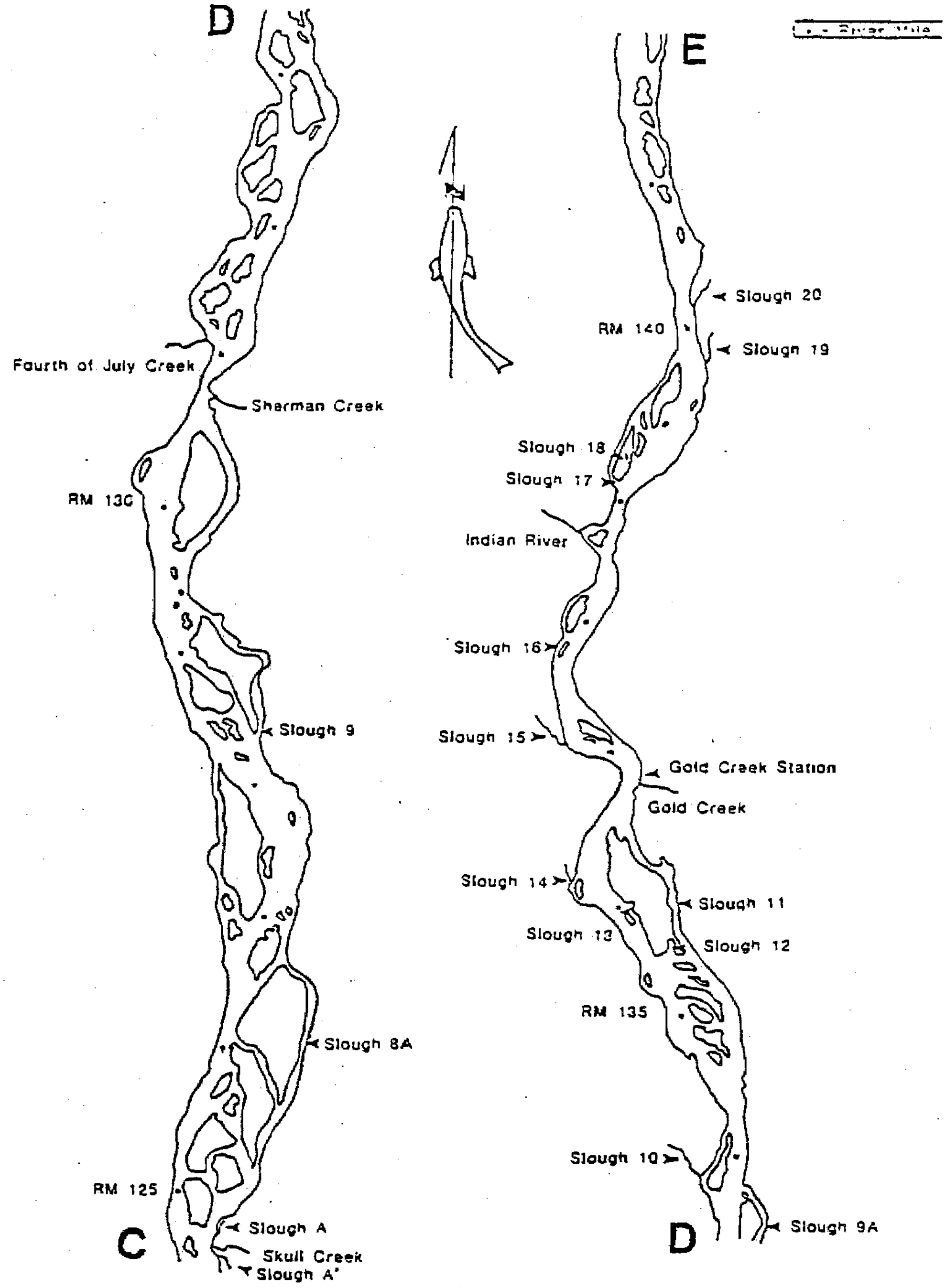
FIGURE E 3.5



SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES OF THE SUSITNA RIVER FROM THE CONFLUENCE OF THE CHULITNA AND TALKEETNA RIVERS TO DEVIL CANYON, ADULT ANADROMOUS, SU HYDRO STUDIES, 1981. (CONT.)

FIGURE E 3.6

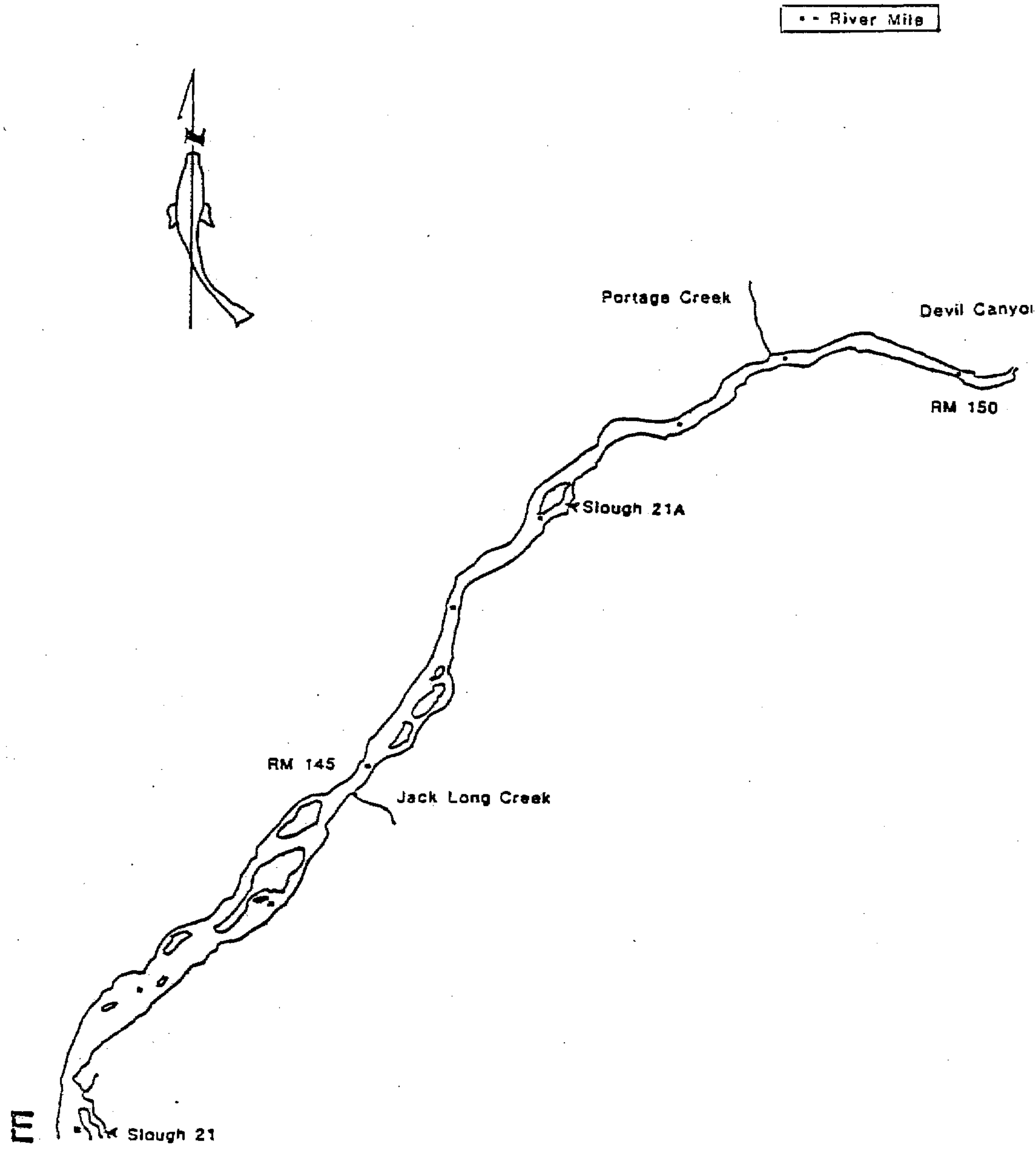
SOURCE: ADF&G 1981b



SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES OF THE SUSITNA RIVER FROM THE CONFLUENCE OF THE CHULITNA AND TALKEETNA RIVERS TO DEVIL CANYON, ADULT ANADROMOUS, SU HYDRO STUDIES, 1981. (CONT.)

SOURCE: ADF&G 1981

FIGURE E 3.7

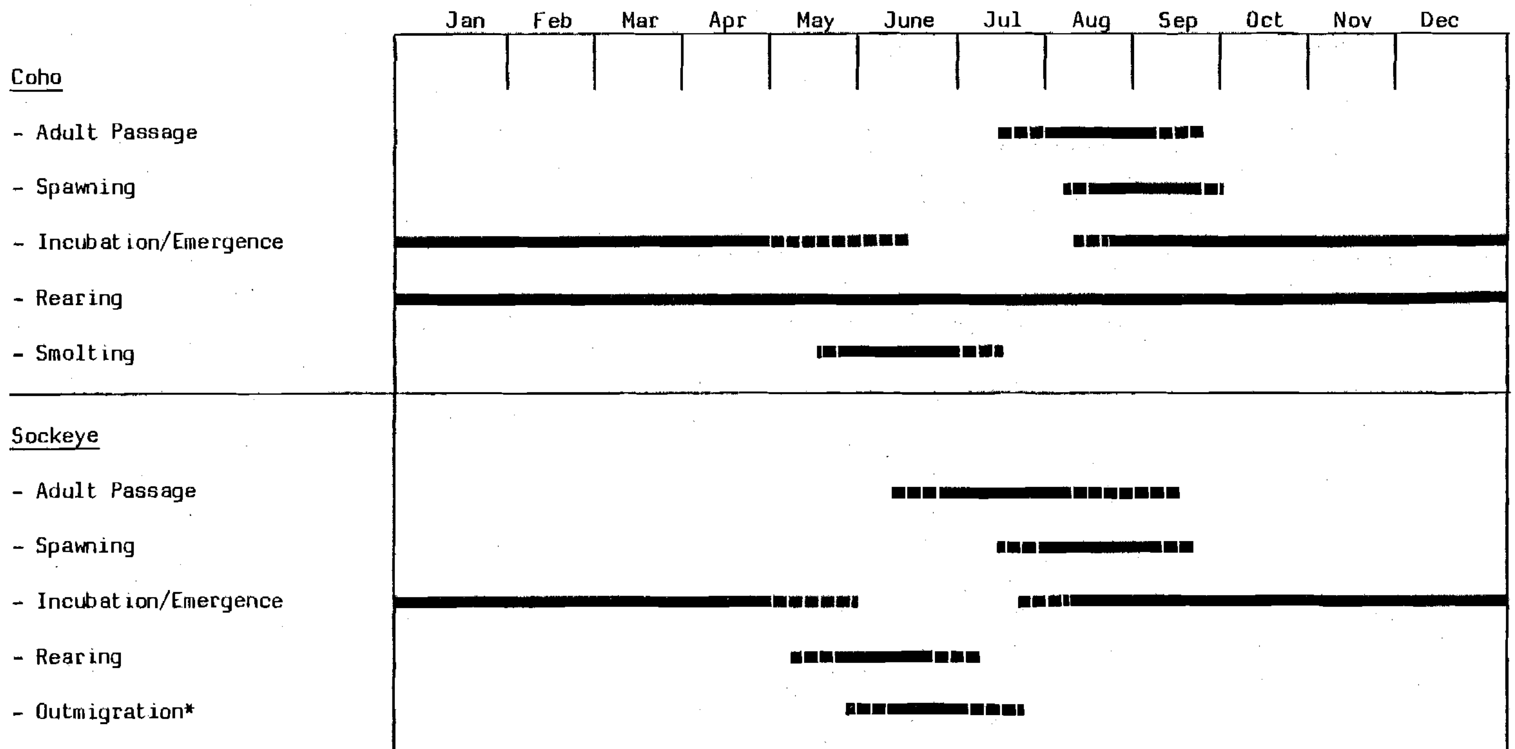


SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES OF THE SUSITNA RIVER FROM THE CONFLUENCE OF THE CHULITNA AND TALKEETNA RIVERS TO DEVIL CANYON, ADULT ANADROMOUS, SU HYDRO STUDIES, 1981. (CONT.)

SOURCE: ADF&G 1981

FIGURE E 3.8

FIGURE E.3.8a: TIMING OF LIFE STAGES OF SALMON IN THE SUSITNA RIVER FROM TALKEETNA TO DEVIL CANYON (Cont'd)



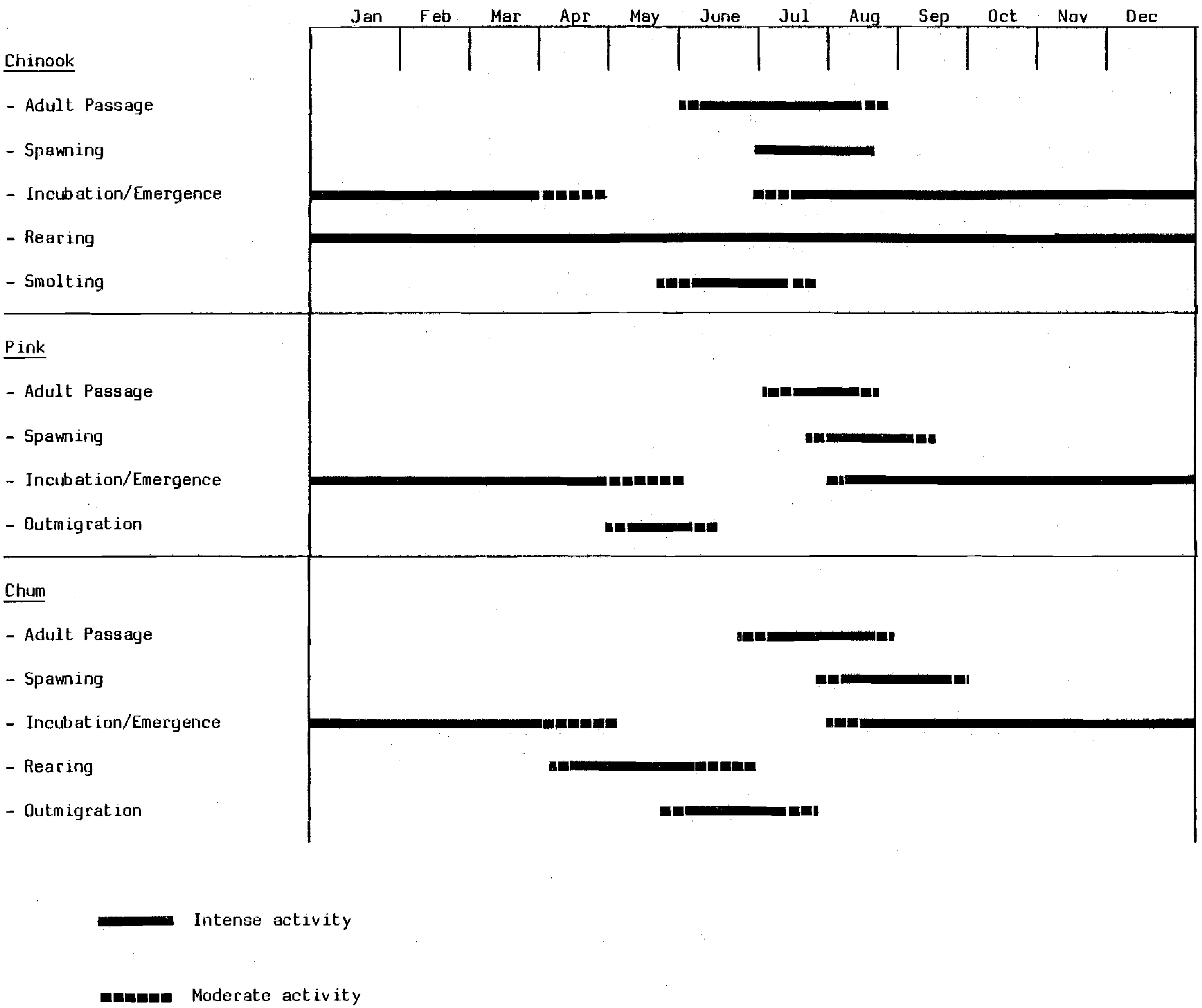
* Juvenile sockeye appear to be absent from this reach.

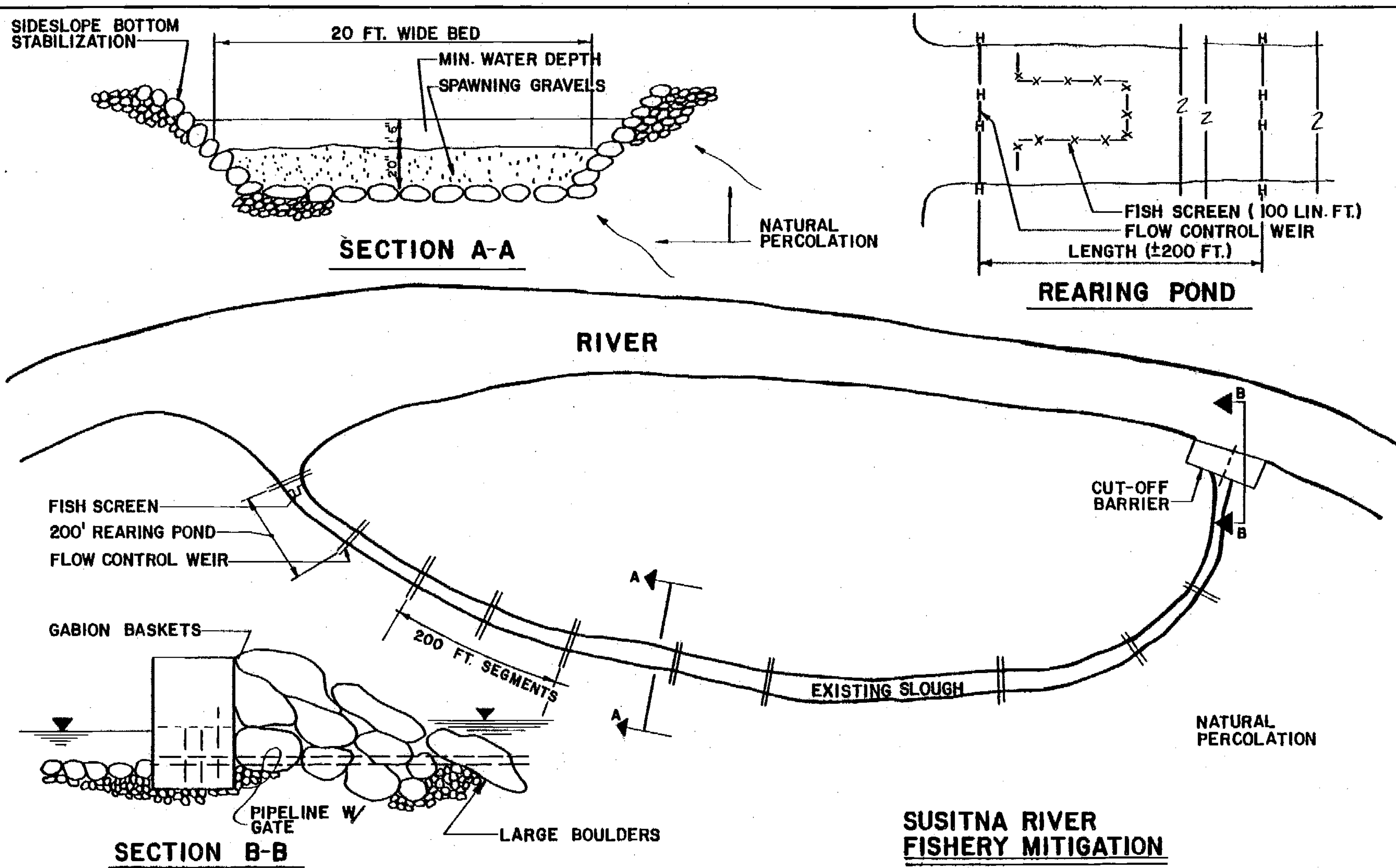
Source: ADF&G 1981a, 1981b, 1981c, 1981d, 1981e, 1981f, and 1982a. Trent 1982; and Morrow 1980.

▬▬▬ Intense activity

■■■■■■ Moderate activity

FIGURE E.3.8a: TIMING OF LIFE STAGES OF SALMON IN THE SUSITNA RIVER FROM TALKEETNA TO DEVIL CANYON



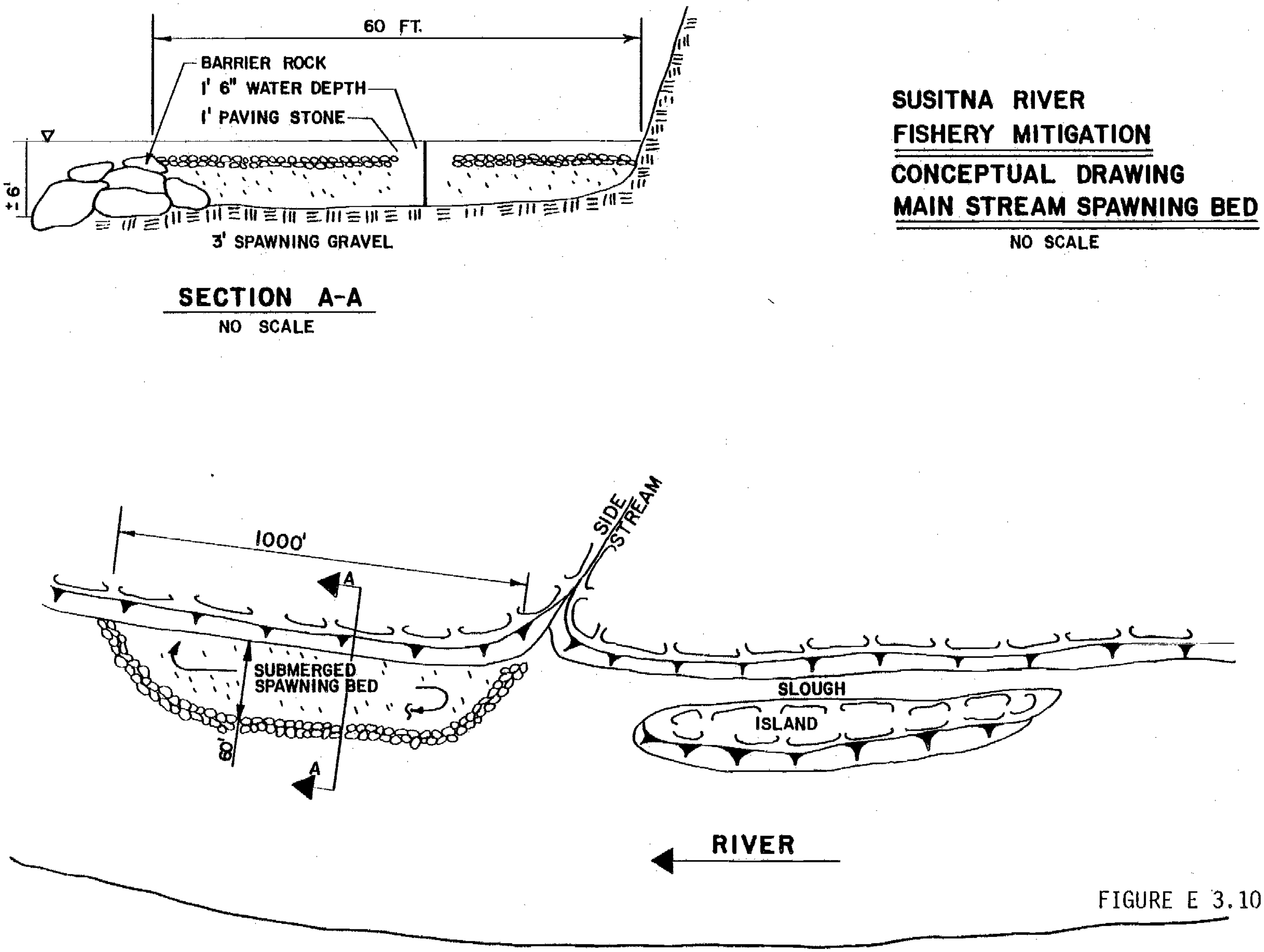


SUSITNA RIVER FISHERY MITIGATION

CHANNEL TYPE SPAWNING FACILITY

NO SCALE

FIGURE E 3.9



60 FT.
BARRIER ROCK
1' 6" WATER DEPTH
1' PAVING STONE
±6'
3' SPAWNING GRAVEL
SECTION A-A
NO SCALE
SUSITNA RIVER
FISHERY MITIGATION
CONCEPTUAL DRAWING
MAIN STREAM SPAWNING BED
NO SCALE
1000'
A
SIDE STREAM
SUBMERGED SPAWNING BED
60'
A
SLOUGH
ISLAND
RIVER

