# Review of Development Impacts Report

## I. INTRODUCTION

In April 1987, the Department of the Interior released the Arctic National Wildlife Refuge Coastal Plain Resource Assessment: Report and Recommendation to the Congress of the United States and Final Legislative Environmental Impact Statement (LEIS). The report was prepared in accordance with section 1002 of the Alaska National Interest Lands Conservation Act and the National Environmental Policy Act. The U. S. Fish and Wildlife Service prepared the report in cooperation with U. S. Geological Survey and the Bureau of Land Management. Within the report, sections for each of the features being reviewed contained definitions of major, moderate, minor or negligible impacts for each of the subjects evaluated.

The report concluded that the full leasing and development of the coastal plain would have major environmental impacts.

In the eight years following the report, many additional studies of fish, wildlife, and habitats have been conducted to better understand the ecology of the coastal plain of the Arctic National Wildlife Refuge and potential effects of oil and gas development. The Service conducted the following preliminary review of the LEIS to determine if the original conclusions of the 1987 LEIS remain valid, considering significant new data. While all studies and analyses have yet to be completed, additional information strengthens the fundamental conclusion that the Arctic Refuge coastal plain is a vital area for a rich mix of Arctic flora and fauna. This review supports the LEIS finding that there would be major environmental impacts from oil and gas development on the coastal plain.

The following discussion features sections focusing on the biological environment, physical environment, and human environment.

## II. BIOLOGICAL ENVIRONMENT

### A. Caribou

The LEIS concludes that full leasing and development of the Refuge coastal plain would have a major effect on the Porcupine caribou herd (PCH). The impacts described include direct habitat modification, displacement, obstructions to movements which could reduce access to important habitats, and disturbance or harassment. The LEIS predicted a decline in caribou use within 3 kilometers of full development. It further stated that, "Significant declines in use by maternal cows and calves could occur within at least the 2-km zone." These conclusions remain valid for all the reasons cited in the LEIS, and are supported by research since 1987.

#### 1. Caribou Use of the Coastal Plain

The coastal plain of the Arctic Refuge, including much of the 1002 area, is the most important area for high-density, concentrated calving by the PCH. In 1995, 92 percent of the PCH calved in the

1002 area.

The LEIS does not adequately portray the full extent of caribou use on the coastal plain. For example, the LEIS states, "From year to year, the distribution of caribou (PCH) on these calving grounds varies considerably, with most calving usually taking place in the area between the Hulahula River and the Canadian border." This implies that the area west of the Hulahula is of low importance for caribou.

Although from 1972 to 1986, concentrated calving occurred west of the Hulahula River in 4 of 15 years, data collected between 1987 and 1995 show that concentrated calving occurred in this area in 5 of 9 years. In addition, the distribution and habitat of the Central Arctic caribou herd (CAH) includes nearly the entire 1002 area west of the Hulahula. It is significant that additional data collected since 1987 show important calving areas west of the Hulahula River. The generalized development scenario used to assess environmental impacts included three major prospects, one of which is located entirely west of the Hulahula River. These new data indicate that a more extensive area than identified in the LEIS is important to caribou when considering the impacts of oil and gas production.

While the LEIS provides considerable discussion on calving distribution and habitat, very little information is presented regarding caribou use of the coastal plain after the calves are born. The LEIS simply says, "Postcalving movements and aggregations show considerable annual variation." No specific examples or maps are provided. Information regarding caribou distribution and movement during the post-calving period was available in the Baseline Report Series, but was not included in the LEIS. Nearly every year, all PCH females and calves use the 1002 area for postcalving activities and, in most years, the majority of bulls also use the area during late June and early July.

Caribou movements studied after the LEIS illustrates a more extensive and dynamic use of the area by the PCH than the LEIS presents. Large post-calving aggregations of PCH caribou, sometimes consisting of most of the herd, gathered in the Canning River delta area from late June to early July in 6 of the last 9 years.

2. Habitat

The LEIS determined relative habitat values using an aerial approach involving a polygon generated by overlapping multiple years of calving concentration maps. Since only calving distribution maps were used, information about post-calving distribution and movement was not included, and thus the analysis inappropriately truncated the geographic scope and frequency of caribou interaction with the development infrastructure.

Habitat research since 1987 provides new data about the distribution of various coastal plain habitats and the quality of their forage. In addition, use of satellite imagery has permitted study of the movement of caribou on the coastal plain relative to snow melt and vegetation phenology. Although some of these data are still being analyzed, research has documented that:
the caribou have a broader use of the coastal plain for calving than the LEIS depicted
snowmelt and "green-up patterns" influence caribou-calving sites each year the concentrated

calving area, where 50 percent of the calves are born, in any year imparts a higher level of predator protection the primary forage species (Eriophorum vaginatum) is higher in nutrition, more digestible, and more available within the 1002 area than in the peripheral areas when caribou are present caribou seek ridge tops on the coastal plain for insect-relief habitat, in addition to the coastline and mountains the LEIS noted.

Analysis of the multi-year data set from radio-collared adult females indicates that birth sites and caribou distribution are associated with snow melt patterns and early plant phenology. The PCH selects the high density portion of the calving ground annually based on areas with the highest rate of plant growth in the two weeks immediately following calving. The new plant growth is highly digestible with a high protein content. This is the period when protein and energy demands on caribou cows, for lactation, are the highest of any time of the year.

3. Development Impacts

The LEIS assessed the effects of development on caribou as being related to the actual acreage impacted by roads, pipelines, and drill pads, often called the "footprint" of development. The LEIS assumed a 3-kilometer sphere of influence from development would affect 37 percent of the PCH concentrated calving area. Both the effects on calving and post-calving habitats caused by the development infrastructure should be considered. When caribou's complete use of the coastal plain is considered, development affects a larger area than the LEIS depicted by considering only areas of concentrated calving.