FIGURE E 3.10

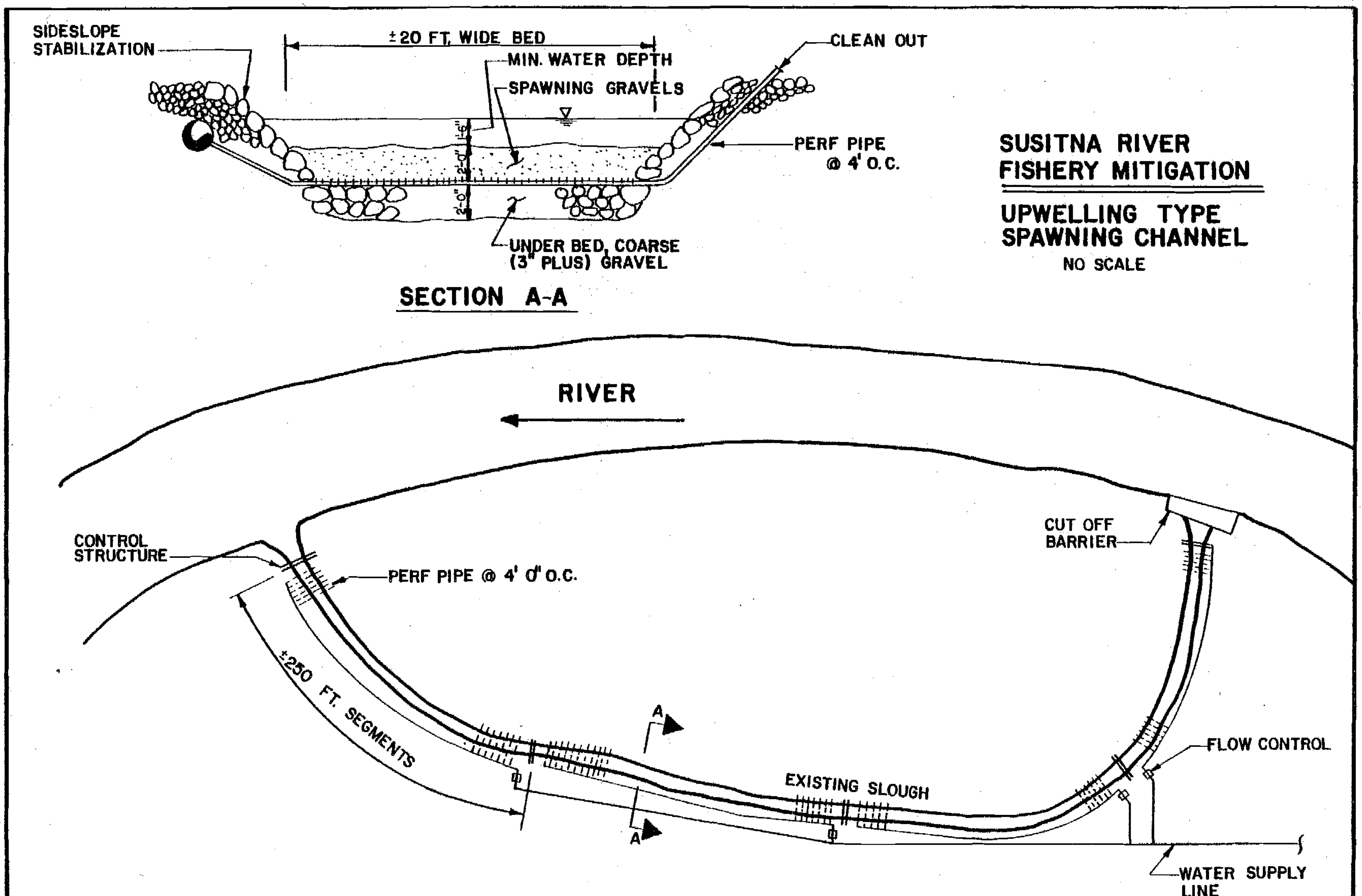
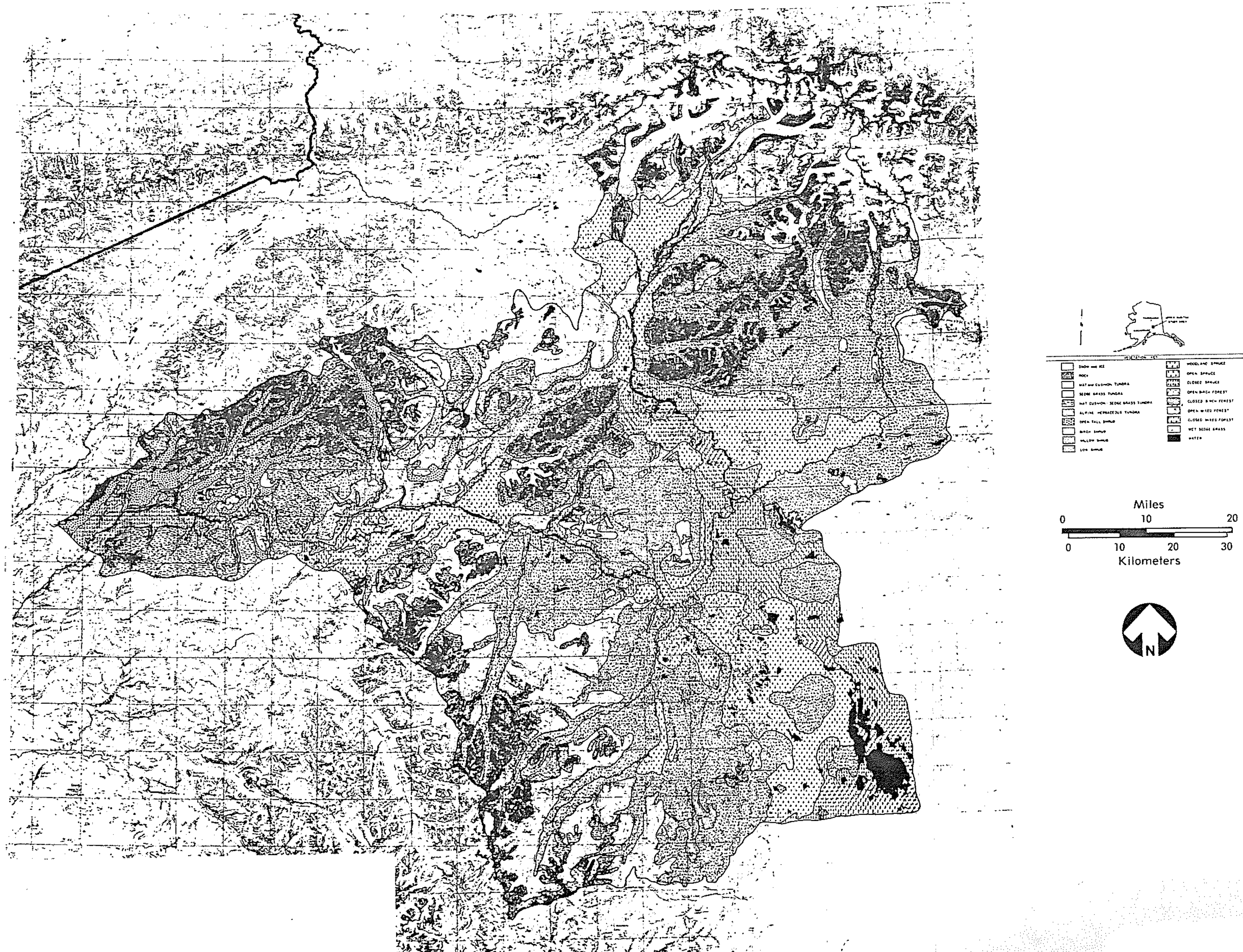

SIDESLOPE
STABILIZATION
±20 FT. WIDE BED
MIN. WATER DEPTH
SPAWNING GRAVELS
CLEAN OUT
PERF PIPE
@ 4' O.C.
1'-6"
2'-0"
2'-0"
UNDER BED, COARSE
(3" PLUS) GRAVEL
SECTION A-A
SUSITNA RIVER
FISHERY MITIGATION
UPWELLING TYPE
SPAWNING CHANNEL
NO SCALE
RIVER
CONTROL
STRUCTURE
PERF PIPE @ 4' 0" O.C.
±250 FT. SEGMENTS
A
A
EXISTING SLOUGH
CUT OFF
BARRIER
FLOW CONTROL
WATER SUPPLY
LINE

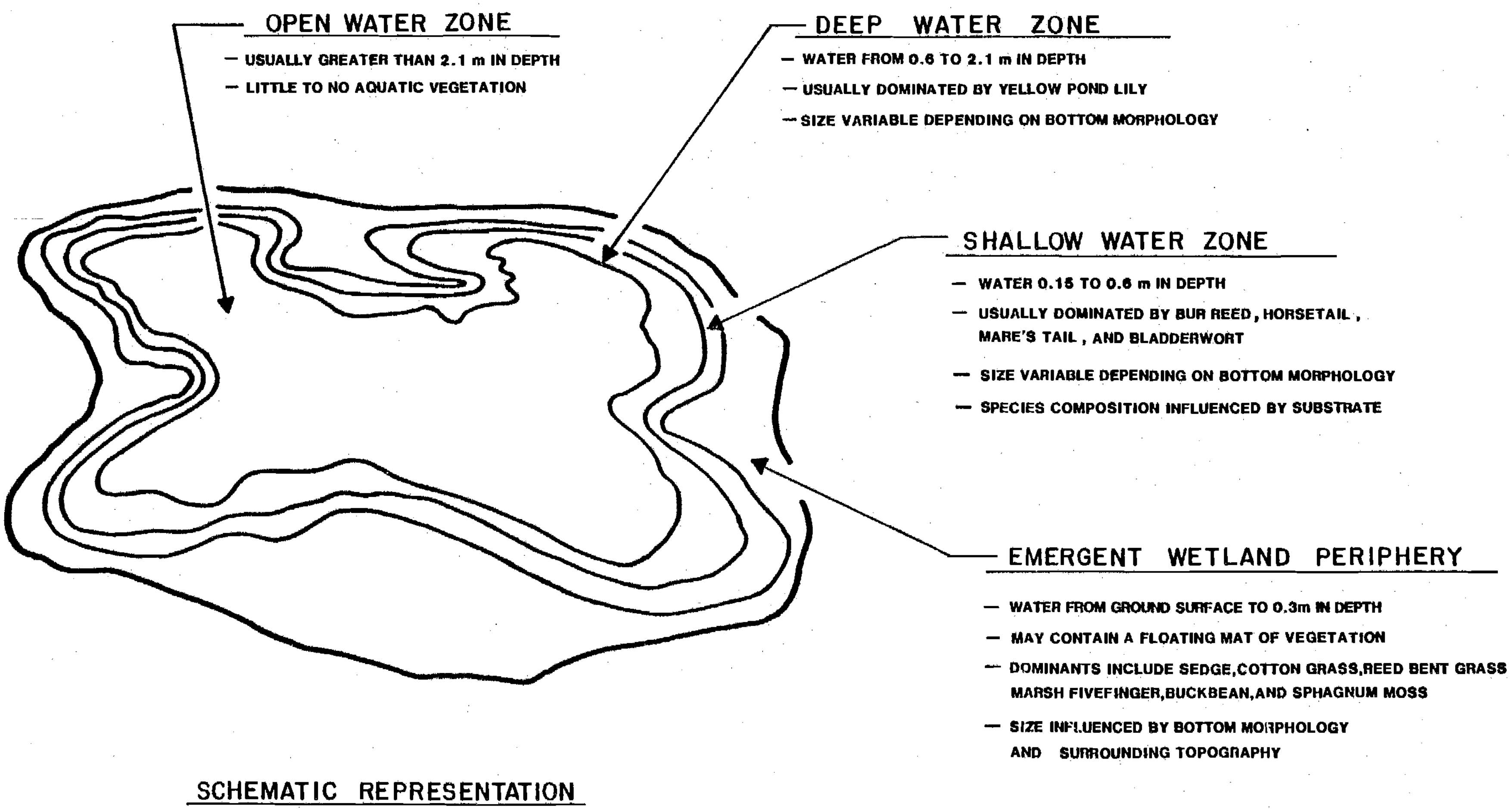
FIGURE E 3.11



VEGETATION MAP OF THE UPPER SUSITNA RIVER BASIN

FIGURE W1

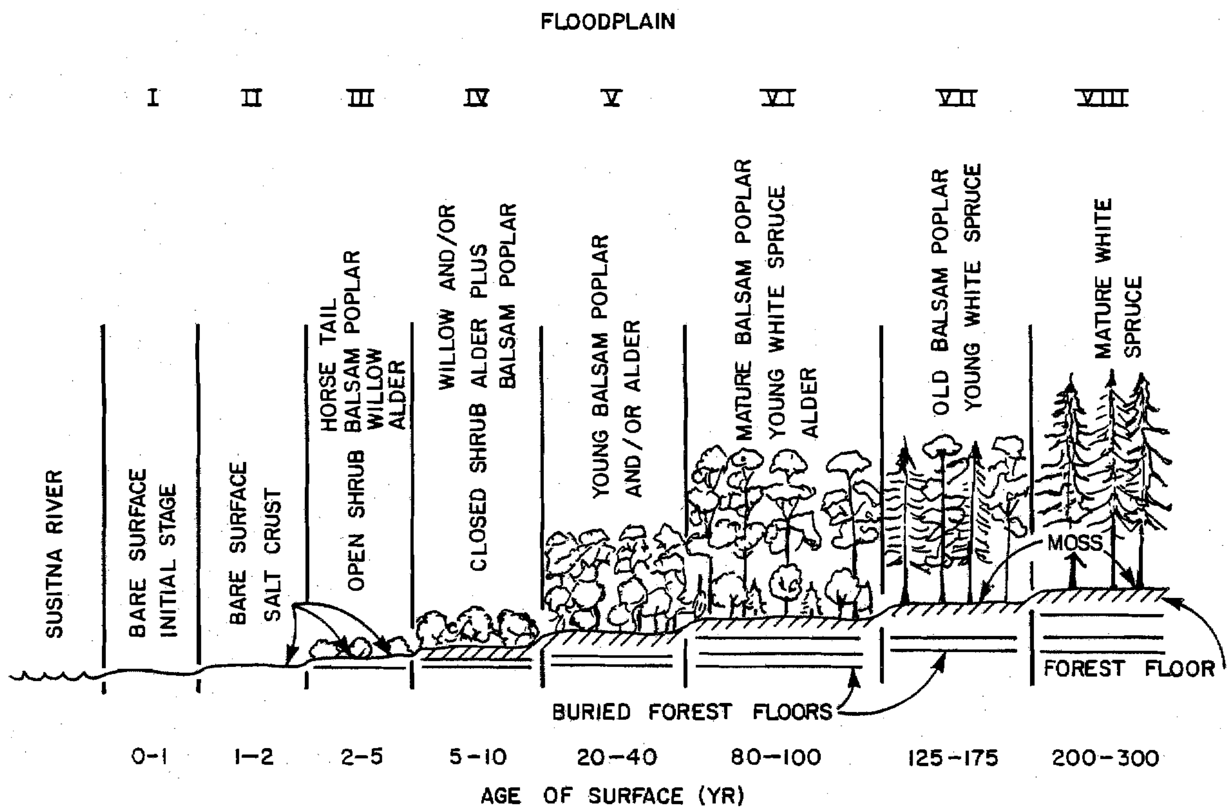
PREPARED BY TES/UNIVERSITY OF ALASKA



A SCHEMATIC REPRESENTATION OF THE DOMINANT VEGETATION ASSOCIATED WITH MANY OF THE LAKES AND PONDS OF THE UPPER SUSITNA BASIN

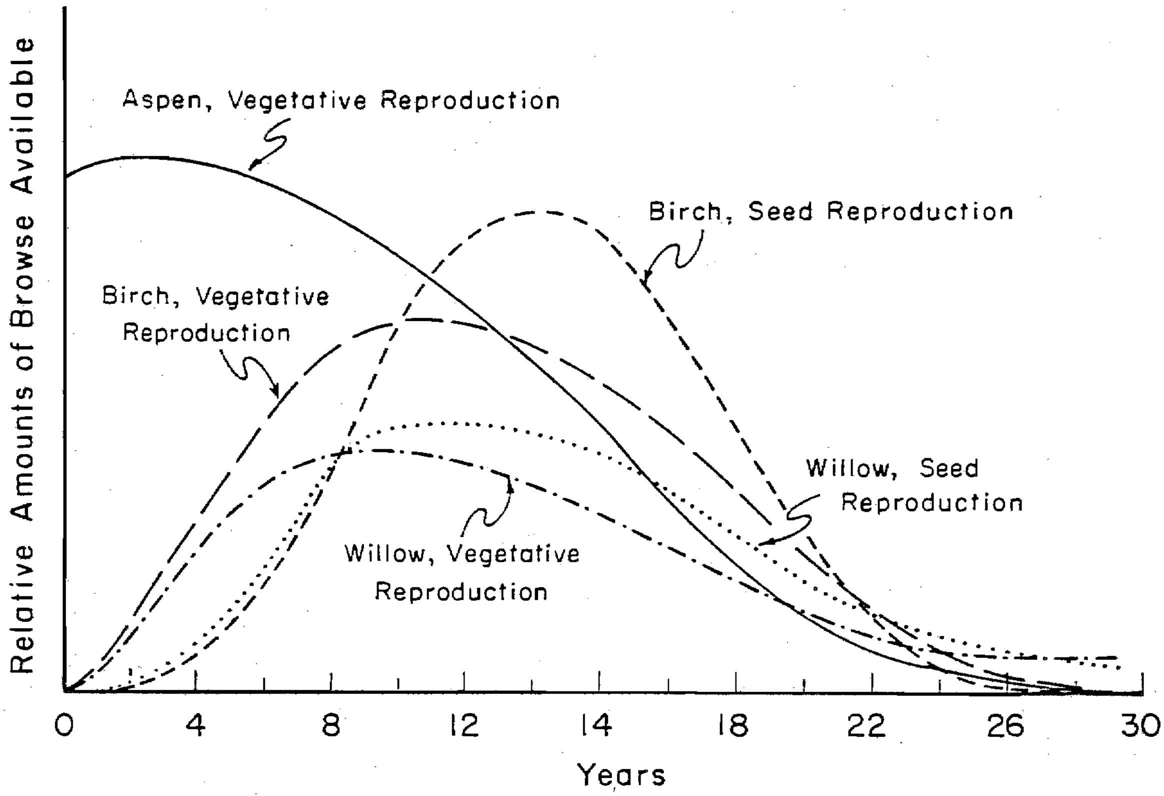
FIGURE W2

(FROM McKENDRICH et al. 1982)



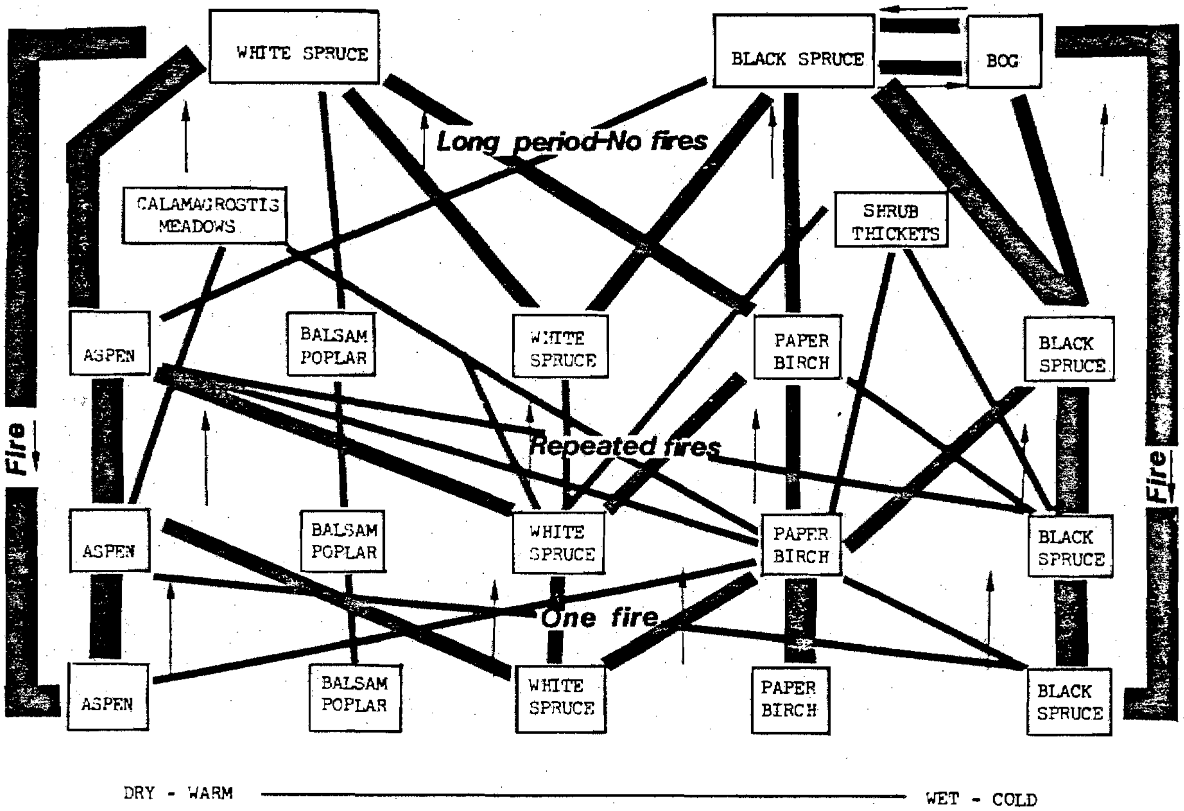
PRIMARY SUCCESSION ON THE SUSITNA FLOODPLAIN
(ADAPTED FROM VAN CLEVE AND VIERECK 1981)

FIGURE W3



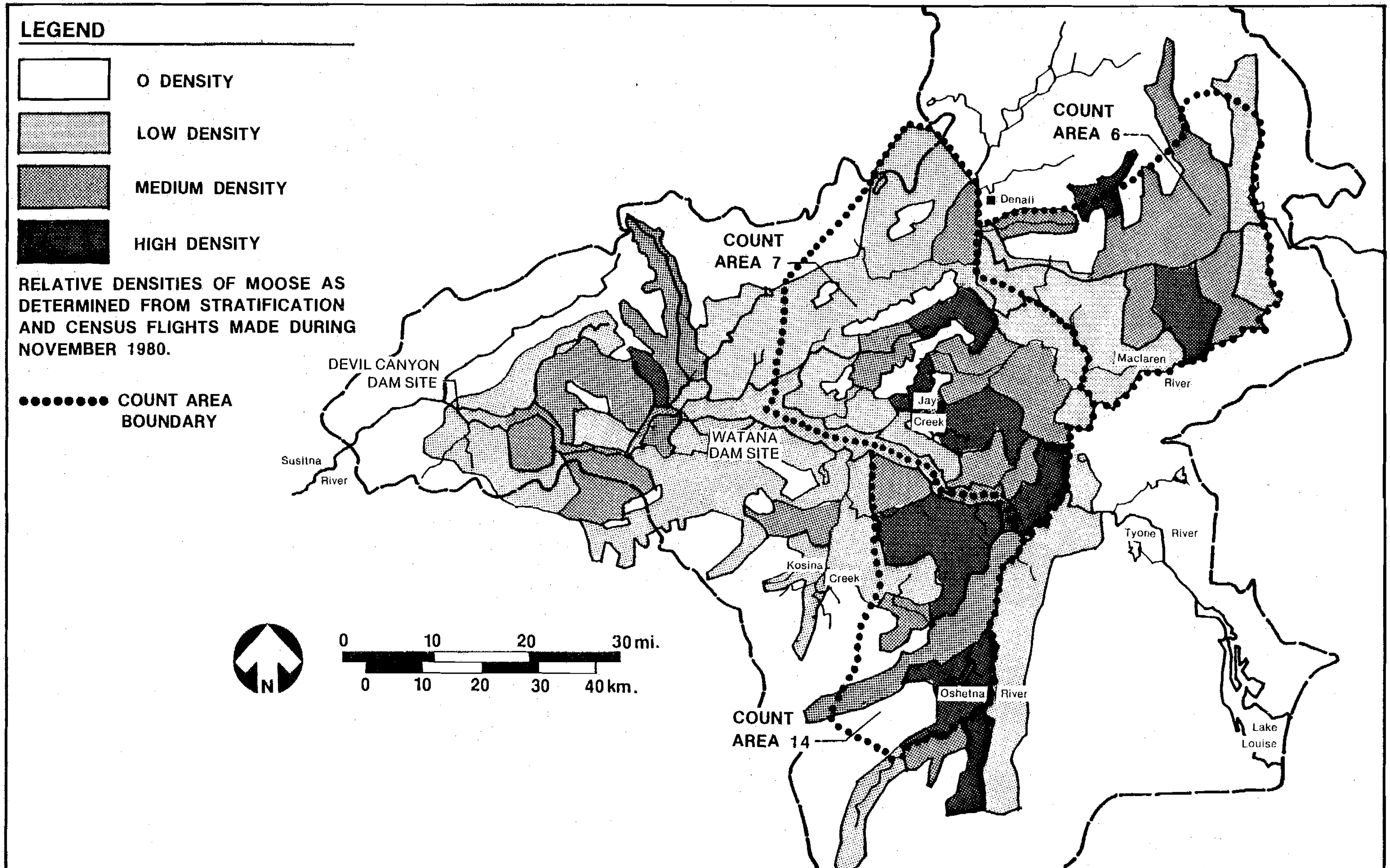
RELATIVE AMOUNTS OF MOOSE BROWSE AVAILABLE COMPARED WITH THE TIME SINCE FIRE OR OTHER DISTURBANCE IN INTERIOR ALASKA (FROM WOLFF AND ZASADA 1979)

FIGURE W4



PATTERNS OF FOREST SUCCESSION FOLLOWING FIRE IN ALASKA (FROM VIERECK & SCHANDELMEIER 1980)

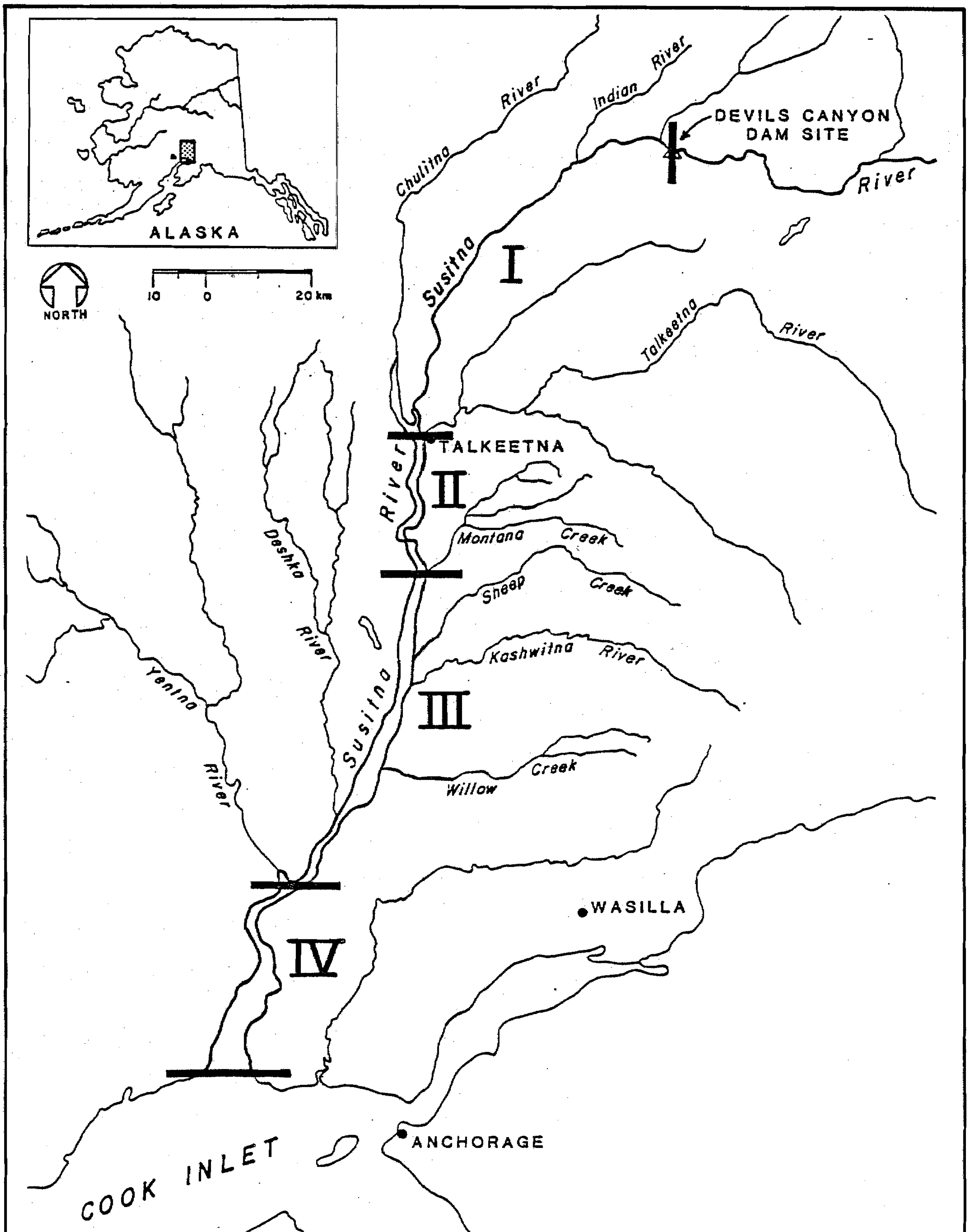
FIGURE W5



BOUNDARIES OF ESTABLISHED MOOSE COUNT AREAS

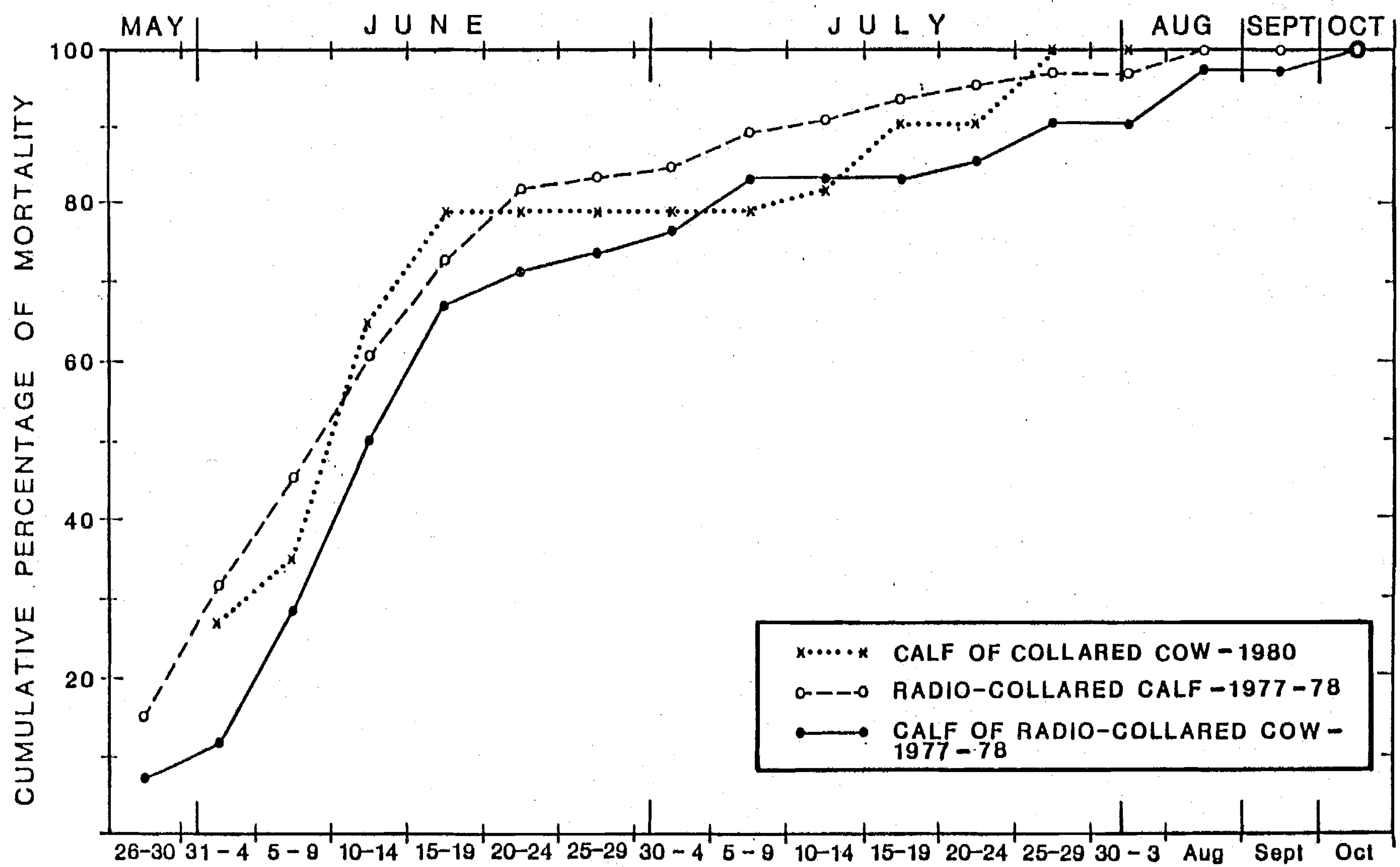
FIGURE W6

PREPARED BY TES/ADF&G



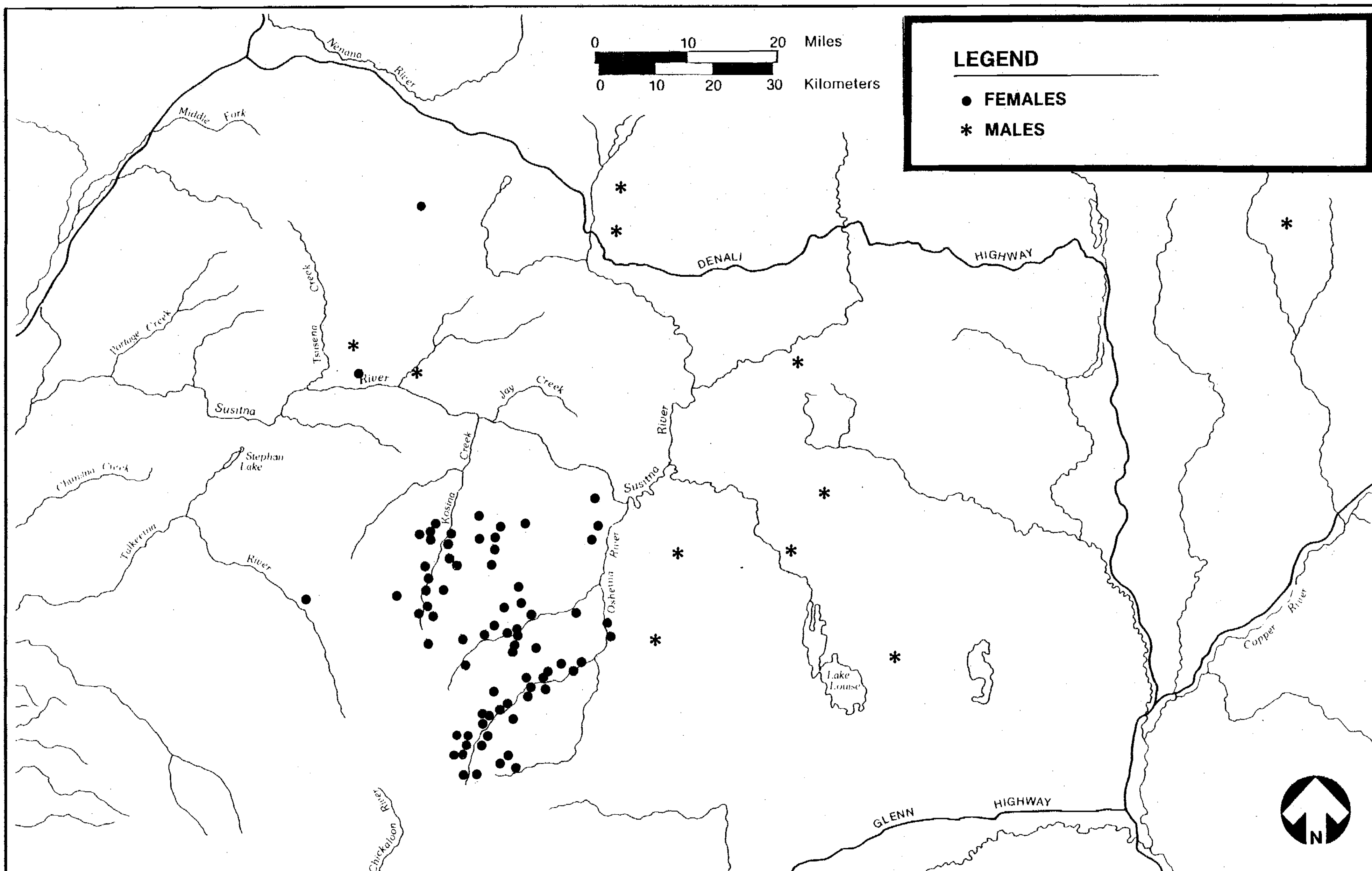
ZONES EMPLOYED BY MODAFFERI (1982) TO ESTIMATE MOOSE DENSITIES WITHIN RIPARIAN COMMUNITIES ALONG THE SUSITNA RIVER

FIGURE W7



DATES OF MORTALITIES OF COLLARED AND UNCOLLARED MOOSE CALVES DURING 1977, 1978, AND 1980 IN THE NELCHINA AND UPPER SUSITNA BASIN, ALASKA (FROM BALLARD ET. AL. 1982)

FIGURE W8

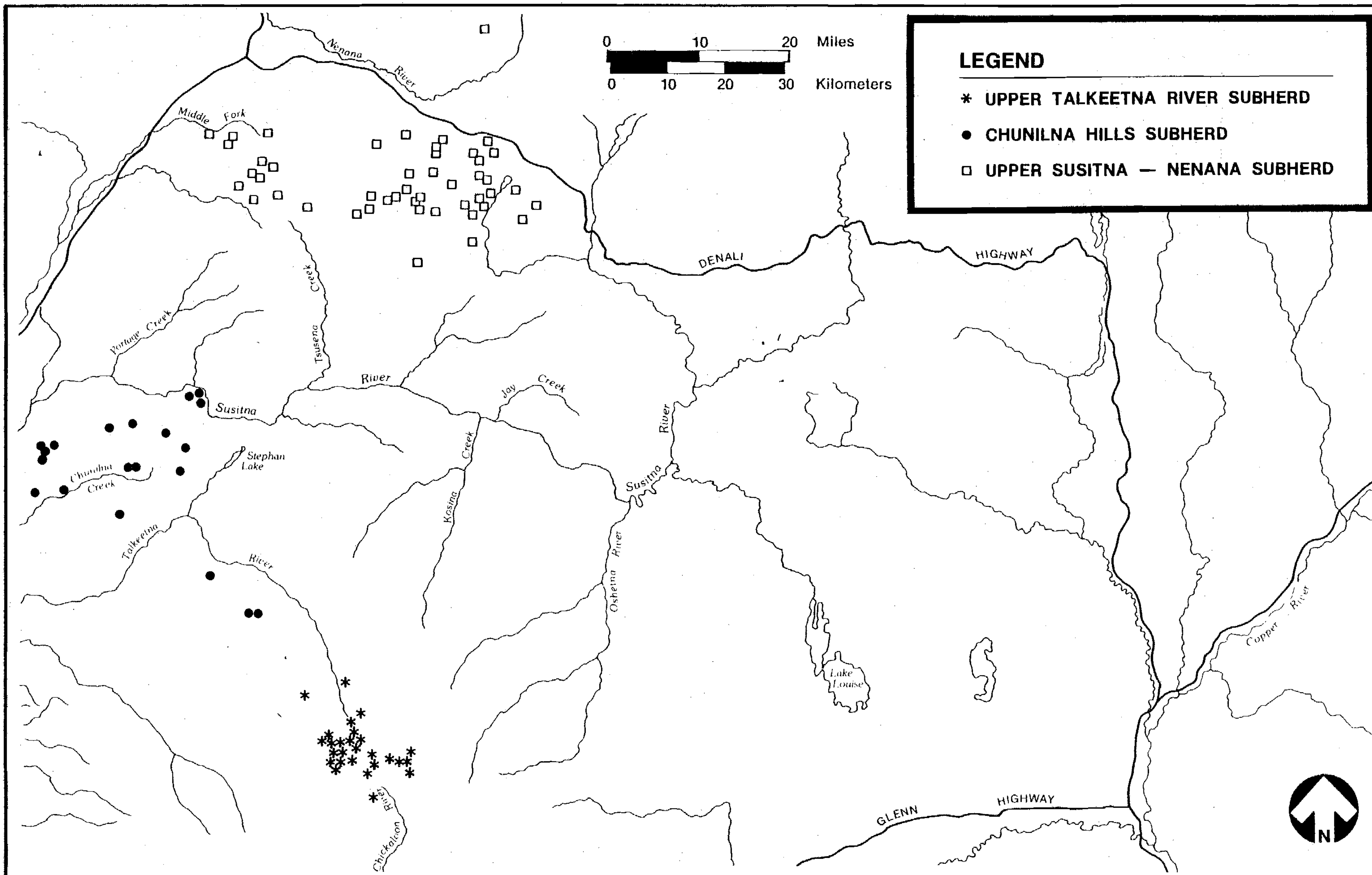


DISTRIBUTION OF NELCHINA RADIO-COLLARED CARIBOU
DURING THE CALVING PERIOD, 15 MAY THROUGH 10 JUNE, 1980 AND 1981

PREPARED BY TES/ADF&G

FIGURE W9

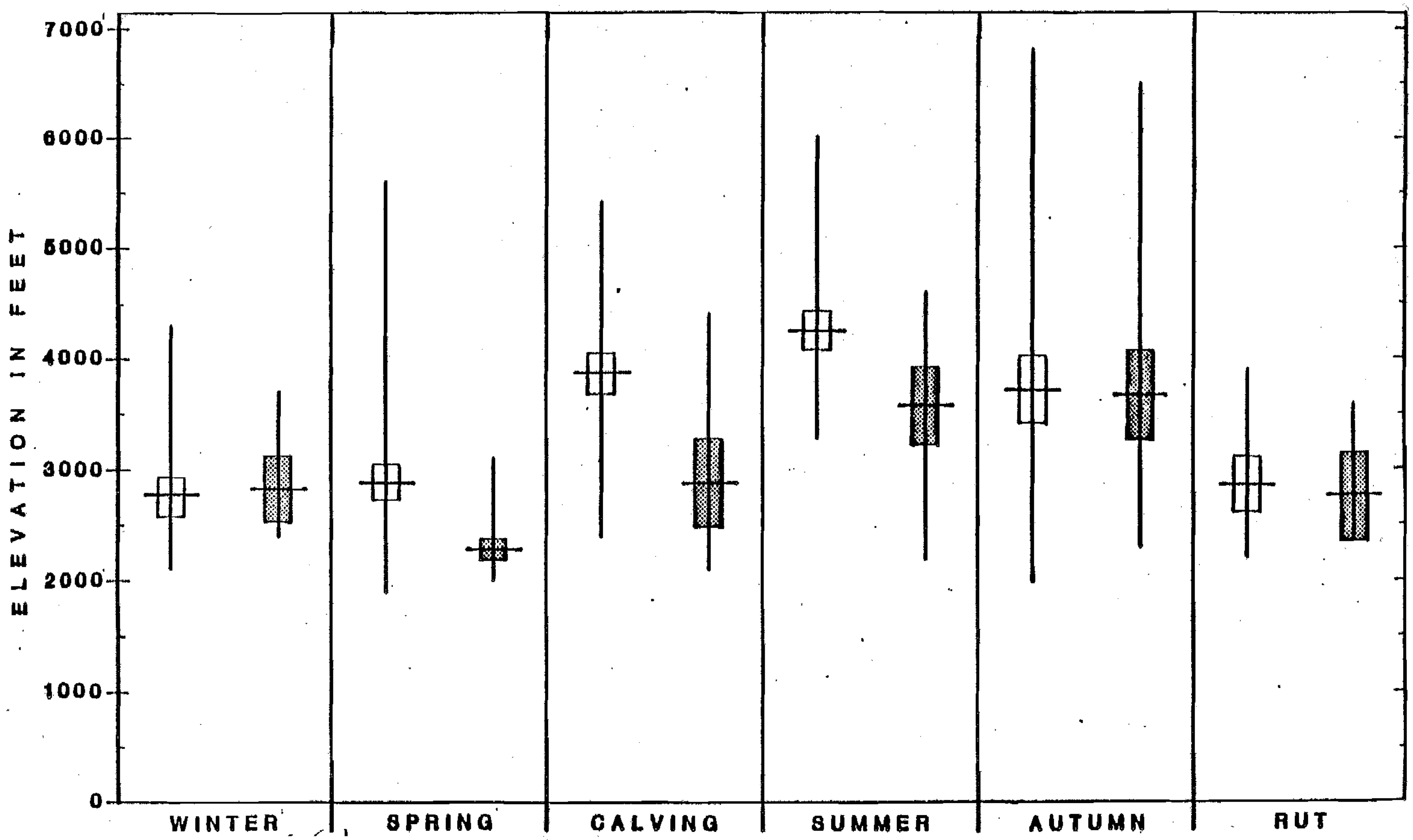
ACRES



LOCATION OF RADIO-COLLARED CARIBOU IN SUBHERDS,
9 MAY 1980 THROUGH 22 SEPTEMBER 1981

FIGURE W10

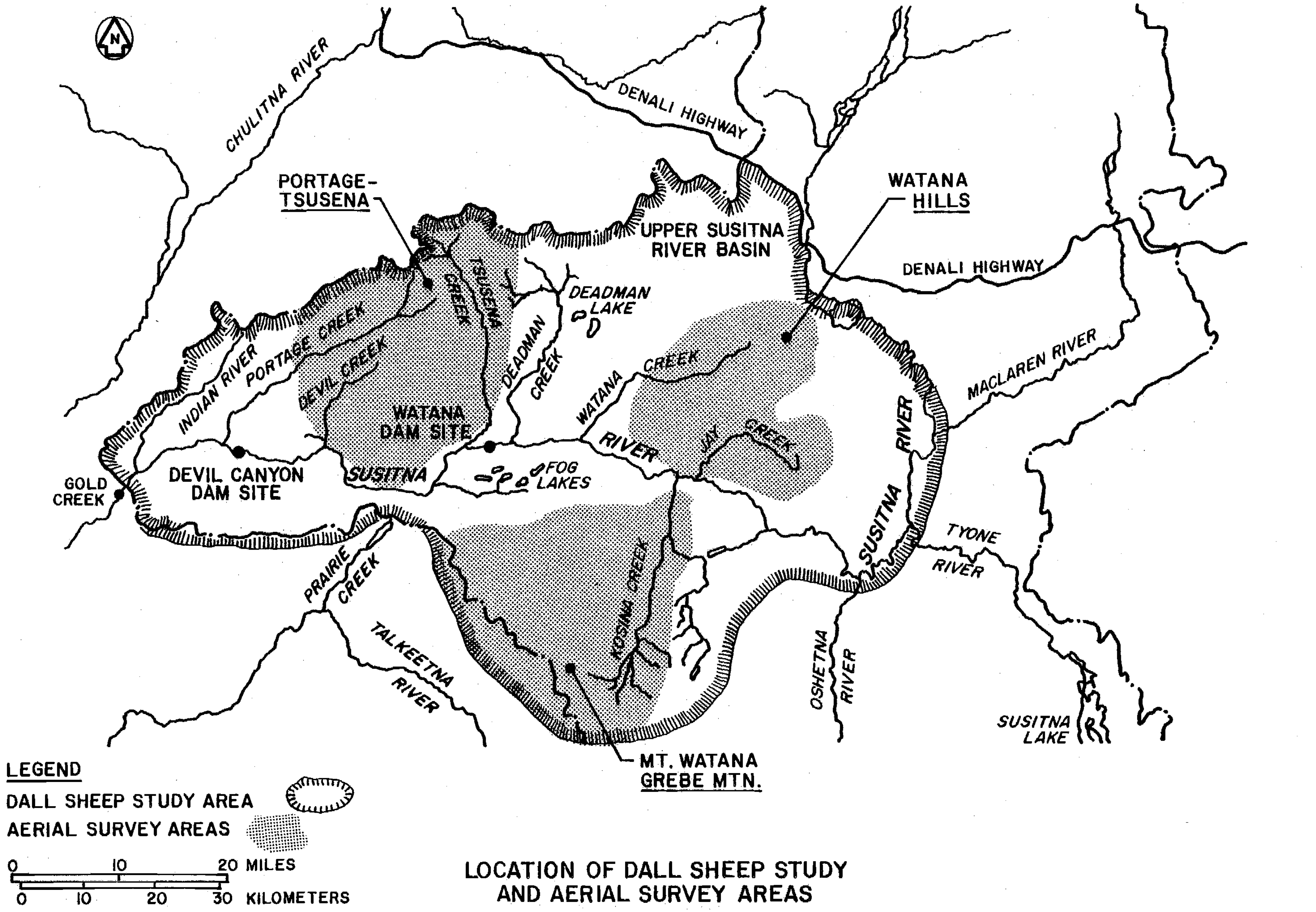
PREPARED BY TES/ADF&G



CARIBOU - SEASONAL ELEVATION USE BY FEMALE (LIGHT BOX) AND MALE (DARK BOX) CARIBOU FROM THE MAIN NEICHINA HERD. HORIZONTAL LINE, MEAN; BOX, 95 % CONFIDENCE INTERVAL LINE, RANGE. (FROM PITCHER 1982).