By focusing on the "footprint" and a sphere of influence immediately adjacent to it, the real impact of the development infrastructure is minimized and underestimated. The effects the development infrastructure have on movements and access to preferred habitats are the primary factors that will determine the impact to the herd's population dynamics. The development scenario used to assess impacts is oriented on a general east - west axis with two corridors connecting to marine facilities at Camden Bay and Pokok Lagoon. This alignment would interact with caribou movements from uplands to the coast to avoid insect harassment as well as westward movements before calving, and eastward movements when the herd moves toward the British Mountains in Canada.

If the infrastructure were oriented north - south, there would also be extensive interaction with these predominant east - west caribou movements. Investigations with the CAH at Prudhoe Bay have shown that the propensity of caribou to cross structures is inversely proportional to the size of the group encountering the structure-that is, large groups have lower success in crossing structures. Since the PCH is 10 times greater in size than the CAH, the probability of large groups occurring in the 1002 area suggests a greater incidence of negative interactions between caribou and the infrastructure. In this case, the "footprint" becomes a barrier and reduces access to habitats beyond the I-, 2-, or 3-kilometer sphere of influence identified in the LEIS.

In all probability, a barrier effect will occur to some extent, causing displacement of the herd. The LEIS agreed that a change in distribution of the PCH could reasonably be expected. There is limited coastal plain habitat available because of the proximity of the mountains to the sea. Therefore, displacement would be to the foothills south and east of the 1002 area. This would: displace the herd to the area of highest predator density reduce the amount and quality of preferred

forage species available during calving, and a restrict access to important coastal insect-relief habitat.

The potential increase in predation from this scenario with the herd at its present population level would have a negative, albeit minimal, impact on the population. On the other hand, reduced food resources due to displacement and potential increased energy expenditure, due to encountering the infrastructure, could have a more noticeable impact. Failure to obtain insect relief would contribute to poor physical condition. The Alaska Department of Fish & Game, in conjunction with the 1002 research program, found that viability of the calf was associated with fall weight of the female. Reduced parturition rates or calf survival will have a negative impact on the population dynamics of the PCH.

The LEIS acknowledged the potential for a population decline resulting from loss of habitat and reduction in habitat values. It simply concluded, "No appreciable decline is expected as a result of development." That conclusion is speculative, cannot be substantiated scientifically, and does not logically flow from the concerns about habitat. Likewise, attempts to precisely predict a numerical population decline would also be speculative. Current studies indicate, however, that the ability to freely locate the calving ground where conditions are most favorable influences calf survival. Small disruptions to free calving ground location may have demonstrable repercussions for herd dynamics. A reduction in annual calf survival of less than 5 percent would be sufficient to change a positive rate of increase in the PCH population to a declining rate. It is reasonable to conclude that the cumulative effects of reduced access to habitat providing preferred forage, predator avoidance, or insect relief for the PCH caused by full development of the 1002 area would result in a major, adverse impact on the herd.

B. Muskoxen

The LEIS predicted a major impact on muskoxen as a result of full development. Information gained from 1987 to the present adds to the understanding of the scope of impacts that would be expected. Additional supporting information provides further insights.

The extirpation of the muskox in Alaska and concern that the species might become extinct worldwide resulted in the return of this animal to the State in the 1930's. After 60 years, the species has been reestablished in areas of its former range in northern Alaska. The muskox population centered in the 1002 area of the Arctic Refuge is the source of animals that colonized adjacent areas in northern Alaska and northwestern Canada.

Muskoxen are one of only two ungulate species adapted to arctic conditions, and the only large mammal present year-round in the 1002 area. This important component of the arctic ecosystem provides continuous food for scavengers and predators and contributes to the biodiversity of the system. Muskoxen are energetically conservative, with a high fidelity to relatively small home ranges, limited daily and seasonal movements, and relatively low rates of reproduction. Most females do not reproduce annually. A single calf is born in late April to May under winter conditions. Females must provide milk to sustain the calf for several weeks before green plants are available in early to mid-June.
The portion of the muskox population that resides within the 1002 area increased throughout the

mid-1980's, reaching a maximum in 1986, then decreased and stabilized at fewer than 300. Muskoxen have expanded their range both within and beyond the 1002 area. About 100-120 muskoxen currently occupy the portion of the 1002 area between the Tamayariak and Canning Rivers (west), similar numbers occur along the Sadlerochit River (central) and fewer than 60 muskoxen live between the Jago and Aichilik Rivers (east). Regionally, population numbers continue to increase. Over 700 currently live between the Sagavanirktok River in Alaska and the Babbage River in Canada.

The muskox population on the Refuge now supports a limited subsistence hunting opportunity for residents of Kaktovik. As many as 10 bulls may be taken each year. Muskoxen provide a protein source during spring when whales and caribou are not present.

Mixed-sex groups have a high fidelity to relatively small geographic areas, and major shifts in distribution are rare. When dispersing, mixed-sex groups move into areas already colonized by bulls; they are unlikely to move into areas devoid of muskoxen.

In winter, muskoxen select locations where snow cover is minimal and dried sedges and willows are available. In winter, muskoxen stay in small areas and reduce their movements and activities to conserve energy. By contrast, in summer, muskoxen are more active, moving longer distances and using larger areas and a greater diversity of habitats as a strategy to regain body weight lost during the long winter, pregnancy, and lactation. Unless females reach a threshold weight before the rut in August, they do not reproduce.

Muskoxen are vulnerable to potential impacts from oil and gas exploration and development because they are present in the area year round and would be subjected to cumulative effects in both winter and summer. Unlike other large vertebrates that migrate or hibernate, muskoxen actively use the arctic coastal plain during winter. This is possible because of their adaptations to cold, their ability to process low-quality forage, and their energyconserving strategies including low rates of movement and activity. Energetic costs will be increased if animals move or become more active in response to construction or facilities operations, aircraft and vehicle traffic, and other human activities. Shifts in distribution in winter, caused by human activities, are also likely to result in less forage availability and higher energetic costs to obtain food if muskoxen move into areas of higher snow cover. Increased energetic costs will likely result in decreased calf production and may cause some additional winter mortalities.