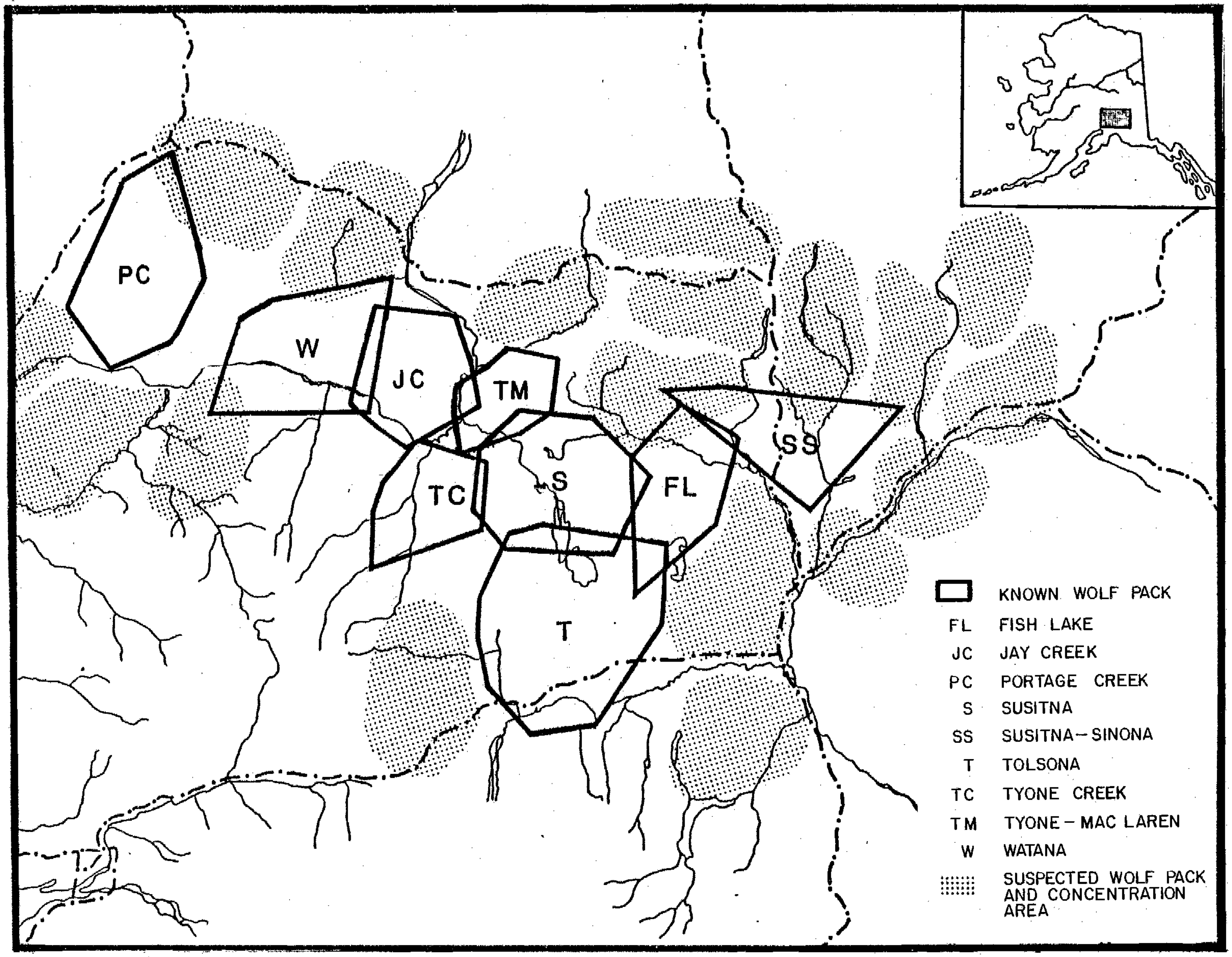
(FROM PITCHER 1982a).

FIGURE W11



LOCATION OF DALL SHEEP STUDY
AND AERIAL SURVEY AREAS

FIGURE W12

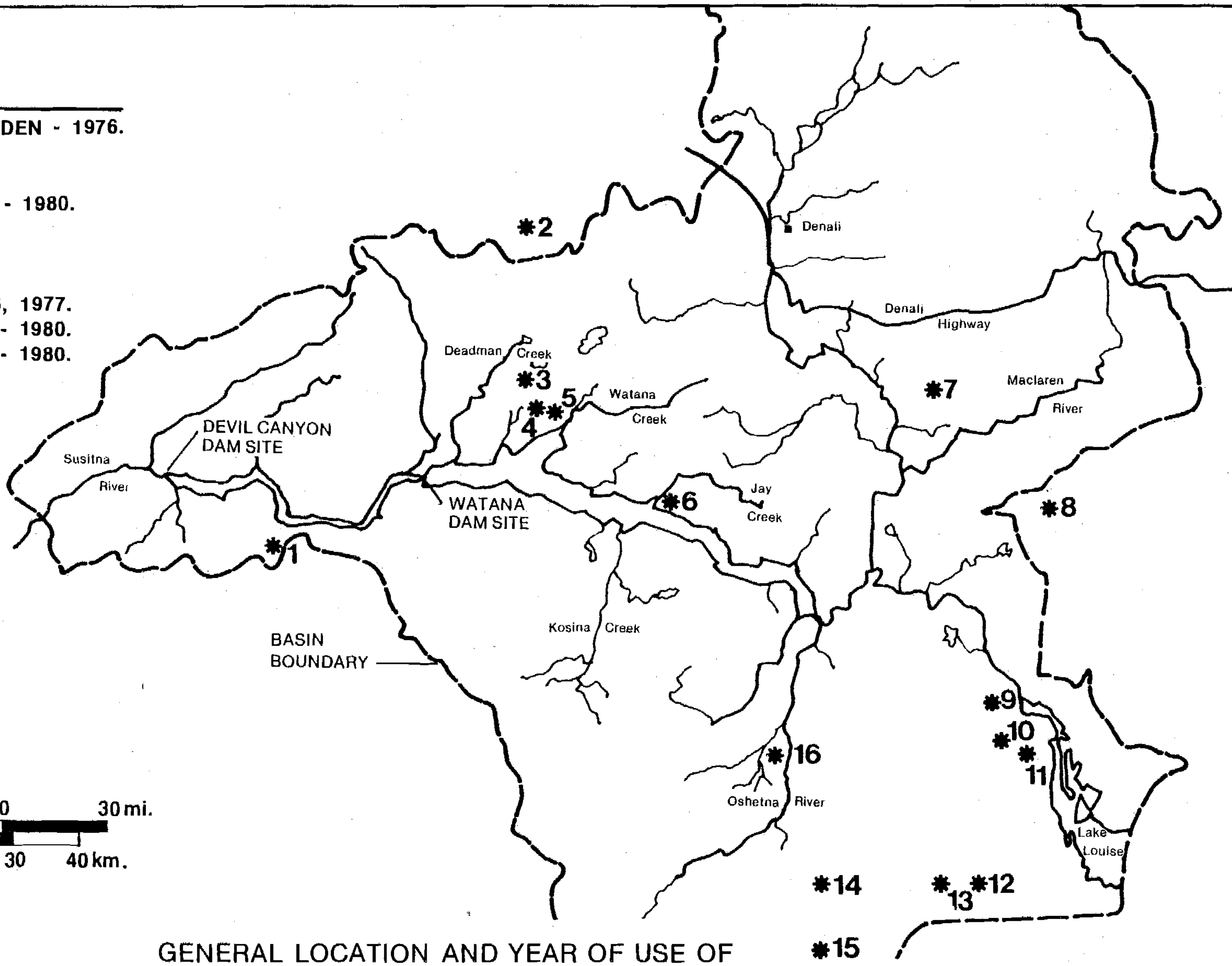


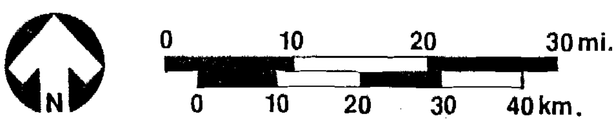
SUSPECTED LOCATIONS AND TERRITORIAL BOUNDARIES OF WOLF PACKS INHABITATING THE SUSITNA HYDROELECTRIC PROJECT AREA DURING 1980 AND 1981

FIGURE W13

LEGEND

1. SUSPECTED STEPHAN LAKE DEN - 1976.
2. BRUSHKANA DEN - 1975
3. DEADMAN DEN - 1975.
4. WATANA RENDEZVOUS SITE - 1980.
5. WATANA DEN - 1980.
6. JAY CREEK DEN - 1978.
7. CLEARWATER DEN - 1976.
8. KEG CREEK DEN - 1975, 1976, 1977.
9. SUSITNA RENDEZVOUS SITE - 1980.
10. SUSITNA RENDEZVOUS SITE - 1980.
11. SUSITNA DEN - 1979, 1980.
12. TOLSONA DEN - 1980, 1981. MENDELTNA RENDEZVOUS SITE - 1977.
13. TOLSONA RENDEZVOUS SITE - 1980. MENDELTNA DEN - 1977.
14. MENDELTNA RENDEZVOUS SITE - 1976.
15. MENDELTNA RENDEZVOUS SITE - 1977.
16. TYONE CREEK DEN - 1979.

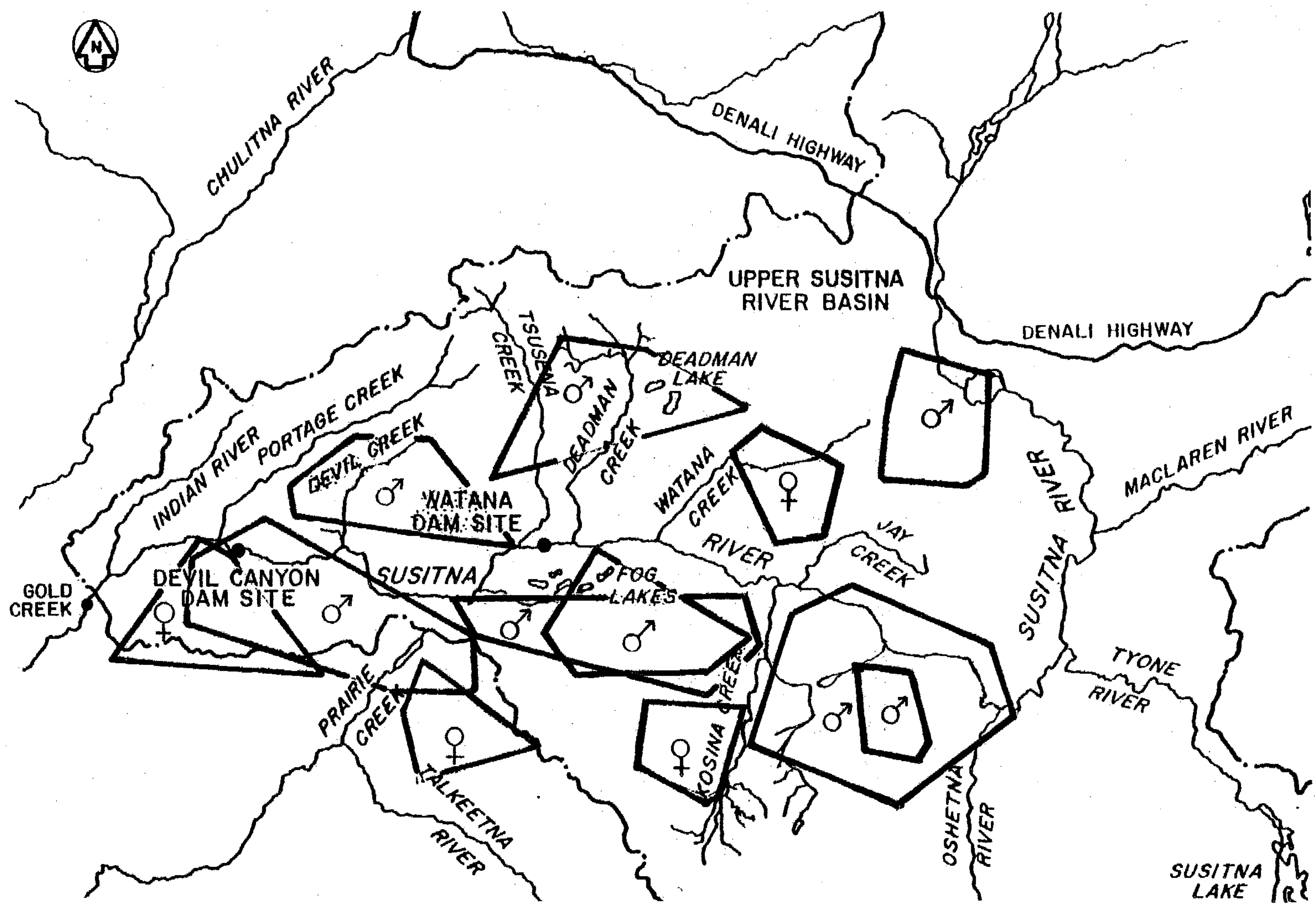




GENERAL LOCATION AND YEAR OF USE OF OBSERVED WOLF DEN AND RENDEZVOUS SITES DISCOVERED IN THE SUSITNA HYDROELECTRIC PROJECT AREA FROM 1975 THROUGH 1981

PREPARED BY TES / ADF&G

FIGURE W14



LEGEND

MALE HOME RANGES ♂

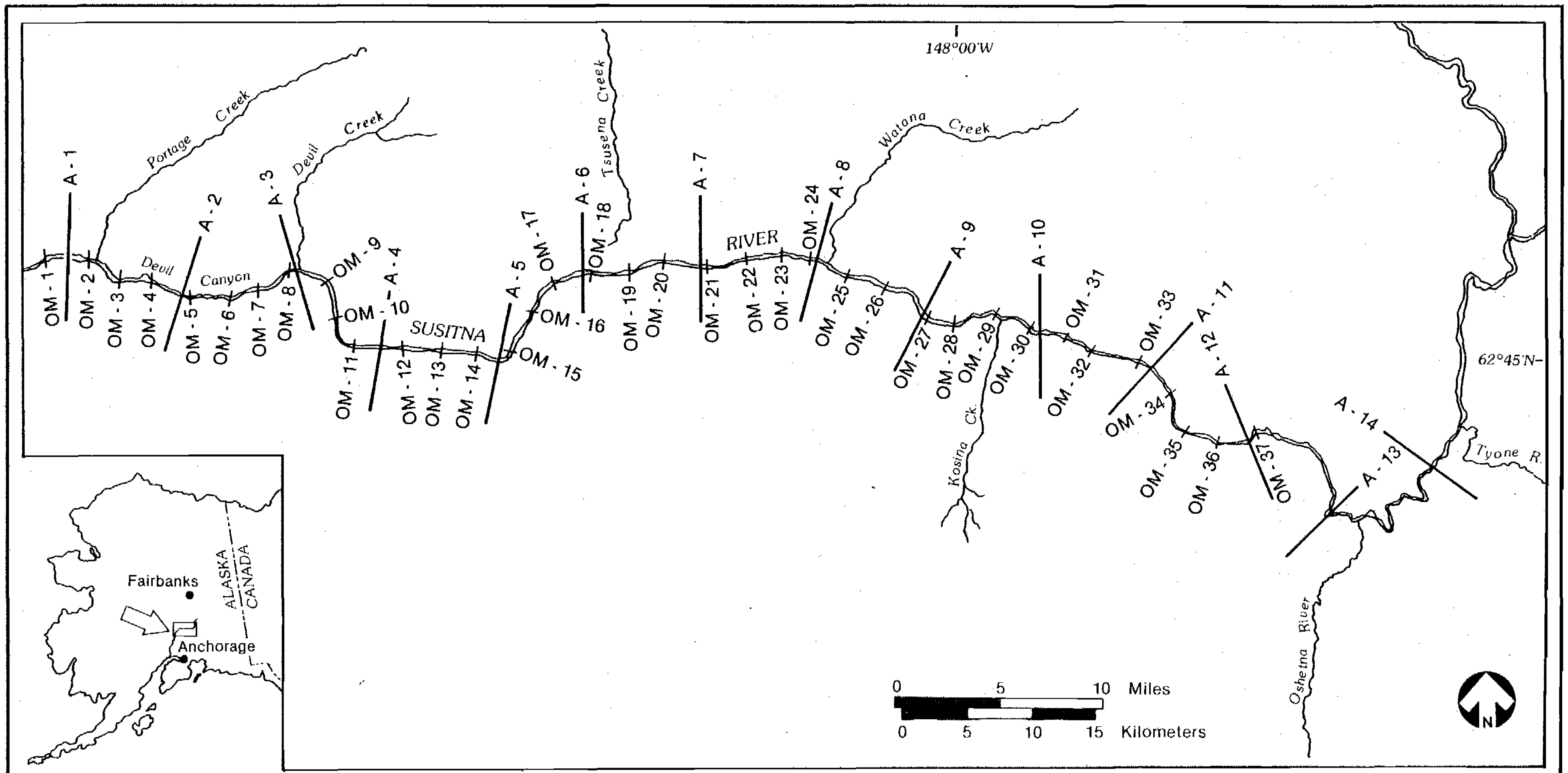
FEMALE HOME RANGES ♀

0 10 20 MILES

0 10 20 30 KILOMETERS

OBSERVED HOME RANGES OF WOLVERINES IN THE UPPER SUSITNA BASIN BASED ON LOCATION OF RADIO-COLLARED ANIMALS (FROM GARDNER AND BALLARD, 1982)

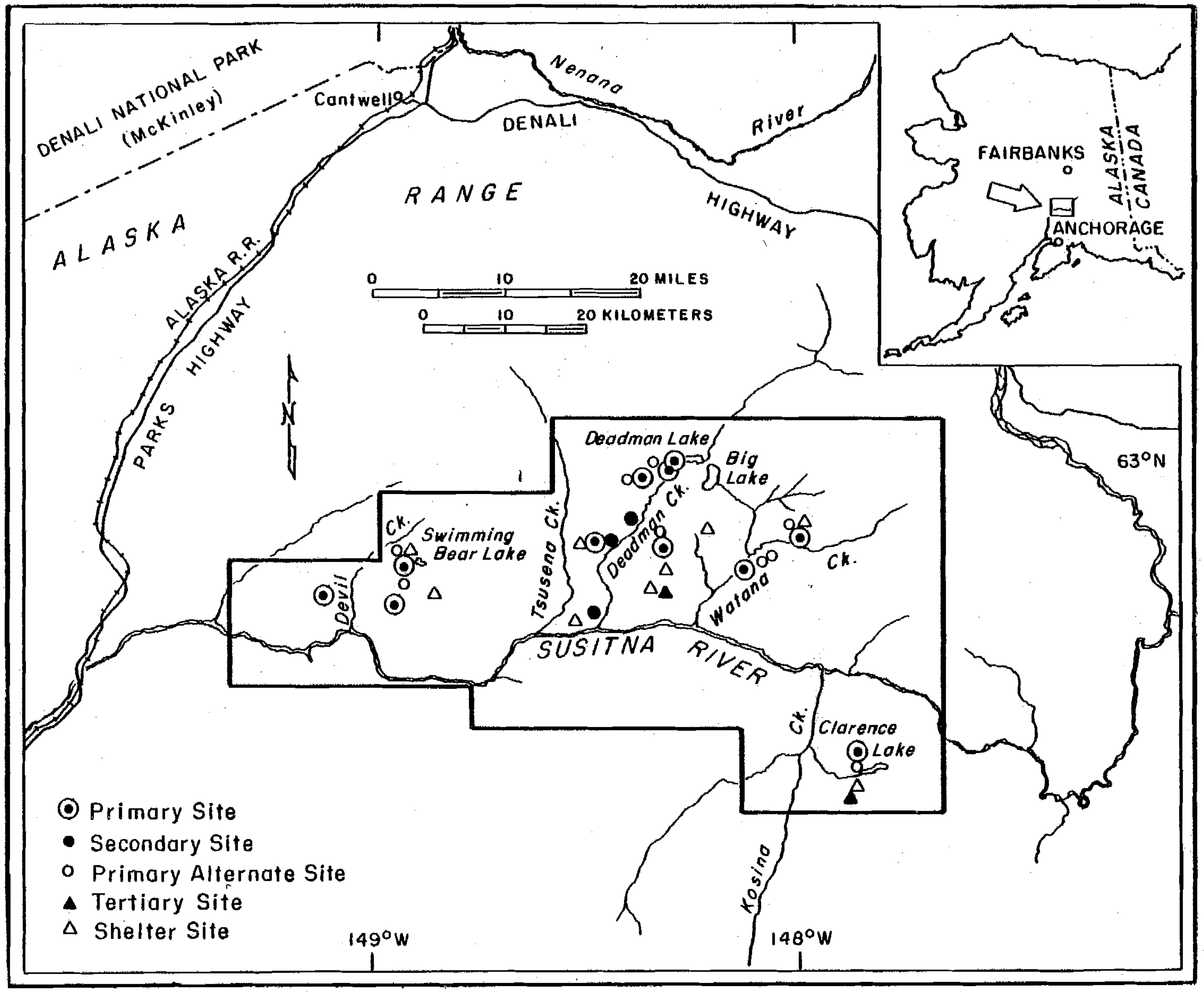
FIGURE W15



AERIAL TRANSECTS FOR FURBEARERS (A) AND CHECKPOINTS FOR SIGNS OF OTTER AND MINK (OM)

PREPARED BY TES/UNIVERSITY OF ALASKA

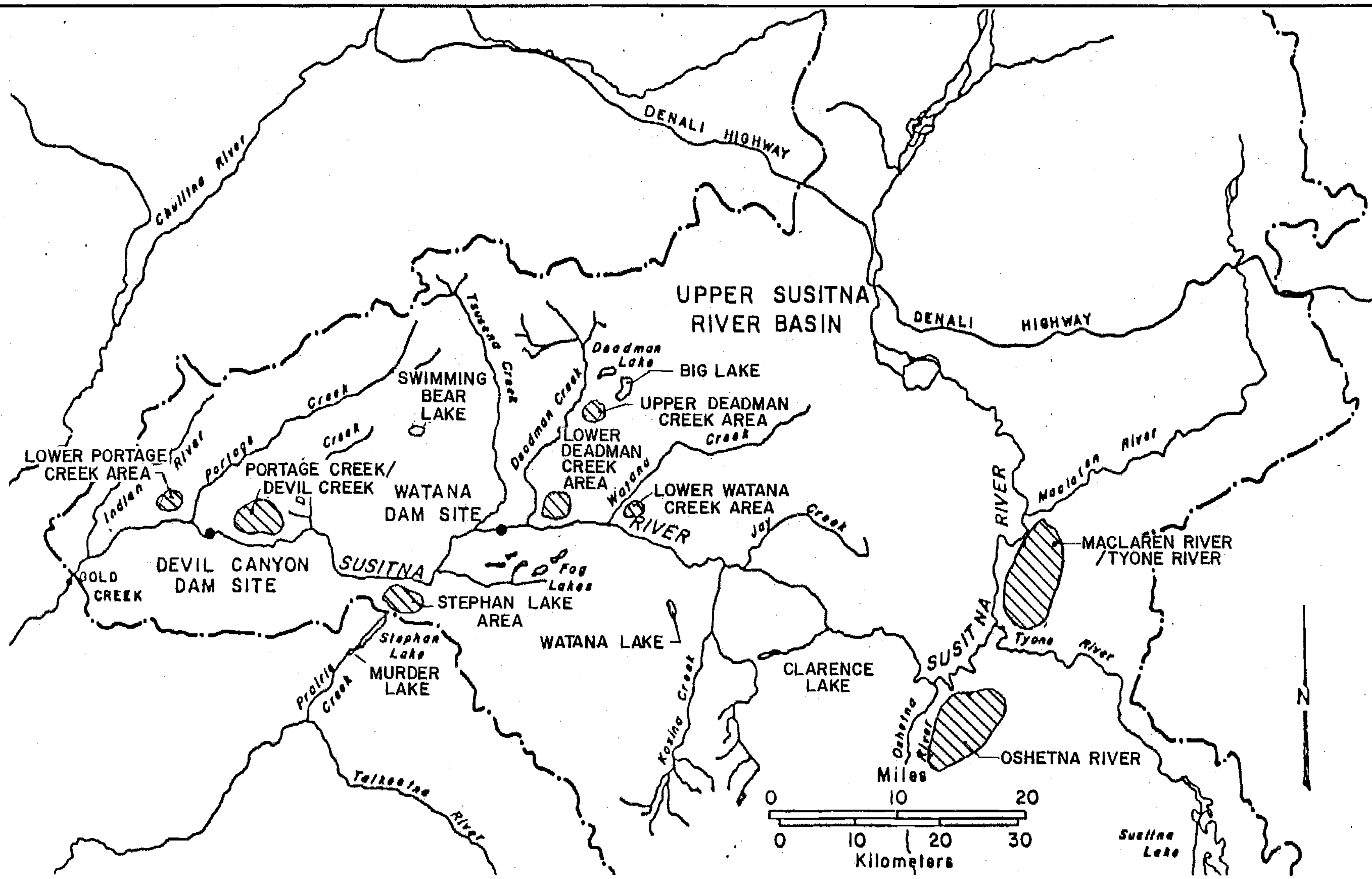
FIGURE W16



LOCATION AND CLASSIFICATION OF FOX DENS

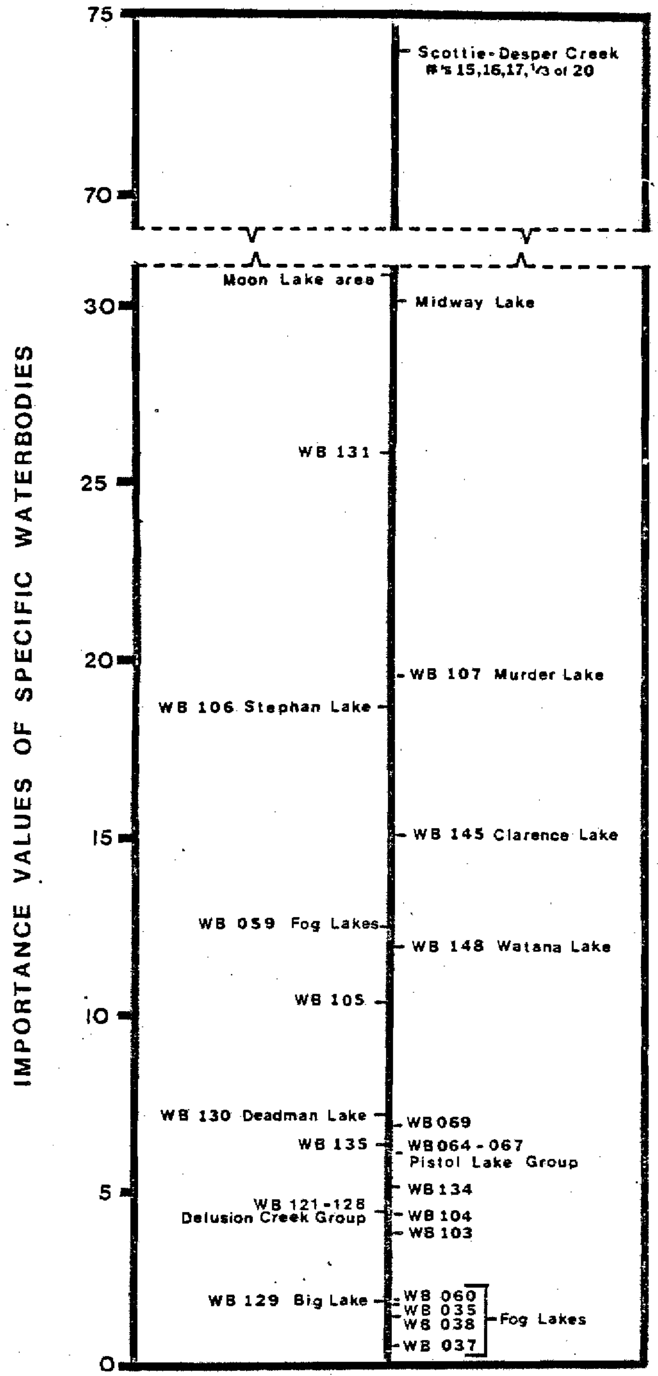
FIGURE W17

(FROM GIBSON et al. 1982).



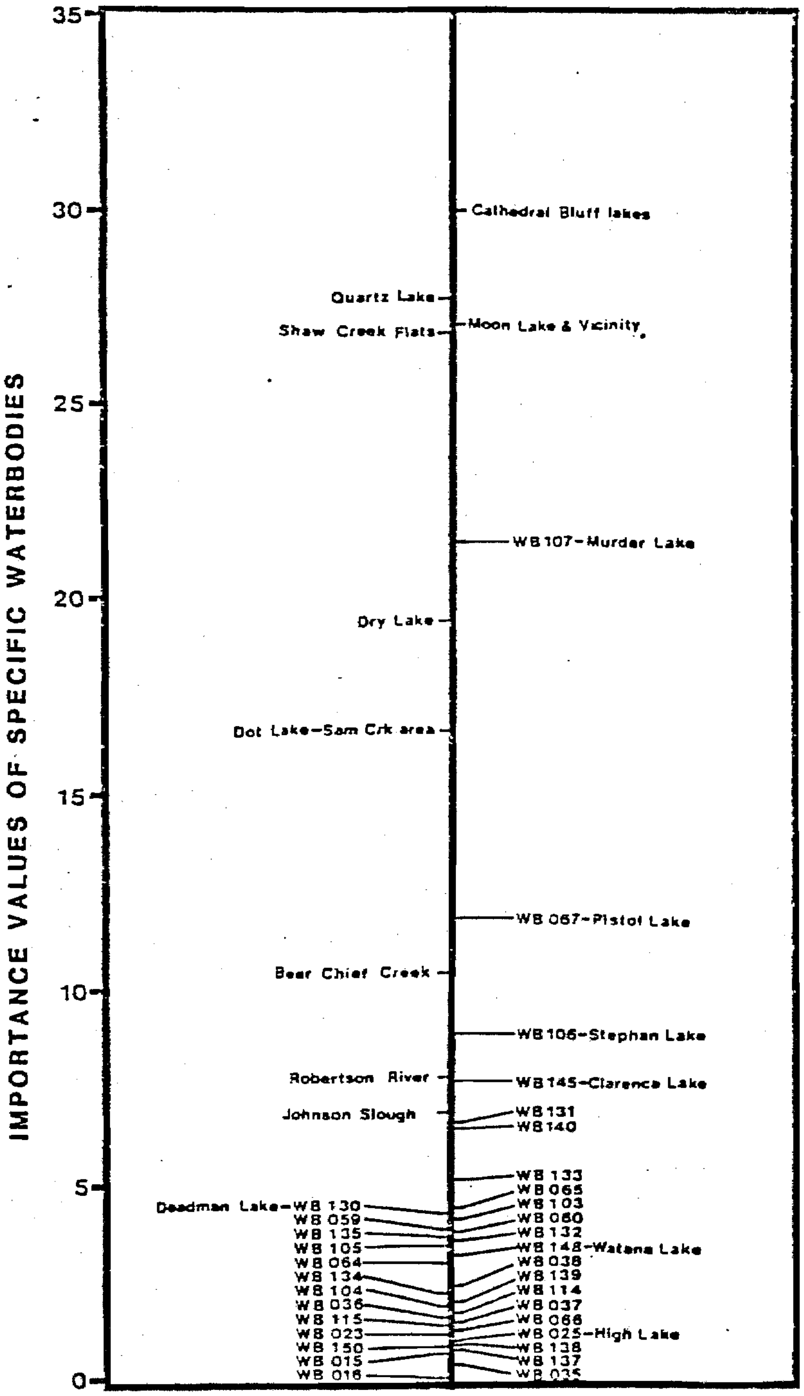
LOCATIONS OF LAKES AND LAKE GROUPS SURVEYED FOR WATERFOWL IN THE UPPER SUSITNA BASIN. TWO TO EIGHT LAKES WERE SURVEYED IN EACH HATCHED AREA

FIGURE W18

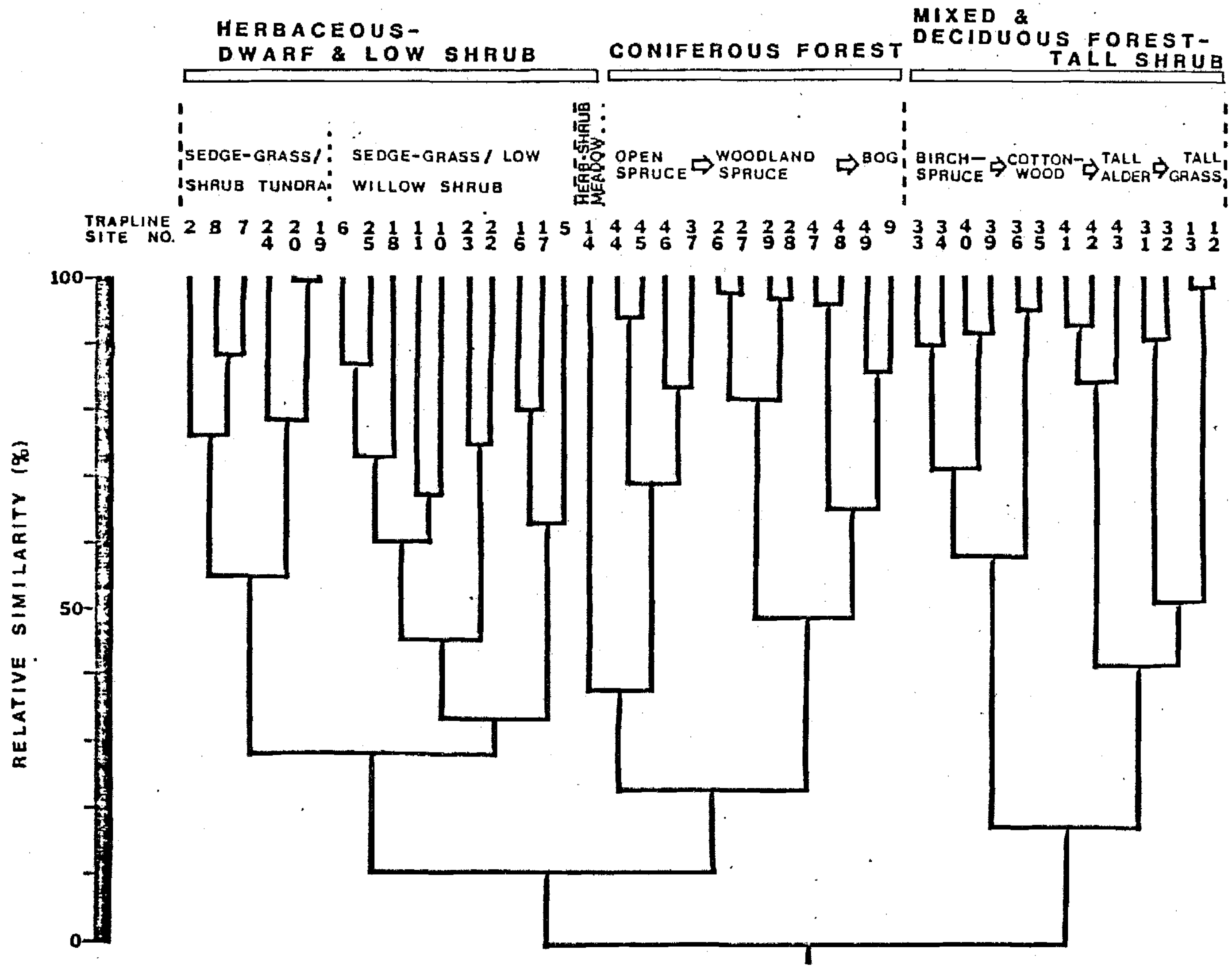


RELATIVE IMPORTANCE OF 20 WATERBODIES IN THE UPPER SUSITNA RIVER BASIN COMPARED TO THREE WATERBODIES IN THE UPPER TANANA RIVER - SCOTTIE CREEK AREA

FIGURE W20



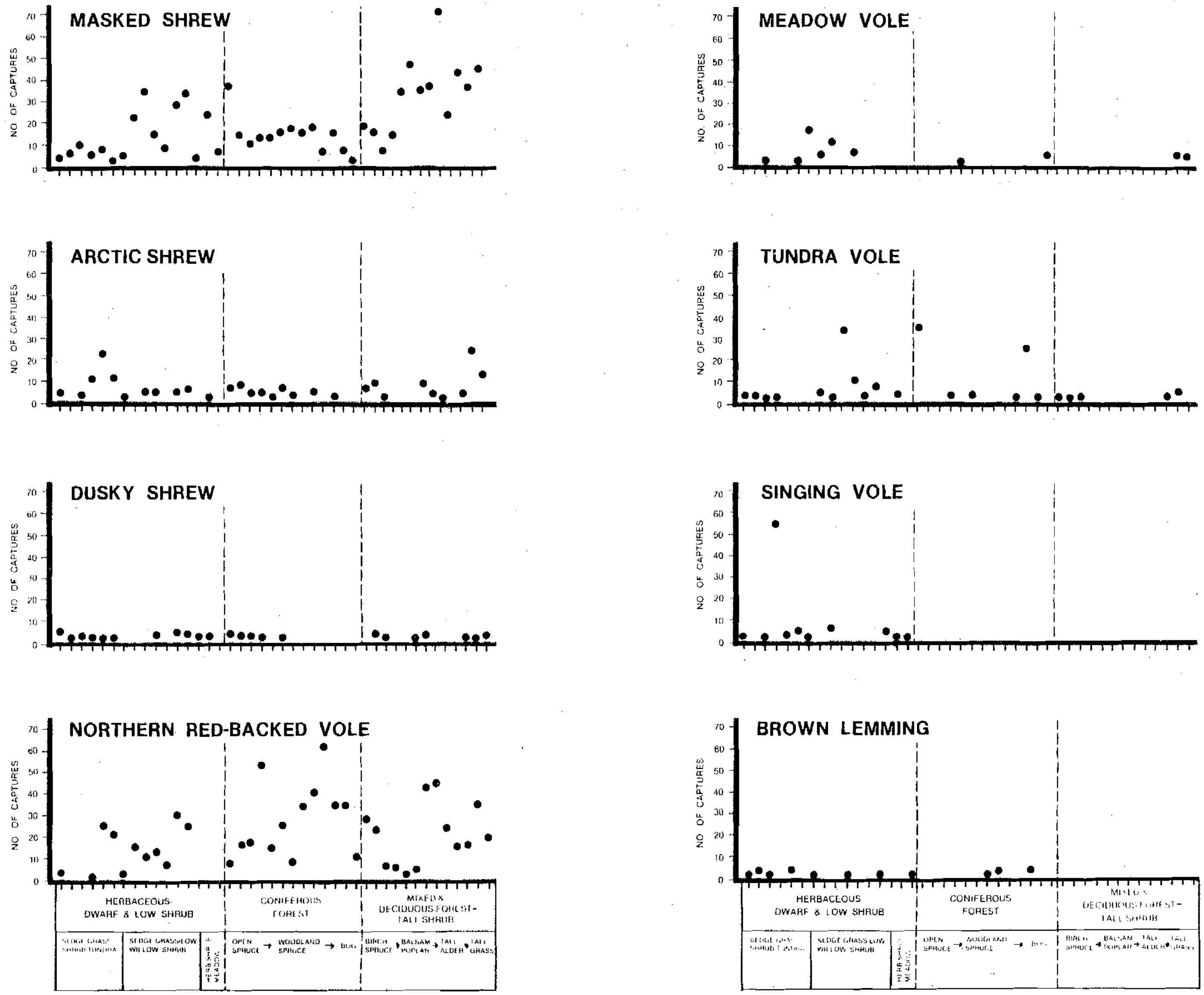
IMPORTANCE INDICES OF WATERBODIES IN THE UPPER SUSITNA BASIN AND THE UPPER TANANA RIVER BASIN



CLUSTERING OF 42 SMALL MAMMAL TRAPLINE SITES INTO SIMILAR VEGETATIVE GROUPINGS, BASED ON AN ANALYSIS OF FREQUENCY COUNTS OF 81 PLANT TAXA IN THE GROUND COVER

(FROM KESSEL et al. 1982).

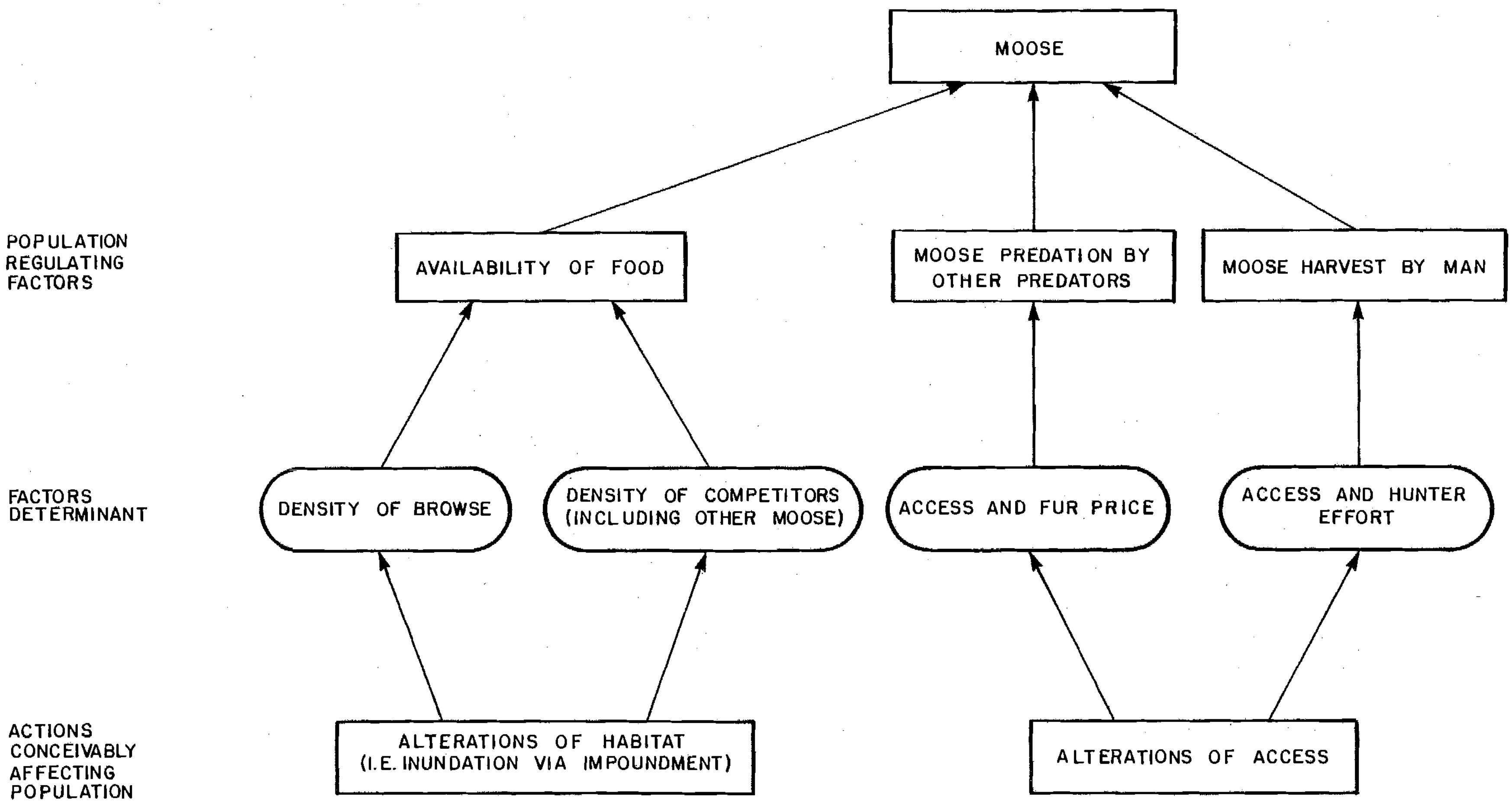
FIGURE W21



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

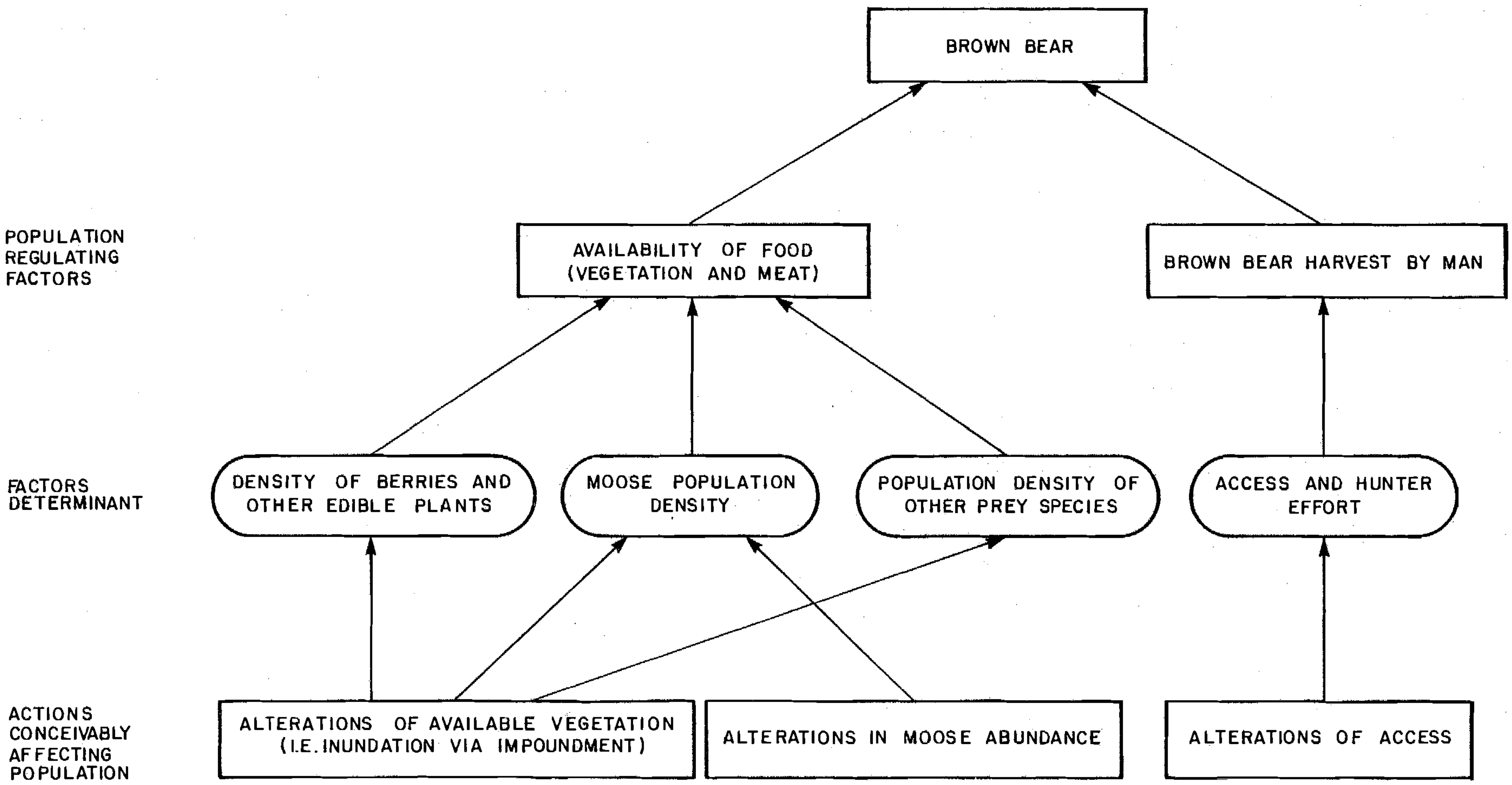
PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE W22