The discussion in the LEIS about the effects of stress and disturbance on muskoxen and on the effects of habitat loss on ungulates is still valid, but more information is available on the response of muskoxen to oil field facilities. Muskoxen dispersing into areas adjacent to the Trans Alaska Pipeline corridor are found in locations about 5 miles from a pump station, and 2 miles from the haul road and pipeline.

Assuming a 2-mile sphere of influence, the amount of muskox high-use range that could be affected under full leasing exceeds that described in the LEIS, as muskoxen have extended their range throughout the 1002 area. The full development scenario would result in the loss of availability of a large percentage of high-use habitat. This would have an adverse affect on muskox productivity and population size.

Muskoxen are often found along rivers that would likely be used for extensive gravel extraction and creation of water storage basins. These activities in drainages the animals use would result in their displacement and in permanent habitat loss. If muskoxen are displaced from portions of the 1002 area, subsistence hunters will have reduced opportunities. Areas vacated by muskoxen may not be recolonized by mixed-sex groups for some unknown period of time.
Because numbers of muskoxen within the 1002 area are small, and the animals live in social groups, negative impacts on only a few groups could be significant. If only a few groups of animals are displaced or disturbed, a large percentage of the population would be affected. Small increases in female mortalities can cause a decline in population numbers. Muskox distribution, reproduction and survival are influenced by winter weather and snow depth; effects from oil and gas development will likely be additive in severe winters.

C. Polar Bears

The conclusion in the LEIS that development might have a moderate level of impact on polar bears is still reasonable. Since completion of the LEIS, considerable data have been collected regarding polar bears. Results of radio-telemetry studies spanning 1 I years indicate that 45 percent of maternal polar bear dens found on land for the Beaufort Sea population were within the Arctic Refuge, and 34 percent were within the 1002 area. Considering the broad region involved (approximately from Wainwright, Alaska to the Bailee Islands in Canada) the Refuge coastal plain is a disproportionately small area for the number of dens documented. These results indicate that the coastal plain of the Arctic Refuge is the most important land denning area for the Beaufort Sea polar bear population.

The LEIS does not include a consideration of the effects of a major oil spill (chronic, acute, and secondary) on polar bear populations, nor does it consider the effects of other intensive developments along coastal areas of Alaska and Canada. If oil development occurs on the coastal plain of the Arctic Refuge, it would provide infrastructure that could encourage new drilling in adjacent offshore waters. The cumulative impacts of Beaufort Sea oil development are a concern with the polar bear population.

D. Brown Bears

According to the LEIS, a moderate decline in the numbers of brown bears using the 1002 area or a change in the distribution could result from the additive effects of direct mortality, decreased prey availability, harassment, and disturbance in denning areas. Brown bears use the coastal plain extensively, particularly east of the Sadlerochit River. Development would result in increased encounters with humans causing additional hunting and mortality attributed to defense of life and property. Concerns about reduced prey availability are speculative and are dependent on effects of development on the PCH.

E. Snow Geese

The LEIS predicted that snow geese would be moderately impacted by full development. It further concluded that direct loss of snow goose habitat to infrastructure would be minimal. The major impact would be aircraft disturbance that displaces geese from feeding habitats, increases energy

expenditure, and reduces the ability of geese to accumulate lipids. The LEIS noted that impacts would be highly variable each year, depending on the size of the staging population.
These conclusions are essentially correct. The most important snow goose feeding habitats occur in small patches that are widely distributed but comprise less than 3 percent of the 1002 area east of the Hulahula River. Because of the widespread distribution of these sites, they are not likely to be significantly affected by infrastructure. However, the heterogeneous distribution of feeding habitats requires that snow geese have access to large areas of tundra so that they can search for forage. For that reason, disturbance that displaces geese will have a greater affect than habitat loss to infrastructure.

Without controls on aircraft activity, disturbance would have widespread effects on snow goose distribution. Studies in Canada and our observations on the Arctic Refuge indicate that small fixed-wing aircraft and helicopters flush snow geese at distances of up to 4 miles from the flight line. Larger aircraft associated with petroleum development could flush geese at greater distances. The distance that flocks are displaced following disturbance is highly variable but often exceeds one mile. Distribution of snow geese in areas near flight corridors would likely be significantly affected.

The disturbance of staging snow geese would reduce the time they spend feeding, and the loss of habitat in which to feed would adversely affect their accumulation of energy reserves essential for migration, threatening their survival.

The LEIS suggests that approximately 60 percent of the preferred staging area on the Arctic Refuge lies within the 1002 Area. Using a slightly different analysis based on frequency of use, we concluded that approximately 80 percent of the most frequently used area on the Refuge is within the 1002 Area. Because of this larger value, the percentage of preferred staging area impacted by development would be slightly higher than indicated in the LEIS.

The LEIS is correct in stating that impacts would be highly variable among years. The numbers of geese on the Arctic Refuge has ranged from approximately 12,800 to 325,000 individuals. Impacts would be greater in years of larger staging populations.

The conclusions of the LEIS regarding impacts to snow geese are still valid and are supported by additional research conducted since 1987.

F. Wolves

The LEIS predicted that the cumulative impact of full development could cause a moderate decline in the wolf population of the 1002 and surrounding area. The number of active dens adjacent to the coastal plain has varied from 3 to 7. Wolf use of the coastal plain is limited and generally associated with the foothills south of the 1002 area. The conclusion in the LEIS that the wolf population could decline due to reduced prey (e.g., caribou) is questionable, when the LEIS earlier had concluded there would be no appreciable decline in the caribou. Although the conclusion that there will be no appreciable decline in PCH is speculative, it is unlikely, given the present size of the PCH and the relative number of predators, that development would greatly impact wolf populations by changes in herd movement, distribution, or size. The LEIS predicted

that additional direct mortality from shooting and trapping could occur because of increased human access. It is reasonable to conclude the effect of development on wolves would be moderate.

G. Wolverine

The LEIS concluded that, "The cumulative effects of displacement, avoidance and reduced food resources could result in localized, long-term changes (a moderate effect) in wolverine distribution. Inadequate controls on access and harvest could possibly reduce by half or more the 1002-area wolverine population. If this occurred, it could result in a major effect on that population." Few data are available on the wolverine population of the 1002 area, and no estimate of total numbers. The conclusion of the LEIS remains a reasonable estimation of impacts on wolverines.

H. Seals and Whales

Since the full development scenario does not involve shipping the oil by tankers, and the development is onshore, the effects on whales and seals is expected to be minor. Barge traffic may increase somewhat during the summer after the whale spring migration has passed and while the seals are pelagic. Seismic work on ice could cause some displacement of ringed seals locally, with the possible loss of some pups.

Again, there is no discussion of the likelihood of onshore production facilities encouraging oil development in adjacent offshore waters. If offshore development is facilitated by the construction of onshore infrastructure, then cumulative impacts need to be considered. Large increases in marine traffic and potential oil spills are the greatest oil development threats to seals and whales.

I. Arctic Peregrine falcon

Since completion of the LEIS, newly collected information regarding status of peregrine falcons in the area indicates the species is increasing and using new nest sites. Pairs with young have been documented at Clarence River, Kongakut River, Ekaluakat River, Hulahula River, Canning River, and on Barter Island, all outside the 1002 area. These locations, except for the Canning River are new nest sites since the LEIS was completed. Adult peregrines have also been observed at locations on the Jago River, and Igilatvik Creek, within the 1002 area, where nesting is likely. Because of the improved status of the Arctic peregrine falcon populations, particularly on habitats located west of the Refuge, the species was removed from the threatened list in November 1994. Populations on the Refuge coastal plain have been the last to show increase, and are still recovering.

J. Vegetation

1. Landsat-TM Map

The interrelationship of wildlife species and their habitat is complex. The Service conducted many studies examining this interrelationship, including forage availability, snowmelt chronology, phenology, plant biomass and nutritive values. This research was designed to quantify the value of

habitats used by caribou and other wildlife species on the arctic coastal plain. The research tried to identify portions of coastal plain that are important during and after calving.

To facilitate this research, the Service produced a LANDSAT-TM map that provides more accurate information on the vegetation types of the coastal plain. Previous maps, from the 1980's, depicted the general distribution of land-cover types. Additional assessment, however, indicated that their site-specific accuracy was inadequate for studies of wildlife habitat. The recently completed LANDSAT-TM map is more accurate. Therefore, the Service now has better knowledge of the distribution and composition of vegetation types of the arctic coastal plain and a better understanding of why these habitats are important to caribou and other species.

2. Seismic Exploration

Previous studies of disturbance from winter seismic exploration on tundra predicted short-term and mainly aesthetic impacts. The Arctic Refuge seismic study has tracked disturbance and recovery from the seismic exploration conducted in 1984 and 1985, with the most recent field data gathered in 1993 and 1994. A random sample of plots on the seismic trails showed that 10 percent of all trails still had measurable disturbance a decade after the exploration. Based on the length of the original trails, including seismic lines and campmove trails, this translates to approximately 400 kilometers of disturbed trails remaining.

Not all visual impacts are readily apparent to casual observers. Three percent of trails (or 120 kilometers, total) had medium- to high-level disturbance remaining. Recovery of these areas is likely to take many more years. Based on permanent study plots, we found that sites that had been moderately to severely impacted during seismic exploration still showed impacts in 1994. Plots still have changes in plant species composition and increased melting of permafrost, compared to control plots. Over one half of the plots still have increased depth to permafrost a decade after disturbance, even at plots with low levels of initial disturbance where changes to the vegetation were no longer visible, indicating long-term changes to the soil temperature regime.
In some areas, ruts or troughs have formed on seismic trails. This is caused by melting of permafrost and settling of the ground surface, which causes a long-term change in plant composition and the elimination of some plant species.

In the summary of recommended mitigation in the LEIS, no mitigation measures appear to address these concerns. Regulation of any future exploration should include more protective stipulations regarding adequate protective cover of snow, types of vehicles used, and routes used for trails.

3. Rehabilitation (Revegetation)

The summary of recommended mitigation for the 1002 area briefly mentions habitat restoration. However, the document stated earlier that literature reviews of revegetation in Alaska had concluded that areas north of the Brooks Range are the most difficult to revegetate, and successful rehabilitation techniques have not been developed for these areas. This remains true today. Extensive experiments on revegetation techniques at Prudhoe Bay, conducted by contractors for the oil companies, have involved great effort and expense and often have been disappointing or have provided only limited success in small areas. Failure to revegetate naturally or with human help is

mainly due to the presence of permafrost, the slow growth and propagation of arctic plants, and the short, cool growing season, particularly close to the arctic coast.

The exploratory drill site that Chevron created on Kaktovik Inupiat Corporation land on the coastal plain in the mid-1980's is the site of the only revegetation effort in the Arctic Refuge. The most advanced techniques were used in this showcase effort, including the construction and later removal (after only a year and a half) of a foam-timber pad on top of flat tundra with no gravel and no disturbance to the tundra surface. Nevertheless, the well-site was still a visible scar on the tundra in 1995.