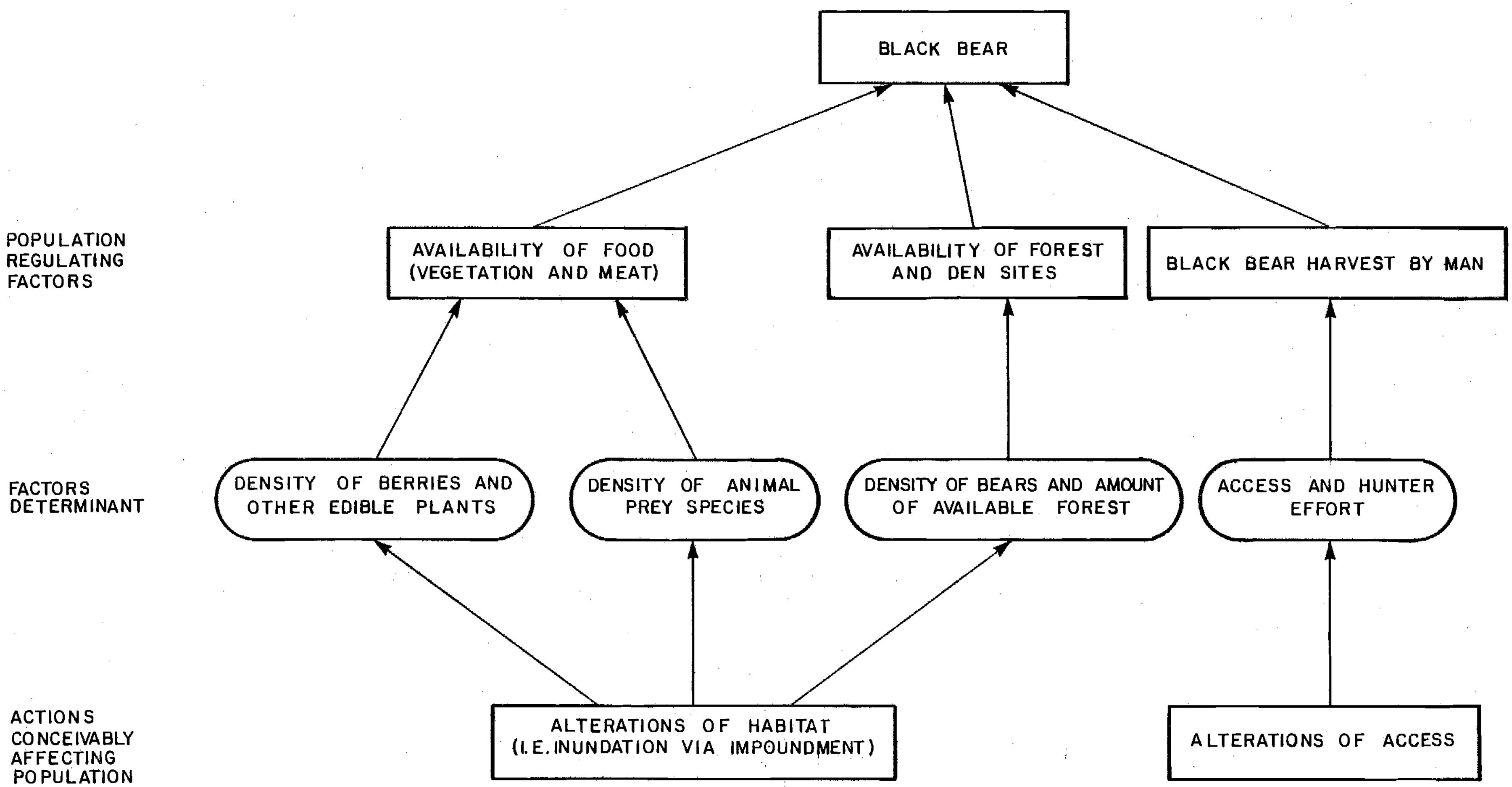
PROBABLE FACTORS REGULATING MOOSE POPULATIONS IN THE UPPER SUSITNA BASIN AND ACTIONS THAT MIGHT AFFECT THESE POPULATIONS

FIGURE W23



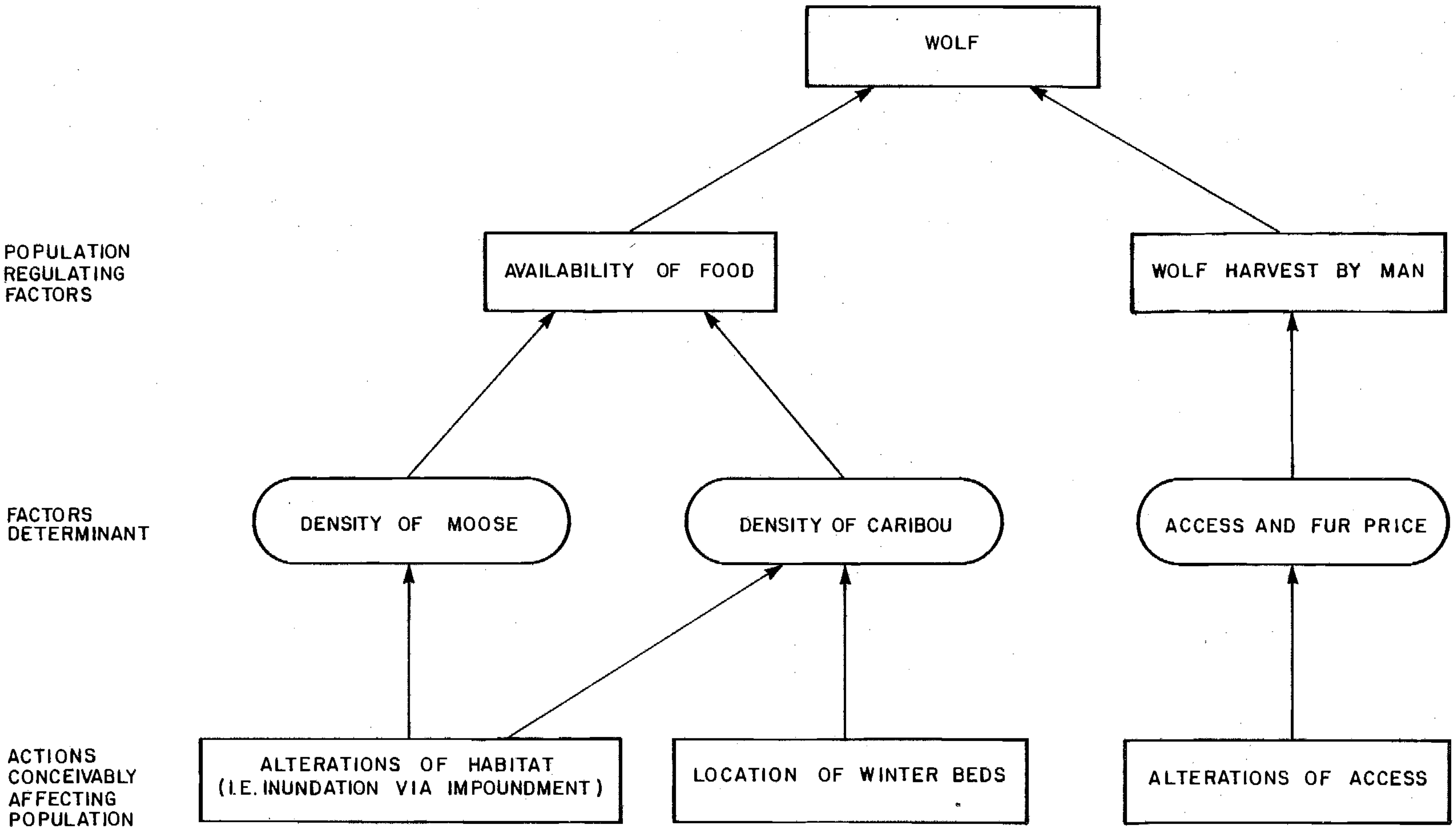
PROBABLE FACTORS REGULATING BROWN BEAR POPULATIONS IN THE UPPER SUSITNA BASIN AND ACTIONS THAT MIGHT AFFECT THESE POPULATIONS

FIGURE W24



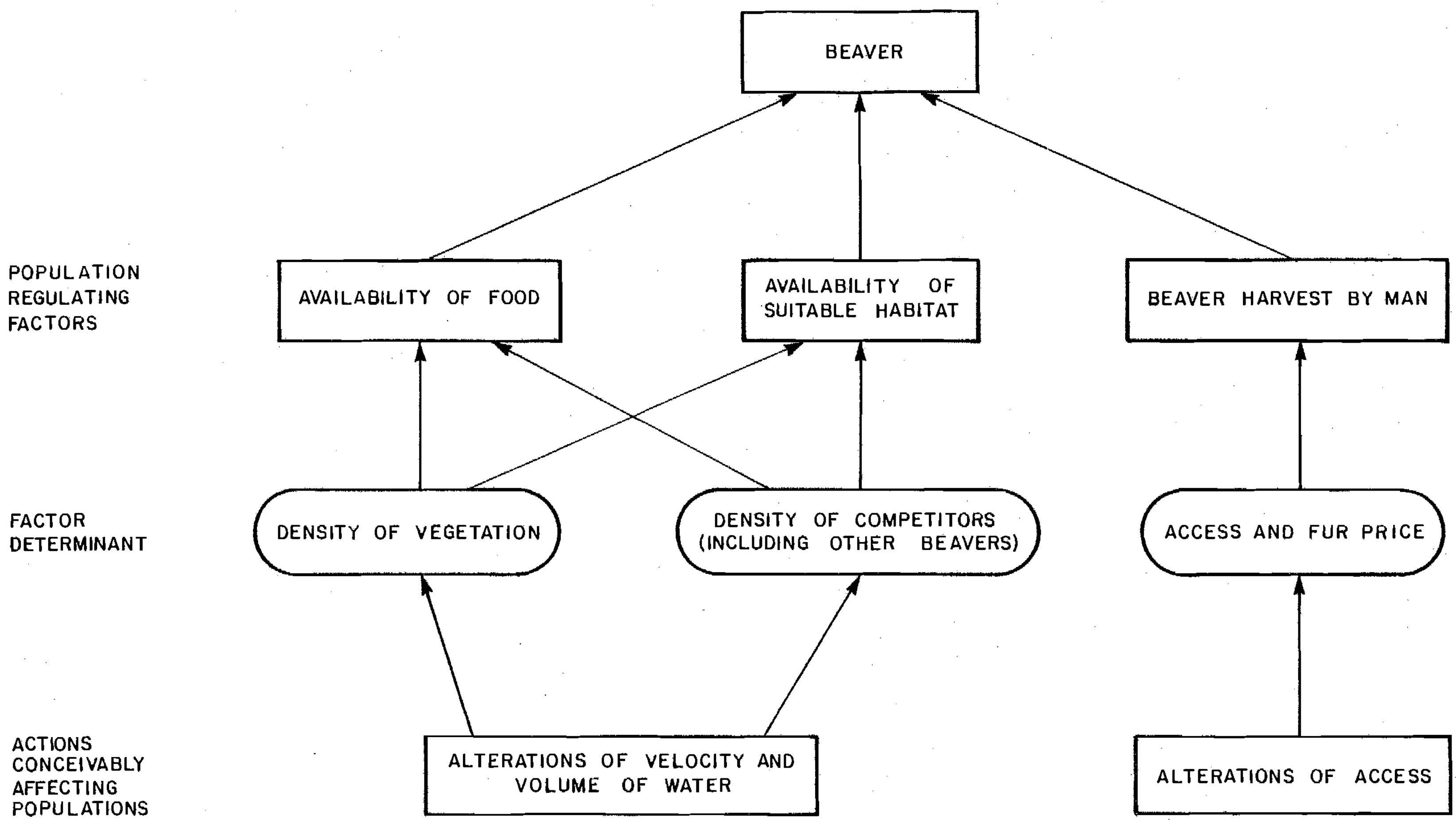
PROBABLE FACTORS REGULATING BLACK BEAR POPULATIONS IN THE UPPER SUSITNA BASIN AND ACTIONS THAT MIGHT AFFECT THESE POPULATIONS

FIGURE W25



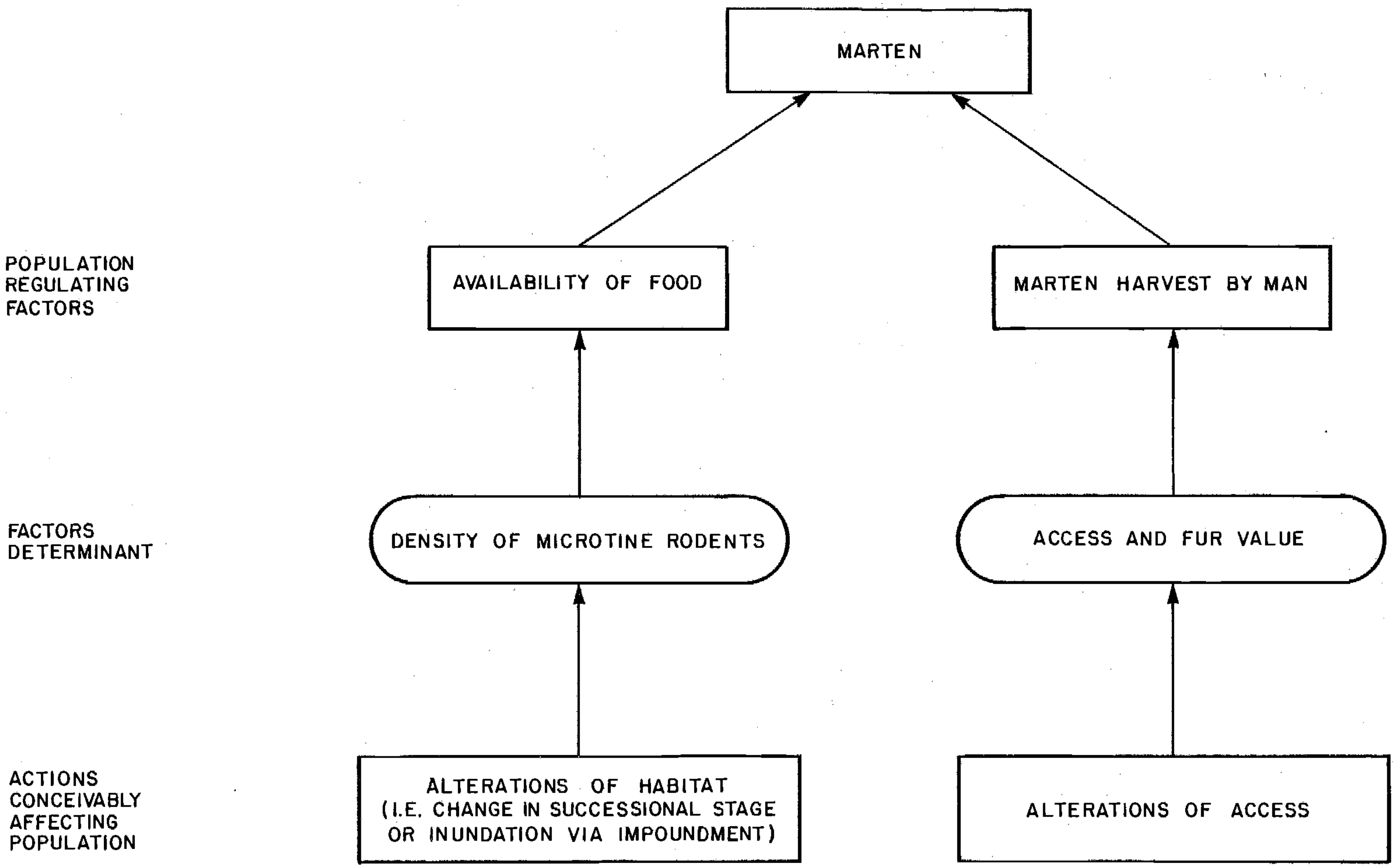
PROBABLE FACTORS REGULATING WOLF POPULATIONS IN THE UPPER SUSITNA BASIN AND ACTIONS THAT MIGHT AFFECT THESE POPULATIONS

FIGURE W26



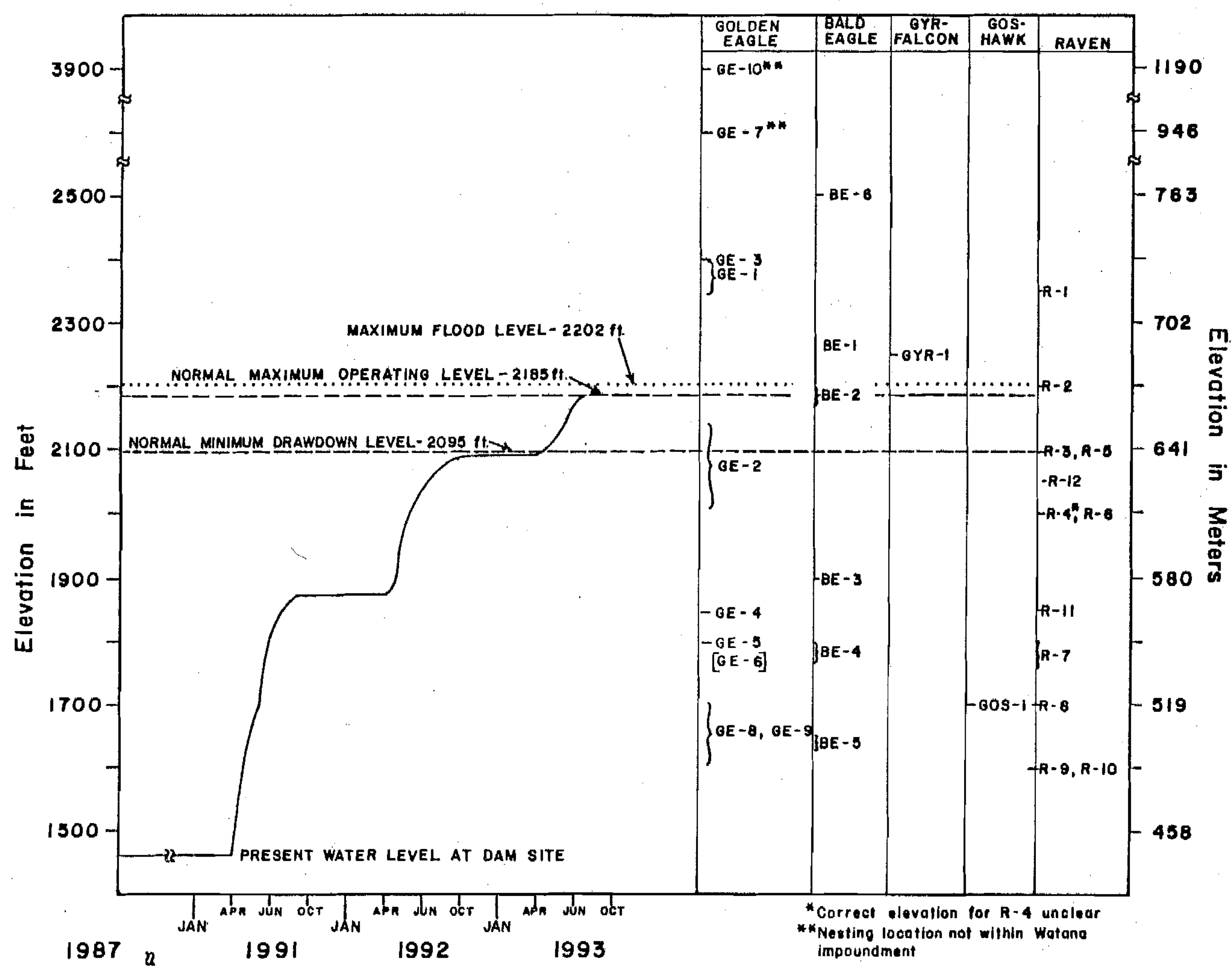
PROBABLE FACTORS REGULATING BEAVER POPULATIONS IN THE UPPER SUSITNA BASIN AND ACTIONS THAT MIGHT AFFECT THESE POPULATIONS