The pad was reseeded in 1987 when drilling was completed. After that reseeding failed, contractors for Chevron visited the site and continued reseeding almost every summer until at least 1992. Service botanists measured the amount of vegetative cover on the pad as 6 percent in 1990 and 23 percent in 1992. A visual estimate in 1994 indicated 25-50 percent cover. The area of the buried reserve pit adjacent to the pad has much better growth of grasses than the pad. However, the surface, originally dry and graded flat, is now very uneven due to subsurface melting. Ponding of surface water has increased each year since 1987; about 25 percent of the surface area is now covered with ponds. The drilling wastes are supposed to remain frozen to be immobilized, raising the concern that drilling wastes will leach into vegetation and ponds.

4. Cumulative Impacts to Vegetation, Wetlands and Terrain Types

In the LEIS summary of effects, a rating of moderate would be more accurate than minor for impacts on vegetation, wetlands, and terrain types. Studies at Prudhoe Bay have documented extensive cumulative impacts to tundra vegetation from oil development. The impacts cover far larger areas than the surface areas of the pads, roads, and development structures, and have been clearly documented by aerial photographs. The most extensive impacts are due to changes in water flow through the area due to "damming" by roads--that is, inundation above roads and drying below them, causing changes in vegetation, wetlands distribution, wildlife feeding, and bird nesting habitat over very large areas.

Another cause of vegetation change at Prudhoe Bay is the "dust shadow" along roads. Road dust on the tundra causes earlier snow-melt in the spring, increases melting of permafrost resulting in thermokarst pits, and raises the pH of the soil, killing many common tundra plants and dramatically changing the plant species composition for about 35 feet on either side of the road. Replacement plants are often pioneering, "weedy" species.

Studies of the effects of development on a landscape rarely take into account the cumulative impacts of many phases of development. The industrial complex at Prudhoe Bay clearly has had landscape-scale impacts on the ecosystem. Studies mapping historical changes to the Prudhoe Bay oil field found that indirect impacts can lag behind planned developments by many years and the total area eventually disturbed can greatly exceed the planned area of construction. For example, in the wettest parts of the oil field, flooding and thermokarst covered more than twice the area directly affected by roads and other construction activities.

K. Fisheries

A significant amount of fisheries data from inland and coastal waters of the 1002 area has been collected and analyzed since 1987. Most notably, the documented distribution of Arctic char (or Dolly Varden) in freshwater systems has been expanded. We now know that the Okpilak River provides important habitat for Arctic char. Arctic char were also found in the Akutoktak River, a tributary to the Okpilak River, in small numbers. These rivers were not identified in the LEIS as supporting char.

With respect to coastal fisheries, biologists have synthesized a large amount of data since 1987, both on the Arctic Refuge coast and from the Prudhoe Bay development area. The most noticeable shortcoming of the LEIS is the lack of recognition of the importance of the Arctic cisco fishery in the region, coupled with the dependence of Arctic cisco, for migration purposes, on the nearshore environment of the central Beaufort Sea coast. The Arctic cisco is a significant subsistence resource for the villages of Kaktovik and Nuiqsut. Past surveys show that Kaktovik natives often harvest more Arctic cisco than Arctic char/Dolly Varden. As stated in the LEIS, Arctic cisco are known to migrate from Canada's Mackenzie River to the central Beaufort Sea (the Colville River delta) region for rearing. The harvest in Kaktovik occurs as the adults migrate eastward to return to the Mackenzie River to spawn. The size of this return migration run is dependent on the number of juveniles that were successfully recruited to the Colville River region several years earlier. Thus, the original westward migration by juvenile Arctic cisco is an extremely critical period in the fishery. It is essential to maintain the integrity of the coastal brackish water zone, which is used by numerous anadromous fish species as a migration corridor. The effects of any specific causeway on the local hydrography, as well as the cumulative impact of additional causeways on migrating fish, are unknown.

Except for accidental spills, the most potentially threatening aspect of oil and gas development on coastal fishes is the construction of docks or causeways. Their potential for disrupting the integrity of the brackish nearshore corridor during summer has been a focus of study in the Prudhoe Bay region. While much of the literature from Prudhoe Bay suggests minimal effects of causeways, caution is required in directly extrapolating those results to the 1002 coastal area. The coast of the Arctic Refuge is situated differently in the migration corridor than is Prudhoe Bay and presents a different hydrographic regime. The proximity and volume of freshwater input are different for the two areas. As stated earlier, the cumulative effects of additional causeways on migrating fish are potentially significant. Direct a priori application of conclusions concerning causeways in Prudhoe Bay to the entire arctic coast is not supported by the recent literature.
The conclusion of minor effects on coastal and freshwater fisheries in the LEIS is inappropriate unless the recommended mitigation measures can be strictly met. With the current knowledge of the potentially affected aquatic systems, it is uncertain that mitigation measures can be adequately addressed. For example, mitigation measure #8 states that docks and causeways are to be constructed so as not to impede fish movement or alter the coastal hydrography. This would certainly be a sufficient measure--if it were realized. Whether this is possible, or feasible, appears uncertain at this time. To biologically demonstrate the "no effect" status of any given causeway, prior to construction, is problematic. Also especially problematic, considering that all the rearing habitat has almost certainly not been identified, is the mitigative measure listed in the LEIS, "Prohibit spring and summer water removal from fish-bearing waters to levels that maintain quality of rearing habitat." The LEIS conclusion of minor effects on coastal and fresh-water fishery resources is dependent on the general premise of maintaining quantity and quality aquatic habitat.

There remains, however, great concern about the feasibility and actual compliance with this requirement, as it remains a biological target that has yet to be clearly defined.

## III. PHYSICAL ENVIRONMENT

### A. Water Quantity

The LEIS concluded that the dedicated industrial use of the limited natural freshwater sources of the 1002 area would be a major effect. Additional investigations since 1987 substantiate the fact that water in the 1002 area is very limited and the impact upon water resources should be considered major. Ice road construction creates the most significant demand on the water resources during oil and gas explorations. Studies show that at the time of maximum ice development in rivers and lakes (March and April) the quantity of available water in 237 miles of river across the coastal plain is enough to build and maintain only 6.6 miles of ice road. Ice mining--scraping and hauling lake and river ice-would be required as a source of ice particles for ice road construction. Ice mining and diversion of water from lakes and rivers earlier in the winter would increase the depth of freezing within the thaw bulb. This deep freezing would kill mud-dwelling invertebrates important in the food chain of waterbirds and fish during the summer months.

In addition, 10 miles has been considered the limit of economic feasibility for hauling ice and water for road construction. There are only 3 or 4 small lakes in the transportation corridor between the Okpilak River to the Canning River, a distance of 60 miles. Sufficient ice and water are not available. Thus, gravel roads may be necessary.

A transportation system consisting of gravel roads would have significant impacts on water resources. Roads through the coastal plain and to Prudhoe Bay would lie across slope. They would dissect the natural flow of water during breakup, melt permafrost, act as dams, trap water upslope, and cause the downslope areas to become dry. Sheetflow across the tundra during spring snow melt is the primary source of water to recharge the lakes and small ponds important to water birds. A road system would interrupt this recharge of the lakes and cause secondary impacts to habitat for waterbirds that breed in the area.

A road system could also have significant effects on the tundra, both downslope and upslope of the roads. When microsite characteristics (moisture and topography) are altered, the resulting species composition differs from the original community. Surface impacts related to gravel fill usually extend beyond the direct loss of the area covered by the fill. These include impoundments of snowmelt, dust, gravel spray from snow removal, small construction spills, thermokarst, and contaminants from road oiling. The recovery of vegetation following disturbance is related to the intensity of the disturbance and the resulting changes in moisture regimes.

During the winter months, water is more abundant in lakes than in pools located beneath ice hummocks along major river drainages of the 1002 area. In April, when ice is at maximum thickness, 90 percent of the available water is contained in 9 of the 119 lakes surveyed. The lakes are not evenly distributed across the 1002 area. Many lakes are congregated near the mouth of the Canning River, and only two lakes are located in the region between the Katakturak and

Sadlerochit Rivers. Observation of fish presence in lakes was more frequent and widespread than previously suspected.

Although winter water occurs over a widespread area in most of the major river drainages in the 1002 area, the quantities are low. Ice cover of river channels is generally frozen to the river bed in all areas of the coastal plain. Only 9 million gallons of water were estimated to be available along the 237 miles of river channel inventoried. It takes approximately 1.35 million gallons of water to construct and maintain each mile of ice road used to support oil exploration activities and 30,000 gallons of water per day to support an oil exploration drill.

B. Water Quality

Very little information is provided in the LEIS regarding water quality. Most of the descriptive information, other than that for springs, is based on studies elsewhere on the North Slope. Most of that information, particularly descriptions of seasonal changes in water quality, is accurate. Since the LEIS, the Service has obtained a large volume of data about the water quality of ponds and lakes on the Arctic Refuge and at Prudhoe Bay including impacts of contaminants there. These data provide additional useful information and document the poor buffering capacity (hence susceptibility to water quality changes) of many Arctic Refuge ponds and lakes. These data also disprove one statement made in the LEIS regarding water quality, "Some shallow lakes are turbid during summer, when wind and wave action disturb bottom sediments." Turbidity measurement data from the Refuge did not reveal any turbid conditions in any of 36 Arctic Refuge shallow ponds and lakes sampled six times over two years of open-water conditions. The original source of this statement in the LEIS was a study in the National Petroleum Reserve - Alaska and was not supported by any measurement data.

The industrial infrastructure required for oil development would produce sewage that would need to be treated and disposed of properly. Currently 7 large and approximately 10 small sewage treatment plants are working in northern Alaska oilfields. All plants discharge under permits from the Alaska Department of Environmental Conservation (ADEC) and several have NPDES permits from the U. S. Environmental Protection Agency. Six of the large plants discharge into tundra ponds and one, Endicott, discharges to the Beaufort Sea. At the end of 1987, 47 sewage treatment plants were permitted to discharge a maximum of 1,201,650 gallons per day. The reduction in the number of plants is a result of decreased activity in the region and consolidation of some facilities.

Environmental effects of sewage effluent discharges include localized nutrient enrichment of wetland areas, in some instances resulting in algal blooms that increase suspended solids and biochemical oxygen demand, increased metals deposition, and discharges of chlorine.

C. Air Quality

No air quality data for Prudhoe Bay or adjacent oilfields were presented in the LEIS. The close proximity of the Brooks Range to the coast within the Arctic Refuge would create greater chances for inversions and poor air quality episodes and could result in greater entrapment of poor air. The composition of the crude oil and emission equipment design would influence air quality impacts from gas/water/oil separations on the Refuge.

Regarding heavy metal and nutrient (nitrogen and phosphorus) impacts, studies have documented enrichment of nutrients and several trace elements in Prudhoe Bay snowpack. The Service has also recently gathered data at Prudhoe Bay and on the Refuge to assess the effects of atmospheric deposition on snowpack contaminant concentrations and on the moss, Hylocomium splendens. We are still analyzing these 1994 data. However, the snow data indicate significant inputs of some major and trace elements, including heavy metals at Prudhoe Bay at two sites, one near drilling operations and the central compression plant, and the other near the North Slope Borough solid waste incineration facility. Effects appear to be local in that the metal enrichment patterns at the two sites differ substantially and no eastwest effects are observed extending into the Arctic Refuge. However, the data suggest significant inputs of nutrients with likely significant effects on the vegetative community. Uptake of certain heavy metals by moss is also occurring.