FIGURE W27



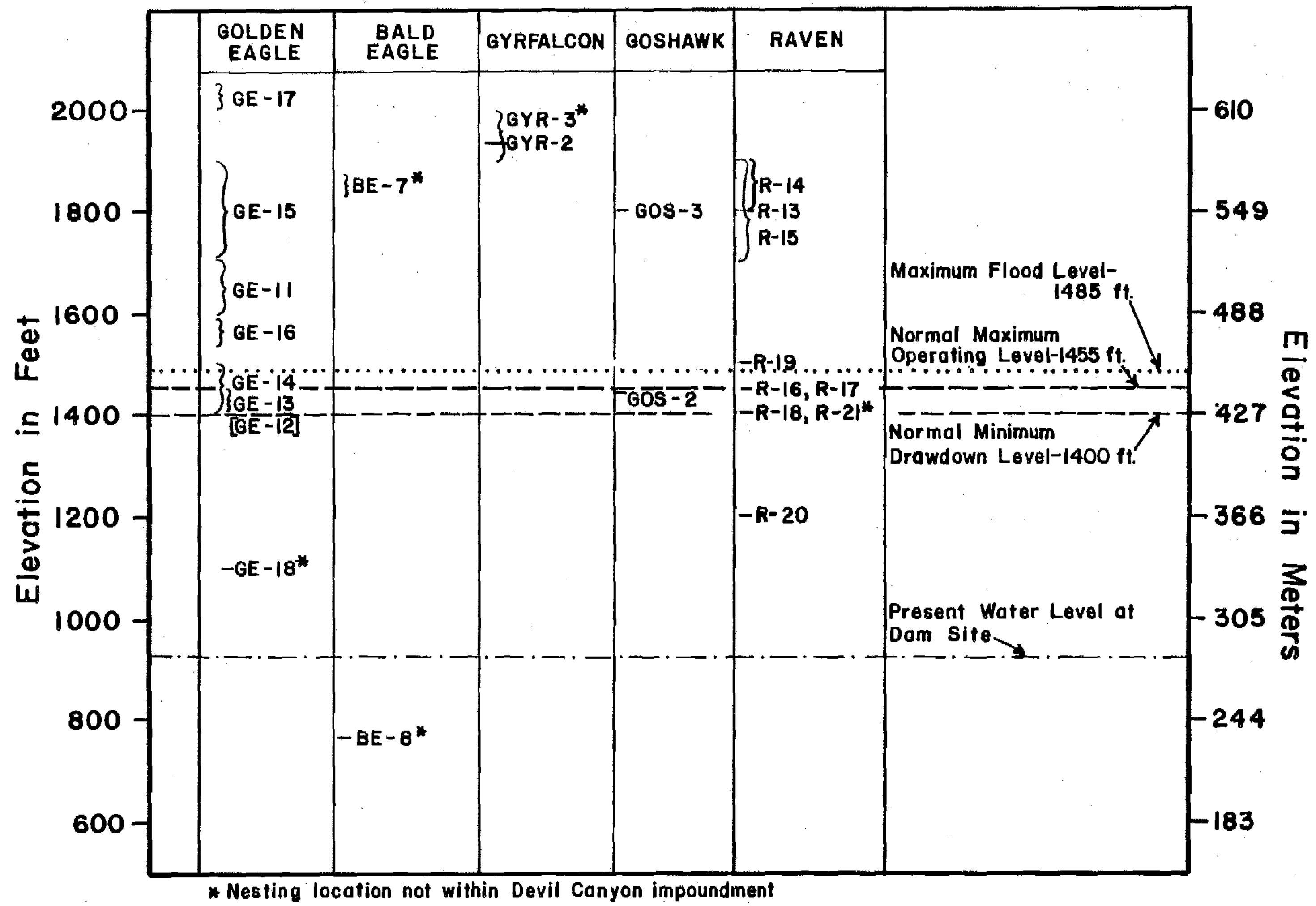
PROBABLE FACTORS REGULATING MARTEN POPULATIONS IN THE UPPER SUSITNA BASIN AND ACTIONS THAT MIGHT AFFECT THESE POPULATIONS

FIGURE W28



ELEVATIONS OF RAPTOR AND RAVEN NESTS IN THE VICINITY OF THE WATANA IMPOUNDMENT AREA IN RELATION TO FILLING AND OPERATION WATER LEVELS

FIGURE W29



CHANGES IN ELEVATION OF THE DEVIL CANYON RESERVOIR DURING OPERATION AND ELEVATIONS OF RAPTOR AND RAVEN NESTS IN THE PROXIMITY OF THE IMPOUNDMENT ZONE

FIGURE W30

APPENDICES EA TO ED

SUSITNA HYDROELECTRIC PROJECT

Environmental Guidelines for Facility Siting, Design Construction, Operation, and Rehabilitation.

A - ALL FACILITIES

1. A 500-foot maximum width buffer of undisturbed vegetation should be maintained between a facility and any stream, lake or wetland.

2. Siting should minimize requirements for clearing removal of vegetation.

3. Where removal of vegetation is required, organic overburden should be segregated and stockpiled for use in subsequent rehabilitation. Stockpiles should be placed in well-drained locations and bermed to contain runoff. Depleted or nonoperational borrow pits should be used as overburden storage areas where feasible.

4. Structures should be consolidated to disturb the minimum necessary area of ground surface.

5. Design should minimize gravel requirements by avoidance of wet areas or permafrost zones, structures consolidation, and balanced cut and fill.

6. Where gravel pads must be used, adequate provision for cross-drainage should be made to avoid impoundment of sheet flow.

7. A minimum distance of 1/2 mile should be maintained between any facility and the following:

   - Salmon spawning area;
   - Bald eagle nest;
   - Golden eagle nest;
   - Brown bear den;
   - Wolf den;
   - Dall sheep lambing area; and
   - Mineral lick.

8. Blasting should avoid times and locations which are sensitive to fish and wildlife. These times and locations should be determined on a case-by-case basis by the environmental consultant and in accordance with resource agency guidelines. Proper sizing and sequencing of blasting charges can minimize fish and wildlife impacts. Streamside excavation should not be done by blasting. Blasting procedures and schedules must be sufficiently flexible to allow alteration at short notice for the protection of wildlife. Alaska Department of Fish and Game blasting guidelines should be followed.

9. Excavation spoil should be disposed of in the future impoundment area of the dam under construction. Where haul distances prohibit this, spoil should be used in the rehabilitation of depleted or nonoperational material sites, or for solid waste disposal site maintenance. Spoil retained for these applications should be stockpiled in stable, well-drained locations, and bermed to contain runoff.

10. Solid waste disposal sites should be established in stable, well-drained locations. Siting should utilize existing excavations such as depleted upland borrow pits. Intermittent drainages, ice-rich soils, or other erosion-susceptible features should be avoided. Deposited material should be covered daily with nonsilty excavation spoil stockpiled for this purpose at the site. Solid waste disposal site design and operation should conform with guidelines established by the Alaska Department of Environmental Conservation.

11. Facility siting should avoid thaw susceptible areas (discontinuous permafrost zones) capable of slumping or thermal erosion.

12. Where hydraulic erosion is unavoidable, appropriate measures (ranging from filtration fabric to settling ponds) should be employed to minimize siltation.

13. Erosion-prone slopes should be fertilized and dry seeded with a fast-growing native grass.

14. Equipment, structures and materials should be removed from a site prior to rehabilitation. The site should be graded to contours which are consistent with surrounding terrain and allow complete drainage with minimal erosion potential.

15. Where it can be demonstrated that erosion is not likely to be a problem, restoration should emphasize fertilization and scarification and minimize seeding, to encourage the invasion of native plants from the surrounding parent population. Where seeding is employed, native grasses appropriate to the climate and geography of the project area should be used.

16. A systematic program to avoid or mitigate project activity-related impacts should be developed during Phase II. At a minimum, this program should include the following components:

   - A Petroleum and Hazardous Substance Plan which sets forth detailed specifications for training of personnel and for procedures and equipment to ensure the safe storage, handling, transporation, collection, and disposal of petroleum products and hazardous substances. This program should include the preparation of a Petroleum and Hazardous Substances Manual to be used by all project personnel. Special attention should be given to the design of this manual so that size, format, and contents facilitate routine on-the-job use.

- An Environmental Briefings Program to familiarize project personnel with environmentally sensitive features of the project area, federal and state regulations, agency permit stipulations, and specific project policies and restrictions regarding protection of vegetation, fish, wildlife, and cultural resources. The Environmental Briefings Program should be combined with the project Safety Program and involve continuing updates and reviews through regularly scheduled weekly meetings. The Environmental Briefings Program should be positive and informative in nature and use visual aids to stimulate interest. The program should strive to explain why a certain feature or organism is vulnerable to disturbance, and therefore why protective measures are needed in each case.

17. Storage containers for fuels and hazardous substances should be located at least 1500 feet from water bodies and bermed to contain 110 percent of the maximum volume to be stored. Containment areas should be lined with impervious material.

18. Project construction and operation activities should be planned and scheduled to avoid or minimize disturbance to fish streams. Where activities affecting fish streams cannot be avoided (e.g., construction of stream crossings), activities should be scheduled for periods when fish are not present. Where stream crossings are planned for winter construction, the thalweg, banks, and other locational features should be identified and staked in the field prior to snowfall or freeze-up.

B - CONSTRUCTION CAMPS

1. To minimize scavenging by birds and mammals, with resultant adverse contacts between people and animals, all putrescible kitchen waste should be stored indoors in sealed containers and incinerated on the same day they are produced.

2. Camp incinerators should be properly sized and operated by trained personnel to ensure that all putrescible wastes are completely burned to mineral ash. Incinerator capacity should be carefully specified to accommodate peak camp occupancy.

3. Camp perimeters should be protected with animal-resistant fencing designed and built to specifications provided by the environmental consultant.

4. The liquid waste treatment system should be operated by state of Alaska accredited personnel. Grey water must be treated along with other liquid wastes. A regular effluent sampling and testing program should be followed to ensure compliance with NPDES and state of Alaska Wastewater Disposal Standards (18 AAC 72). Effluent testing should be conducted by a state of Alaska certified water quality laboratory. Effluent discharge to streams should be located to achieve maximum dilution.

5. Wells should be established for potable water withdrawal. If wells are not feasible at a given location, water should be withdrawn from lakes. Streams should be considered only as a last resort, and only after a determination is made on a case-by-case basis that fish or wildlife will not be adversely affected by water withdrawal, particularly during overwintering and reproductive periods. Intake structures should be designed to preclude entrapment or entrainment of fish eggs or larvae.

C - ACCESS ROADS

1. Road design speeds should be kept to the minimum consistent with project requirements and should not exceed 40 miles per hour. Lower design speeds allow greater flexibility for alignment adjustments to avoid environmentally sensitive features and reduce requirements for major road cuts. Lower design speeds also enable routing to follow higher, drier terrain, thereby reducing requirements for gravel extraction and fill placement in wetlands. A 40-mile-per-hour design speed will increase road safety and enhance recreational resource potential.

2. Road profile elevations should be minimized and side slopes made sufficiently gentle to allow free passage of big game.

3. Routes should avoid wetland and riparian areas, and minimize stream crossings and encroachments.

4. Road design should keep gravel extraction requirements to a minimum by avoiding wet areas and emphasizing balanced cut and fill.

5. Where stream crossings cannot be avoided, they should be aligned at right angles to the stream and located to minimize requirements for bank cutting and streambed disturbance. Fish spawning and overwintering areas within streams should be avoided by route adjustments.

6. Bridges should be installed in preference to culverts or low-water crossings (fords). Bridge supports should be located outside active channels.

7. Culverts should be properly sized to accommodate all species and age groups of fish utilizing that portion of the stream (see Alaska Department of Fish and Game stream crossing guidelines).

8. Culverts should be placed to conform with the slope of the undisturbed streambed at the place of installation and should not be perched.

9. Low-water crossings should be used only where a stream will sustain infrequent, light traffic. Such crossings should conform to the slope of the undisturbed streambed and should be constructed of materials that will preclude water percolating through rather than over them.

10. Where stream crossings are planned for winter construction, the thalweg, banks, and other locational features should be identified and staked in the field prior to snowfall or freeze-up. Overwintering areas of fish or aquatic mammals must not be disturbed during winter construction.

11. All access roads not required for project operation or recreational purposes, should be "put to bed" as soon as they are no longer required, if possible during the same season. Drainage structures should be removed and the roadbed recontoured to a stable configuration providing proper drainage. Rehabilitation should include scarification, fertilization, and blockage with a berm followed by a cut. Erosion-prone locations should be seeded with fast-growing native grasses. Where impoundment of sheet flow has occurred, nonoperational roads should be structurally altered to restore normal flow.

12. Road dust control should utilize water rather than oil or other synthetic compounds. Water withdrawal procedures and sources for dust control should be approved on a case-by-case basis by environmental personnel following site-specific inspection.

13. Grading or other road maintenance activities should not push material into streams. Culverts should be checked periodically and kept free of ice and debris to avoid blocking flows. Special attention to culverts is required immediately prior to, during, and following spring break-up.

D - MATERIAL SITES

1. A detailed, site-specific mining plan should be prepared for each borrow operation. Design should be an interdisciplinary team effort involving civil engineers and environmental specialists experienced in design, construction, and permit requirements. Mining plans should include all roads, facilities, mining techniques, schedules, and rehabilitation procedures.

2. Borrow areas required for dam and ancillary facility construction should be sited in the future impoundment area of the dam under construction.

3. Siting of borrow areas outside the impoundment zone should place first priority on well-drained upland locations. Second priority consideration should be given to first-level terrace sites. Active floodplain and streambed sites should be avoided unless they are within the impoundment area of the dam under construction. Stockpiling within active floodplains should be prohibited. Floodplain gravel mining should follow the guidelines set forth in the U. S. Fish and Wildlife Service "Gravel Removal Guidelines Manual for Arctic and Subarctic Floodplains," 1980.

4. All material sites should be developed in phases by aliquots. The phases should be prioritized to save until last those portions of the site which are more sensitive from an environmental standpoint.

5. First-level terrace sites outside the impoundment zone should be located on the inactive side of the floodplain and mined by pit excavation rather than by shallow scraping. Excavations should be separated from the active floodplain by a 500-foot buffer of undisturbed, vegetated terrain.

6. If wet processing is required, water withdrawal and discharge locations should be carefully sited to minimize fish and wildlife disturbance. Drawdown in overwintering pools used by fish or aquatic mammals and any disturbance to spawning areas must be avoided. Water intake structures should be designed to preclude entrapment or entrainment of fish eggs or larvae. Gravel washing should employ recycled water. If pit dewatering is required because of ponding or wet processing, settling ponds should be designed, operated, and monitored to ensure that NPDES standards for discharge are achieved. Settling ponds should be designed and sited to avoid fish entrapment. Water discharge should be directed in a manner that will minimize erosion. Energy dissipators should be used where necessary.

7. Abandoned access roads, camp pads, and airstrips should be used wherever feasible as material sources for operations in lieu of expanding existing sites or initiating new ones. Where riprap is required, material produced during excavation of the powerhouse, galleries, and tunnels should be used if feasible.

8. Material site design features should facilitate restoration. Sites should have irregular boundaries, including projections of undisturbed, vegetated terrain into the site. Slopes should incorporate a diversity of contours created during actual excavation, rather than during restoration.

9. Where ponding will occur, as in first-level terrace sites, irregular boundaries and slope contours should be accentuated. Islands of undisturbed vegetated terrain should be left within the perimeter of the operational site.

10. Organic overburden, slash, and debris stockpiled during clearing should be distributed over the excavated area prior to fertilization. This includes sites which have ponded.

11. Once operational material sites are depleted or no longer required, they should be rehabilitated by the end of the next growing season following last use.

E - TRANSMISSION CORRIDORS

1. Where they are not adjacent to an existing road, transmission corridors should be constructed by helicopter support to avoid necessary clearing of vegetation. In tundra locations where clearing is not required for access, winter construction on a snow base may be an acceptable substitute for helicopter-supported construction, provided Rolligon or flat-tread, Nodwell-type vehicles are used. Transmission corridor development should avoid creating an alternate access route for all-terrain vehicles.

2. Transmission line additions should be made adjacent to established transmission corridors. Where transmission lines have a common destination, they should follow a common route.

3. Transmission towers should not be placed in active floodplains and should avoid streams and lakes by a minimum 500 feet.

4. Herbicides should not be used for vegetation control along transmission corridors.

5. Transmission corridors should follow the forest edge (i.e., the transition zone between forest and shrub or forest and tundra) and avoid crossing wetlands.

APPENDIX EE: SCIENTIFIC NAMES OF MAMMAL SPECIES FOUND IN THE PROJECT AREA

Common Name	Scientific Name
Moose	*Alces alces*
Caribou	*Rangifer tarandus*
Dall Sheep	*Ovis dalli*
Brown Bear	*Ursus arctos*
Black Bear	*Ursus americanus*
Wolf	*Canis lupus*
Wolverine	*Gulo gulo*
Belukha Whale	*Delphinapterus leucas*
Beaver	*Castor canadensis*
Muskrat	*Ondatra zibethica*
River Otter	*Lutra canadensis*
Mink	*Mustela vison*
Marten	*Martes americana*
Red Fox	*Vulpes fulva*
Lynx	*Lynx canadensis*
Coyote	*Canis latrans*
Short-Tailed Weasel	*Mustela erminea*
Least Weasel	*Mustela nivalis*
Masked Shrew	*Sorex cinereus*
Dusky Shrew	*Sorex monticolus*
Arctic Shrew	*Sorex arcticus*
Pygmy Shrew	*Sorex hoyi*
Collared Pika	*Ochotona collaris*
Snoweshoe Hare	*Lepus americanus*
Hoary Marmot	*Marmota caligata*
Arctic Ground Squirrel	*Spermophilus parryii*
Red Squirrel	*Tamiasciurus hudsonicus*
Northern Red-Backed Vole	*Clethrionomys rutilus*
Meadow Vole	*Microtus pennsylvanicus*
Tundra Vole	*Microtus oeconomus*
Singing Vole	*Microtus miurus*
Brown Lemming	*Lemmus sibiricus*
Northern Bog Lemming	*Synaptomys borealis*
Porcupine	*Erethizon dorsatum*

APPENDIX EF

STATUS, HABITAT USE AND RELATIVE ABUNDANCE OF BIRD SPECIES IN THE UPPER SUSITNA BASIN

(Based on Kessel et al, 1982)

Species	Status[1]	Main Habitats	Relative Abundance[2]
Common loon *Gavia immer*	B	lakes	U-sp, F; FC-S
Arctic loon *Gavia arctica*	B?	lakes	U-sp, S
Red-throated loon *Gavia stellata*	B?	lakes, rivers	U-sp, S
Red-necked grebe *Podiceps grisegena*	B	lakes	U
Horned grebe *Podiceps auritus*	B	lakes	U
Whistling swan *Olor columbianus*	T	lakes	U-sp, F
Trumpeter swan *Olor buccinator*	B	lakes	U-sp, F, FC-S
Brant			
Canada goose *Branta canadensis*	T	lakes, rivers	U-sp, F
White fronted goose *Anser albifrons*	T	lakes	U-sp
Snow goose *Chen caerulescens*	T	lakes	U-sp
Mallard *Anas platyrhynchos*	B	lakes, rivers	C-sp, FC-S,F
Gadwell *Anas strepera*	T, S	lakes	R-sp
Pintail *Anas acuta*	B	lakes	C-sp, FC-S, U-F
American green-winged teal *Anas crecca carolinensis*	B	lakes	FC-sp, S, U-F
Blue-winged teal *Anas discors*	T	lakes	R-sp, F
American wigeon *Anas americana*	B	lakes	FC
Northern shoveler *Anas clypeata*	B	lakes	U
Redhead *Aythya americana*	T	lakes	U-sp
Ring-necked duck *Aythya collaris*	T	lakes	R-sp, F

APPENDIX EF

STATUS, HABITAT USE AND RELATIVE ABUNDANCE OF BIRD SPECIES IN THE UPPER SUSITNA BASIN (Cont'd)

(Based on Kessel et al, 1982)

Species	Status[1]	Main Habitats	Relative Abundance[2]
Canvasback *Aythya valisineria*	T	lakes	U-sp
Greater scaup *Aythya marila*	B	lakes	C-sp, F
Lesser scaup *Aythya affinis*	B	lakes	FC-S
Common goldeneye *Bucephala clangula*	B	lakes, rivers	FC-sp, F, U-S
Barrow's goldeneye *Bucephala islandica*	B	lakes, rivers	
Bufflehead *Bucephala albeola*	T	lakes	U-sp, FC-F
Oldsquaw *Clangula hyemalis*	B	lakes	FC-sp, S; U-F
Harlequin duck *Histrionicus histrionicus*	B	rivers	
White-winged scoter *Melanitta deglandi*	T	lakes	FC
Surf scoter *Melanitta perspicillata*	B	lakes	
Black scoter *Melanitta nigra*	B	lakes	
Common merganser *Mergus merganser*	B	lakes, rivers	U
Red-breasted merganser *Mergus serrator*	B	lakes, rivers	U
Goshawk *Accipiter gentilis*	B	deciduous and mixed forest	U
Sharp-shinned hawk *Accipiter striatus*	B?	coniferous and mixed forest	U
Red-tailed hawk *Buteo jamaicensis*	B	coniferous and mixed forest	U
Golden eagle *Aquila chrysaetos*	B	cliffs	FC
Bald eagle *Haliaeetus leucocephalus*	B	forests, cliffs	U
Marsh hawk *Circus cyaneus*	B?	meadows	FC-sp, F; U-S
Osprey *Pandion haliaetus*	T	lakes	R-sp

APPENDIX EF

STATUS, HABITAT USE AND RELATIVE ABUNDANCE OF BIRD SPECIES IN THE UPPER SUSITNA BASIN (Cont'd)

(Based on Kessel et al, 1982)

Species	Status[1]	Main Habitats	Relative Abundance[2]
Gyrfalcon Falco rusticolus	B, W	cliffs	U
Peregrine falcon Falco peregrinus	T?	cliffs	2 records (1974)
Merlin Falco columbarious	B?	scattered woodland, forest edge	U
American kestrel Falco sparverius	T	open forest	R-F
Spruce grouse Canachites canadensis	B, W	coniferious and mixed forest	FC
Ruffed grouse Bonasa umbellus	V	forest	R
Willow ptarmigan Lagopus lagopus	B, W	low shrub land	C
Rock ptarmigan Lagopus mutus	B, W	low , dwarf shrubland, block fields	C
White-tailed ptarmigan Lagopus leucurus	B, W	high elevation dwarf shrub tundra and block fields	U
Sandhill crane Grus canadensis	T	wetlands	U
American golden plover Pluvialis dominica	B	dwarf shrub mat and meadow	C
Surfbird Aphrixa virgata	B?	dwarf shrub mat	R
Semipalmated plover Charadrius semipalmatus	B	alluvial bars	U
Common snipe Capella gallinago	B	wet meadows	C
Whimbrel Numerniu phaeopus	B?	dwarf shrub meadow	U
Upland sandpiper Bartramia longicauda	B?	dwarf shrub meadow near scattered woodland	R
Spotted sandpiper Actitis macularia	B	alluvial bars	C

APPENDIX EF

STATUS, HABITAT USE AND RELATIVE ABUNDANCE OF BIRD SPECIES IN THE UPPER SUSITNA BASIN (Cont'd)

(Based on Kessel et al, 1982)

Species	Status[1]	Main Habitats	Relative Abundance[2]
Solitary sandpiper *Tringa solitario*	B?	scattered woodland, forest edge near lakes	U
Greater yellowlegs *Tringa malanoleuca*	B?	wet, meadows, lakes and river shorelines	U
Lesser yellowlegs *Tringa flavipes*	T, S	lake and river shorelines	FC-sp; R-S
Pine grosbeak *Pinicola enucleator*	T, S (B?)	open coniferous forest	
Gray-crowned rosy finch *Leucosticte tephrocotis*	B?	cliffs, block fields	U
Common redpoll *Carduelis flammea*	B, W	low shrubs, open woodland	A
Pine siskin *Carduelis pinus*	B?	mixed forest, tall shrubs	U
White-winged crossbill *Loxia leucoptera*	S, B?	coniferous forest	FC
Savannah sparrow *Passerculus sandwichensis*	B	low shrubs with graminoid ground cover	A
Dark-eyed junco *Junco hyemalis*	B	open and closed forest	C
Tree sparrow *Spilella arborea*	B	low shrubs	A
White-crowned sparrow *Zonotrichia leucophrys*	B	low and medium shrubs	C
Golden-crowned sparrow *Zonotrichia atricapilla*	B?	low shrubs, dwarf spruce	U
Fox sparrow *Passerella iliaca*	B?	medium and tall shrubs with forest overstory	FC
Lincoln's sparrow *Melospize lincolnii*	B?	low and medium shrubs near water	U
Lapland longspur *Calcarious lapponicus*	B	dwarf shrub, meadow and mat	A
Smith's longspur *Calcarius pictus*	B?	dwarf shrub, meadow and mat	U
Snow bunting *Plectrophenax nivalis*	B?	high elevation cliffs and block fields	FC