D. Reserve Pits

The LEIS reviews some of the contaminant impacts of reserve pits and mitigation measures, such as closeout under Alaskan solid waste regulations and requirements. The Service has documented additional impacts of reserve pit fluids. It has also been suggested, but not documented, that caribou may utilize abandoned reserve pits and exploratory sites as salt licks, adding a potential contaminant impact not considered in the LEIS. However, new techniques in waste management now allow for pitless drilling (i.e., no reserve pits). Disposal of drilling wastes can now occur by subpermafrost injection, and drilling cuttings have also been successfully ball-milled, with injection of the fines. If these technologies were to be stipulated for development on the Refuge, the impacts from reserve pit fluids would be minimized beyond those estimated in the LEIS.

Statements in the LEIS regarding State of Alaska solid waste requirements for closeout of reserve pits are no longer accurate. The State no longer requires closeout of all abandoned pits, and requirements for closeout have been substantially "loosened" when closeouts are required. To provide the same level of mitigation as described in the LEIS, stipulations would be needed regarding closeouts and solid waste management.

E. Oil Spills

The ADEC has continued to maintain records on the number and volume of oil and other hazardous waste spills on the North Slope since 1987. In general, reporting of spills has increased, indicating a need to revise the description of spills presented in the LEIS. Also, at least two well-blowouts have occurred on the North Slope since the LEIS was prepared. The potential for blowouts and their possible consequences in the Refuge were not detailed in the LEIS. Furthermore, the Exxon Valdez oil spill occurred after the LEIS was produced and therefore was not discussed in the LEIS.

F. Mitigation

The LEIS relied on mitigative measures to offset many of the adverse environmental impacts of potential oil development within the Arctic Refuge. Many of these mitigative measures are unproven. The LEIS discussion of mitigation states, "Surface effects of seismic surveys can be minimized by confining operations to the winter after the active soil layer is frozen to a depth of at

least 12 inches and the average snow depth is about 6 inches." Use of the words "average" and "about" are examples of word choices that reduce the impression of problems. If snow-depth only averages 6 inches, there must be significant areas that have less than 6 inches. In most years that is the case, due to the topography and wind characteristics of the area. The patterns of light snowcover make it virtually impossible to traverse some areas with surface vehicles without damaging vegetation and soils.

The 1984-1985 seismic study resulted in extensive damage precisely because of these factors. In reality, vehicles could not avoid all the areas of tight snow-cover as permit stipulations implied. These stipulations are the same ones proposed in the preferred alternative. Further, statements that the stipulations used for 1984-1985 seismic studies "would result in avoidance or minimization of impacts to vegetation" are optimistic. Experience has shown and extensive data exist to illustrate that damage to vegetation was not avoided in spite of stipulations. Observations at study plot sites in 1994 indicate that the recovery trend at some disturbed sites has reversed towards greater deterioration. This new information requires further study to more accurately predict consequences of future exploration activities.

In terms of mitigating impacts of gravel removal, the LEIS states, "Gravel removal should be prohibited from active fish-bearing watercourses and their tributaries." This does not indicate that it would be prohibited. Furthermore, if removal of gravel were limited to non-fishbearing watercourses, then few riparian gravel sources would ultimately be used, in which case most of the gravel would be extracted from upland sources, resulting in greater impact to landscapes where the visual effects would be very long-lasting.

As for vegetation, the LEIS says, "Localized removal or destruction of tundra vegetation resulting from the construction of gravel pads, gravel roads and gravel mines could occur." Vegetation destruction would occur. The issue of gravel and water required for development and production needs further evaluation. Analysis of data regarding predicted versus actual impacts of Prudhoe Bay oilfields and the Trans Alaska Pipeline completed after the LEIS indicate that the amount of gravel used was 400 percent greater than had been predicted.

In describing surface geological surveys within the 1002 area only, the LEIS does not explain that past surveys have largely focused in the mountain terrain to the south, where various rocks are exposed for investigation and testing. Congress designated this region as wilderness under provisions of the Wilderness Act. It is likely that if full development were authorized, there would be some work in the adjoining Wilderness area. The effect of noise associated with helicopter access in the Wilderness area is not adequately discussed. Accordingly, the LEIS underestimates the impacts to wilderness recreation and the disturbance of wildlife in the wilderness area.

Statements that docks and causeways should be constructed so that along the shore, water transport and water lagoon chemistry are not affected, and fish movements are not impeded, imply that the Prudhoe Bay experience is directly applicable to the Arctic Refuge coast. The coast of the Arctic Refuge is situated differently in the migration corridor than is Prudhoe Bay and presents a different hydrographic regime. Whether such an endeavor is possible, or feasible, is uncertain at this time.

IV. HUMAN ENVIRONMENT

A. Wilderness

The LEIS acknowledged that full development of the coastal plain would result in the irretrievable loss of the wilderness character of the area.

1. Historical Perspective

In the early 1950's, senior National Park Service planner George Collins visited the coastal plain. He found "a magnificent place of beauty . . . not the spectacular beauty of the mountains to the south, but a subtle beauty that comes largely from being part of a much larger, varied and interconnected natural system."

Collins was leading an extensive survey designed to determine which areas in Alaska most deserved formal protection. After traveling extensively throughout Alaska, he concluded that the area now established as the Arctic Refuge provided the nation's finest opportunity to preserve a vast arctic wilderness.

Collins was but the first of many to extol the presence of a complete and undisturbed spectrum of Arctic ecosystems as a primary value of the Refuge. Based on Collins' research, in 1957 Bureau of Sport Fisheries Director, D.H. Janzen, declared the proposed Range " . . . an ideal opportunity, and the only one in Alaska, to preserve an undisturbed portion of the Arctic large enough to be biologically selfsufficient."

Two years later, before a U.S. Senate hearing on the Arctic National Wildlife Range proposal, Interior Secretary Fred Seaton repeated Janzen's summation, adding, "It would comprise one of the most magnificent wildlife and wilderness areas in North America . . . Certain portions of the Arctic coast and the north slope river valleys, such as the Canning, Hulahula, Okpilak, Aichilik, Kongakut, and Firth, and their great background of lofty mountains, offer a wilderness experience not duplicated elsewhere."