APPENDIX EF

STATUS, HABITAT USE AND RELATIVE ABUNDANCE OF BIRD SPECIES IN THE UPPER SUSITNA BASIN (Cont'd)

(Based on Kessel et al, 1982)

Species	Status[1]	Main Habitats	Relative Abundance[2]
Wheatear Oenanthe oenanthe	B	block fields	U
Townsend's solitaire Myadestes townsendi	B	cliffs	U
Arctic warbler Phylloscopus borealis	B	scattered forest, medium shrubland	FC
Golden-crowned kinglet Regulus satrapa	T	coniferous and mixed forest	U
Ruby-crowned kinglet Regulus calendula	B	coniferous forests	C
Water pipit Anthus spinoletta	B	dwarf shrub mat, block field	C
Bohemian waxwing Bombycilla garrulus	B?	scattered forest	CTsp,F, U-S
Northern shrike Lanius excubitor	B	scattered forest, tall shrubs	U
Orange-crowned warbler Vermivora celata	B	scattered forest, medium and tall shrubland	U
Yellow warbler Dendroica petechia	T, S?	riparian willows	R
Yellow-rumped warbler Dendroica coronata	B	forest	C
Blackpoll warbler Dendroica striata	B	tall shrubs, forest	FC
Northern waterthrush Seiurus noveboracensis	B?	tall shrubs near water	FC
Wilson's warbler Wilsonia pusilla	B	medium shrubs with or without forest overstory	C
Rusty blackbird Euphagus carolinus	T, S? (B?)	open coniferous forest, tall shrubs	U
Wandering tattler Heteroscelus incanus	(B?), T	tundra streams	U
	T	alluvial bar	R

APPENDIX EF

STATUS, HABITAT USE AND RELATIVE ABUNDANCE
OF BIRD SPECIES IN THE UPPER SUSITNA BASIN (Cont'd)

(Based on Kessel et al, 1982)

Species	Status[1]	Main Habitats	Relative Abundance[2]
Pectoral sandpiper Calidris melanotos	T	wet meadows, pond, lake edges	U
Baird's sandpiper Calidris bairdii	B	dwarf shrub mat	U
Least sandpiper Calidris minutilla	B?	wet and dwarf shrub meadow	FC
Semipalmated sandpiper Calidris pusilla	T, S	lake and river shores and bars	U-sp, R-S
Sanderling Calidris alba	T	lake and river shores and bars	R-F
Northern phalarope Lobipes lobatus	B?	wet meadows with ponds	FC
Long-billed dowitcher Limnodromus scolopaceus	T	lake and river shores and bars	U-sp
Long-tailed jaeger Stercorarius longicaudus	B?	dwarf shrub mat and meadow	FC
Herring gull Larus argentatus	T, S	lakes, rivers	U
Mew gull Larus canus	B, S	lakes, rivers	C
Bonaparte's gull Larus philadelphia	B, S	lakes, rivers, scattered spruce woodland	U
Arctic tern Sterna paradisea	B	lakes and lakeshores	FC
Great horned owl Bubo virginianus	B?, W	open and closed forest	U
	T?	tundra	R
Hawk owl Surnia ulula	B?, W	mixed forest	U
Short-eared owl Asio flammeus	T, S, (B?)	open habitat	U
Boreal owl Aegolius funereus	B? W	mixed forest	R
Belted kingfisher Megaceryle alcyon	B?	cutbanks, rivers	U
Common flicker Colaptes auratus	B	forest edge	U

APPENDIX EF

STATUS, HABITAT USE AND RELATIVE ABUNDANCE OF BIRD SPECIES IN THE UPPER SUSITNA BASIN (Cont'd)

(Based on Kessel et al, 1982)

Species	Status[1]	Main Habitats	Relative Abundance[2]
Hairy woodpecker *Picoides villosus*	B, W	deciduous and mixed forest	U
Downy woodpecker *Picoides* pubescens	B?, W	open deciduous and mixed forest	U
Black-backed three-toed woodpecker *Picoides arcticus*	B?, W	coniferous forest	R
Northern three-toed woodpecker *Picoides tridactylus*	B, W	coniferous forest	U
Eastern kingbird *Tyrannus tyrannus*	A	open shrubland	-
Say's phoebe *Sayornis saya*	B	upland cliff	U
Alder flycatcher *Empidonax alnorum*	B?	medium and tall shrubs	U
Olive-sided flycatcher *Nuttallornis borealis*	B?	open and scattered forest	U
Western wood pewee *Contopus sordidulus*	B?	deciduous forest	R
Horned lark *Eremophila alpestris*	B	dwarf shrub mat, block field	C-sp, F; FC-S
Violet-green swallow	B?	riparian cliffs, rivers	FC
Bank swallow *Riparia riparia*	B	cutbanks, rivers	U
Tree swallow *Iridoprocne bicolor*	B?	rivers, lakes	FC
Cliff swallow *Petrochelidon pyrrhonota*	B	rivers, lakes	U, L
Gray jay *Perisoreus canadensis*	B, W	coniferous and mixed forest	C
Black-billed magpie *Pica pica*	S, (B?) W	open tall shrubs, scattered forest	U
Common raven *Corvus corax*	B, W	riparian and upland cliffs	C
Black-capped chickadee *Parus atricapillus*	B, W	deciduous forest	U

APPENDIX EF

STATUS, HABITAT USE AND RELATIVE ABUNDANCE OF BIRD SPECIES IN THE UPPER SUSITNA BASIN (Cont'd)

(Based on Kessel et al, 1982)

Species	Status[1]	Main Habitats	Relative Abundance[2]
Boreal chickadee *Parus hudsonicus*	B, W	coniferous and mixed forest	FC
Brown creeper *Certhia familiaris*	B	deciduous and mixed forest	U
Dipper *Cinclus mexicanus*	B? W	rivers, streams	U
American robin *Turdus migratorius*	B	forest, medium and tall shrubland	C-sp,S; U-F
Varied thrush *Ixoreus naevius*	B	forest, tall alder thickets	O-sp,S; U-F
Hermit thrush *Catharus guttata*	B	strip forested slopes, tall-alder thickets	C-sp,F; U-F
Swainson's thrush *Catharus ustulatus*	B	forest	FC
Gray-cheeked thrush *Catharus minimus*	B	scattered spruce, dwarf spruce, deciduous forest	FC

[1] B = breeding confirmed, B? - probably breeds, (B?) = possibly breeds, T = transient, W = winters, S= summers, A = accidental

[2] A = abundant, C = common, FC = fairly common, U = uncommon, R = rate, sp = srping, S = summer, F = fall, L = local

APPENDIX EG

STATUS AND RELATIVE ABUNDANCE OF BIRD SPECIES OBSERVED ON THE LOWER SUSITNA BASIN DURING GROUND SURVEYS CONDUCTED JUNE 10 TO JUNE 20, 1982

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
Arctic loon	M		0 (2 seen in May 1982)
Red-throated loon	M, (PB)[2]		6 (2 seen in May 1982)
Red-necked grebe	M		0 (5 seen in May 1981)
Double-crested cormorant		(R)[2]	1
Tundra swan	M		0 (60 seen near mouth of river in May 1981 and 420 seen near mouth of river in May 1982)
Brant	M		0 (2 seen in May 1981)
Greater white-fronted goose	M		<50 (89 seen in May 1981 and 51 seen in May 1982)
Snow goose	(M)		1
Canada goose	M, (PB)		3 (1 seen in May 1981 and 26 seen in May 1982)
Green-winged teal	M, (PB)	U	Several 2's and 3's (42 seen in May 1981)
Mallard	M, (PB)	U	6
Northern pintail	M, (PB)	U	≤6
American widgeon	M, (PB)	U	Most numerous surface feeding duck; seen in pairs along main river and sloughs almost every day
Greater scaup	M		2
Harlequin duck			6
Surf scoter	M		2
Common goldeneye	M, B	U	4
Common merganser	M, (PB)	FC	Small flocks of up to 10 seen along the main river; most numerous ducks seen in May and June
Bald eagle	(M), B	U	17 active nests seen in riparian cottonwood stands
Sharp-shinned hawk	(M), (PB)		Several seen
Northern goshawk	(R), (PB)		Several seen
Red-tailed hawk	(M), (PB)		1

APPENDIX EG

STATUS AND RELATIVE ABUNDANCE OF BIRD SPECIES OBSERVED ON THE LOWER SUSITNA BASIN DURING GROUND SURVEYS CONDUCTED JUNE 10 TO JUNE 20, 1982 (Cont'd)

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
American kestrel	(M), (PB)		1
Merlin	(M), (PB)		A few seen hunting along river
Sandhill crane	M		Several heard at a distance along main river (27 seen near mouth of river in May 1982)
Semipalmated plover	(M), B	U	Nests in alluvium along the river
Greater yellowlegs	(M), PB	U	Seen and heard foraging along river
Solitary sandpiper	(M), (PB)	FC	Courtship rituals observed along river
Spotted sandpiper	(M), B	C	Regularly seen; 5 nests seen along shores of main river, sloughs and feeder streams
Whimbrel	M		Only 1 observed; assumed to be late northbound migrant
Common snipe	(M), (PB)	FC	Winnowing snipe were heard and/or seen along the river
Red-necked phalarope			2
Parasitic jaeger			3
Bonaparte's gull	(M), PB	FC	Pairs and small groups seen feeding along main river and sloughs
Mew gull	(M), PB	FC	
Herring gull	(M), B	C	7 breeding colonies of 20 - 100 pairs seen on alluvial islands along river between Talkeetna and mouth of river
Black-legged kittiwake	(T)	(R)	130; normally a pelagic species; nearest breeding colony at Chisik Island in lower Cook Inlet
Arctic tern	(M), B	FC	Pairs and small groups

APPENDIX EG

STATUS AND RELATIVE ABUNDANCE OF BIRD SPECIES OBSERVED ON THE LOWER SUSITNA BASIN DURING GROUND SURVEYS CONDUCTED JUNE 10 TO JUNE 20, 1982 (Cont'd)

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
Great horned owl	(R), (PB)		Tracks seen; signs found in beach sand below Bell Island indicate this owl was feeding on dead eulachon
Short-eared owl	(M)		Remains of one owl were found below Bell Island
Belted kingfisher	(PB)	U	Pairs regularly seen on feeder streams
Downy woodpecker	(R), (PB)		1 male observed in riparian cotton-wood forest
Hairy woodpecker	(R), B	FC	Seen or heard regularly
Northern 3-toed woodpecker	(R), (PB)		2 seen in mixed forests along lower river
Northern flicker	(M), (PB)		A few seen and heard in riparian cottonwood
Alder flycatcher	PB	C	Seen regularly (4th most numerous landbird
Tree swallow	(M), B	FC	Seen regularly; 3 nests seen
Violet-green swallow	(M), (PB)	U	Small numbers seen
Bank swallow	(M), B	FC	Some colonies of 30 - 50 pairs
Cliff swallow	(M), B	LC	Seen only at Talkeetna where commonly breeds around building eaves
Gray jay	(R), (PB)		Very few seen or heard
Black-billed magpie	(R)		1
Common raven	(R), (PB)	U	Uncommon but widely distributed
Black-capped chickadee	(M), B	FC	Seen regularly
Brown creeper	(M)		1
Golden-crowned kinglet	(M)		1
Ruby-crowned kinglet	(M), PB	FC	Seen regularly
Gray-checked thrush	(M), B	C	Seen regularly (5th most numerous passerine on census

APPENDIX EG

STATUS AND RELATIVE ABUNDANCE OF BIRD SPECIES OBSERVED ON THE LOWER SUSITNA BASIN DURING GROUND SURVEYS CONDUCTED JUNE 10 TO JUNE 20, 1982 (Cont'd)

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
Swainson's thrush	(M), (B)	C	Seen regularly (7th most numerous small landbird)
Hermit thrush	(M), PB	U	Not recorded downstream from Talkeetna
American Robin	(M), B	FC	2 nests observed
Varied thrush	(M), B	FC	Seen regularly (10th most common passerine
Bohemian waxwing	(M)	U	Fewer than 12 seen
Northern shrike	(M), (PB)		2
Orange-crowned warbler	(M), (PB)	FC	Seen regularly
Yellow warbler	(M), B	FC	1 nest seen; tall shrubs
Yellow-rumped warbler	(M), B	C	2nd most common passerine seen regularly in mixed forest, cottonwood and tall shrubs
Blackpoll warbler	(M), B	C	3rd most common passerine seen regularly in tall riparian shrubs, cottonwood and mixed forest
Northern water thrush	(M), B	C	Most numerous passerine seen regularly in riparian cottonwood and mixed cottonwood
Wilson's warbler	(M), PB	FC	
Savannah sparrow	(M), PB	U	
Fox sparrow	(M), B	C	1 nest seen
Lincholn's sparrow	(M), B	FC	
Golden-crowned sparrow	(M), B	U	1 individual was heard just above Bell Island
White-crowned sparrow	(M), B	C	9th most numerous passerine seen regularly in medium to tall shrub thickets and cottonwood forests on small islands
Dark-eyed junco	(M), B	FC	

APPENDIX EG

STATUS AND RELATIVE ABUNDANCE OF BIRD SPECIES OBSERVED ON THE LOWER SUSITNA BASIN DURING GROUND SURVEYS CONDUCTED JUNE 10 TO JUNE 20, 1982 (Cont'd)

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
Rusty blackbird	(M), B	U	2
White-winged crossbill	(M)	U	48
Common redpoll	(M)	FC	
Pine siskin	(M)	U	A few were heard or seen in cottonwoods along river

[1] Includes information on migration from aerial surveys in May 1981 and 1982.
[2] ( ) indicates assessments of status or relative abundance other than those provided by the University of Alaska museum.

APPENDIX EH

DESCRIPTION

GE-1 — 2.4 km upriver from Vee Canyon and 0.5 to 0.6 km up a narrow canyon on the north side of the Susitna River. Three nests present; 1980 nest 26 m up a 33 m cliff, 100 m back from and 67 m above unnamed creek, 1981 nest 8 m up 12 m cliff 81 m back from and 67 m above unnamed creek (Kessel, et al, 1982, unpubl. data).

GE-2 — 4.2 km up the Susitna River from the mouth of Jay Creek and in a canyon on the north side of the Susitna River. Three nests were present; 1980 nest 5 m up 13 m cliff, 10 m back from and 18 m above unnamed creek, 1981 nest 1 m up 5 m, vegetated cliff, 14 m back from and 33 m above unnamed creek (Kessel, et al, 1982, unpubl. data).

GE-3 — 2.4 km up Jay Creek from its confluence with the Susitna River. Three nests were present; 1981 nest 5 m up 30 m cliff, 150 m from west bank and 115 m above Jay Creek (Kessel, et al, 1982, unpubl. data).

GE-4 — 1.6 km up Kosina Creek from its confluence with the Susitna River and on the east side of Kosina Creek. This nest was identified as an inactive raven nest in 1981 but Golden Eagles nested there in 1982 (B. Cooper, pors. comm. 1982).

GE-5 — 1.0 km down the Susitna River from the mouth of Kosina Creek. The nest is 32 m up 38 m cliff on north riverbank (Kessel, et al, 1982).

GE-6 — 2.8 km down the Susitna River from the mouth of Kosina Creek on the north bank of the river. White (1979) reported a Golden Eagle nest at this location in 1974 but his location may correspond to GE-5 since the area he indicated does not contain suitable nesting habitat.

GE-7 — 9.6 km down the Susitna River from the mouth of Kosina Creek and 7 m up a 12-m cliff on a south-facing hillside above the south bank of the river (Kessel, et al, 1982).

GE-8 — 4.0 km down the Susitna River from the mouth of Watana Creek and 13 m up a 23-m cliff, 40-m bank from and 34 m above the north bank of the river. This nest was inactive in 1981 although it did have a fresh spruce lining (Kessel, et al, 1982, unpubl. data).

GE-9 — 5.4 km up the Susitna River from the mouth of Deadman Creek on a cliff on the north bank of the river (Kessel, et al, unpubl. data).

GE-10	11.2 km north of the proposed Watana damsite, high on the southeast side of Tsusena Butte (Kessel, et al, unpubl. data).
GE-11	1.0 km down the Susitna River from the mouth of Tsusena Creek and 0.8 km up and on the east bank of a small unnamed drainage (Kessel, et al, unpubl. data).
GE-12	10.0 km down the Susitna River from the mouth of Fog Creek on the north bank of the river. White (1979) reported a Golden Eagle nest at this location in 1974, but his location probably corresponds to GE-13, since the area he indicated does not appear to contain suitable nesting habitant.
GE-13	9.4 km up the Susitna River from the mouth of Devil Creek on a cliff on the north bank of the river (Kessel, et al, unpublished data).
GE-14	5.6 km up the Susitna River from the mouth of Devil Creek. A Golden Eagle nest was reported at this location on the west side of the river in 1974 (White 1974); but the nearest suitable habitat appears to be 1.4 km and 2.0 km further downstream (B. Cooper pers. comm. 1982) and one of these locations may represent the actual 1974 location.
GE-15	2.8 km up Devil Creek from its confluence with the Susitna River. Two nests (alternates) are present; one on the cliffs on the west side of Devil Creek and one on the cliffs on the north side of a small, unnamed tributary that empties into Devil Creek (Kessel, et al, unpubl. data).
GE-16	0.6 km up Devil Creek from its confluence with the Susitna River and 30 m up 45 m vegetated clilff, 100 m back from and 120 m above Devil Creek on the west bank (Kessel, et al, 1982).
GE-17	6.8 km down the Susitna River from the mouth of Devil Creek and 3.5 km up and on the east side of a small drainage that joins the river from the south (Kessel, et al, unpubl. data).
GE-18	3.4 km up the Susitna River from the mouth of Portage Creek on a moderate sized cliff on the north bank (Kessel, et al, 1982).
BE-1	4.2 km up the Susitna River from the mouth of Tyone River. White (1974) reported two closely associated nests on the east side of the Susitna River in 1974 but they appeared to be gone by 1980-81.
BE-2	3.4 km up the Oshetna River from its confluence with Susitna River and 4 m from edge of the west bank in a 22-m white spruce (Kessel, et al, 1982).

BE-3	4.0 km down the Susitna River from the midpoint of Vee Canyon on the south bank of the Susitna River, just west of the mouth of a small unnamed tributary (White 1974, Kessel, et al, unpubl. data).
BE-4	1.8 km up the Susitna River from the mouth of Kosina Creek and 25 m up a 33-m cliff on the north bank of the river (White 1974, Kessel, et al, 1982).
BE-5	8.8 km up the Susitna River from the mouth of Watana Creek on a wooded island in a live white spruce (White 1979, Kessel, et al, 1982).
BE-6	9.2 km up Deadman Creek from its confluence with the Susitna River on top of a 15-m, broken-topped cotton wood, 25 m from the north bank of Deadman Creek (Kessel, et al, 1982).
BE-7	On the south shore of a small pond (W8105), 1.2 km east of the northeast end of Stephan Lake and on top of a 13-m, broken-topped poplar (Kessel, et al, 1982).
BE-8	1.0 km up the Susitna River from its confluence with Indian River and on top of a 23-m, broken-topped poplar, 4 m from the north riverbank (White 1974, Kessel, et al, 1982).
GYR-1	At midpoint of Vee Canyon and 100 m up a 113-m cliff on the south bank of the Susitna River (White 1974, Kessel, et al, 1982).
GYR-2	6.8 km down the Susitna River from the mouth of Devil Creek and 2.6 km up a gorge on the south side of the river. Nest is 100 m up 105-m cliff in the creek canyon (White 1974, Kessel, et al, 1982).
GYR-3	1.8 km due south of the proposed Devil's Canyon damsite. An active nest was reported in 1974 and White (1974) commented that it was "....back from high water limits about 1/2 mile...".
GOS-1	0.3 km west of the mouth of Kosina Creek on the south bank of the Susitna River (B. Cooper pers. comm. 1982).
GOS-2	1.6 km up the Susitna River from the mouth of Fog Creek and on the southeast side of the river. Goshawk nests reported at this location in 1974 (White 1974).
GOS-3	2.0 km southeast of the Devil's Canyon damsite and on the west shore of a small lake (B. Cooper pers. comm. 1982).
R-1	2.4 km upriver from Vee Canyon and 0.6 km up a narrow canyon on the north side of the Susitna River. A nest was reported on the east side of the narrow canyon about 0.2 km from a small stream in 1974 (White, 1974).

R-2 0.6 km up the Susitna River from the midpoint of Vee Canyon. An active nest was reported on the north side of the Susitna River on a south-facing cliff in 1974 (White 1974).

R-3 At midpoint of Vee Canyon an active rest was reported on the south-facing slope of the north bank of the Susitna River in 1974 (White 1974).

R-4 5.6 to 6.6 km down the Susitna River from the midpoint of Vee Canyon on the north bank. An active nest was reported at this general location in 1974 (White 1974). It was probably located on one of the two small existing south-facing cliff areas.

R-5 1.6 km up Jay Creek from its confluence with the Susitna River. An active nest was reported about 0.1 km east of Jay Creek up a small unnamed tributary that joins Jay Creek (White 1974).

R-6 1.4 km up Kosina Creek from its confluence with the Susitna River. An active nest was reported about 0.2 km east of Kosina Creek on a northwest-facing hill (White 1974).

R-7 4.6 km down the Susitna River from the mouth of Kosina Creek. An active nest was reported on the north bank of the Susitna River in 1974 (White 1974).

R-8 5.0 km up the Susitna River from the mouth of Watana Creek. An active nest was reported on the north bank of the Susitna River in 1974 (White 1974).

R-9 1.0 km up the Susitna River from the mouth of Watana Creek. An active nest was reported on the north bank of the Susitna River in 1974 (White 1974).

R-10 4.6 km down the Susitna River from the mouth of Watana Creek. An active nest was reported on the north bank of the Susitna River in 1974 (White 1974). The nest was inactive in 1980 (Kessel, et al, 1982).

R-11 0.2 km down the Susitna River from the mouth of Deadman Creek. A nest was reported on the south bank of the Susitna almost opposite the mouth of Deadman Creek (White 1974).

R-12 1.4 km up Deadman Creek from its confluence with the Susitna River and 13 m up a 32-m cliff on the east bank of the creek (Kessel, et al, 1982).

R-13 4.2 km up Tsusena Creek from its confluence with the Susitna River. Two nests (alterates) were reported to be on a cliff on the east bank of the creek. (Kessel, et al, 1982).

R-14 3.8 km up Fog Creek from its confluence with the Susitna River. Two nests (alternates) were located on the north side of the creek and another alternate nest was located on the south side. (Kessel, et al, 1982).

R-15 2.4 km up Fog Creek from its confluence with the Susitna River. Two nests (alternates) were located on the north side of the creek and an active nest was located on the south side of the creek (Kessel, et al, 1982).

R-16 7.4 km up the Susitna River from the mouth of Devil Creek. Nests were reported on the north bank of the Susitna River in 1974 (White 1974).

R-17 7.4 km up the Susitna River from the mouth of Devil Creek and 0.5 km up a small drainage that flows south into the Susitna River. A nest was reported at this location in 1974 (White 1974).

R-18 2.4 km up the Susitna River from the mouth of Devil Creek. A nest was reported on the north shore of the Susitna River in 1974 (White 1974).

R-19 1.0 km up Devil Creek from its confluence with the Susitna River and near the top of a cliff on the west bank of the creek. An active nest was reported here in 1974 (White 1974) and it was active in 1980 (Kessel, et al, 1982).

R-20 1.9 km down the Susitna River from the mouth of Devil Creek on cliffs on the northwest side of the river (Kessel, et al, unpubl. data).

R-21 3.6 km up the Susitna River from the mouth of Portage Creek and 0.6 km downstream from the proposed Devil Canyon damsite on the north bank of the river. A nest was reported at this location in 1974 (White 1974).