Wilderness values, along with wildlife and recreational values, are among the three stated purposes of Public Land Order 2214 that established the Arctic National Wildlife Range in 1960. Those values came into focus again in 1973 when, following an agency wilderness review, the entire Range, including the coastal plain, was recommended for wilderness designation.

The issue of Refuge wilderness was extensively debated during the ANILCA hearings of the late 1970's. In 1978 the administration's position was stated by Interior Secretary Cecil Andrus in a speech before the Outdoor Association of America:

"In some places, such as the Arctic Refuge, the wildlife and natural values are so magnificent and so enduring that they transcend the value of any mineral that might lie beneath the surface. Such minerals are finite. Production inevitably means changes whose impacts will be measured in geologic time in order to gain marginal benefits that may last a few years."

The LEIS acknowledged the 1002 area's "outstanding wilderness qualities: scenic vistas, varied wildlife, excellent opportunities for solitude, recreational challenges, and scientific and historical

values." It did not, however, expand on these values, nor discuss the uniqueness and national importance in the area.

2. Wilderness Qualities

The Refuge is the only conservation area in the nation that provides a complete range of Arctic ecosystems, functioning in balance to perpetuate wildlife populations. The area offers more wildlife diversity than any other region of the Arctic. The LEIS states that the 1002 area is the most biologically productive part of the Refuge and the heart of wildlife activity. This productivity results from the combination of factors that make the area a unique wilderness: the proximity of mountains to ocean, the landscape diversity, the climate, and the permafrost. The coastal plain has unique ecological qualities vital to species such as caribou, brown bears, muskox, wolves, swans, and snow geese. Several species, such as the caribou, use the area during sensitive and critical periods in their life cycle. Many of the species also are of international significance--for example, the massing of the Porcupine caribou herd is one of North America's greatest wildlife spectacles. Many of these species are sensitive to human activities and require large areas of essentially unaltered habitat.

The 1002 area provides more diverse landforms and varied scenery than any other part of Alaska's coastal plain. Here the Brooks Range is only 20 to 40 miles from the Arctic Ocean. From many vistas within this area, visitors can enjoy awe-inspiring views of 9,000 foot snow-clad peaks, glacial valleys, braided rivers, rolling tundra meadows and terraces, shallow lakes, beaded streams, and sea ice--an opportunity not available elsewhere on American soil. The effect of standing water over permafrost adds further interest and dynamic change to the landscape. Rivers rise rapidly, creating cut banks and new gravel bars. In winter, the frozen soil moves and cracks the surface, exposing underground ice structures, forming polygons and other permafrost features, and creating micro-environments for new plants and animals.
Remote and roadless, the 1002 area and the adjacent fragment of Refuge coastal plain Wilderness east of the 1002 area comprise the most pristine of any large segment of arctic tundra remaining in the nation.

3. Impacts on the Wilderness Resource

The LEIS states that, "losses in . . . wilderness values on the 1002 area would be the consequence of a long-term commitment to oil and gas development in the area." However, the LEIS did not address, in any significant way, what those losses would be.

Development also would substantially reduce wilderness qualities in large parts of the adjacent Wilderness, significantly reducing its value. An oil field would be seen by recreationists from the many northern foothills and mountains within sight of the 1002 area. An oil field would destroy the wilderness value that people derive from seeing the coastal plain. Hearing the attendant sounds of the oil industry, the helicopters and aircraft traffic, would erode the sense of wilderness for miles beyond the 1002 boundary.

The LEIS accurately states that "most recreationists currently visit the 1002 area for a wilderness experience." However, the LEIS significantly understates the effects of oil development on their

experience. The fact is that an oil field would eliminate the wilderness experience for almost all of the recreationists, primarily hikers and floaters, who currently use the 1002 area and areas in the adjacent Wilderness.

4. Regional Uniqueness

Almost all of the Nation's coastal arctic environment is open to oil development or currently leased. Along Alaska's entire north slope, only the Arctic Refuge coastal plain is currently protected from development. The 1002 area represents only about five percent of the Nation's arctic coastal plain. protection of the area's unique wildlife and wilderness resources would help to ensure a needed balance with current and expanding development of Alaska's north slope. This is especially important because no other coastal areas in northern Alaska or the Nation provide the unique mix of landscapes, wildlife, habitats, and scenery that the 1002 area does. For these reasons, the area has incomparable and irreplaceable scientific, ecological, historical, and educational values for the American people. The LEIS acknowledged that development would result in an irretrievable loss of the wilderness character of the coastal plain.

V. CONCLUSIONS

The 1987 LEIS assessment of environmental effects of full development of the Arctic Refuge coastal plain predicted a number of major impacts. Reviewing scientific information subsequent to the 1987 report, the information provided in this review concludes that the prediction of major impacts is still valid. This review also concludes that the 1987 LEIS adapted a highly compartmentalized assessment, and considered impacts to species in isolation rather than as interconnected components of a complex ecosystem; a more scientifically sound evaluation requires consideration of the interrelationship of the species and the surrounding environment of the coastal plain. Further, this review concludes that the major impacts predicted in the 1987 report were characterized as acceptable risks in reliance on mitigative measures, some of which are speculative and unproven. Finally, an examination of biological and historical data indicate that, contrary to the 1987 conclusion, the Arctic Refuge coastal plain is unique among the refuges and parks of the United States.

Information received since the 1987 report confirms that impacts from development would be major, and that measures to reduce or remediate those impacts are uncertain. For its biological richness, undisturbed vastness, and fragility as an arctic ecosystem, the coastal plain of the Arctic National Wildlife Refuge is a national treasure, and would be irreparably altered by development.

U.S. Fish and Wildlife Service, 1995 Review of Development Impacts Report.