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ENVIRONMENTAL IMPACT OF OIL DEVELOPMENT

NORTHERN ALASKA

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It is reported that in the spring of 1969 a high official of one of the oil companies was flying over the area of oil development in the vicinity of Prudhoe Bay. He is quoted as saying "If the American people could see what we are doing to their land here, they would want to abolish the use of the reciprocating engine."

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## Environmental Impact of Oil Development

Northern Alaska

By Luna B. Leopold 1/

The Conservation Imperative

The last really large area of wilderness in the United States is the Brooks Range and the Arctic Coastal Plain which stretches from that range to the Arctic Ocean. The proving of the exploratory oil wells which have been drilled on the coastal plain in the vicinity of Prudhoe Bay makes it virtually certain that this heretofore mostly unknown country will rapidly and vigorously be exposed to a variety of changes caused by the influx of men and their equipment. Even within the first four months of 1969 the whole aspect of the central part of the region has been importantly changed by the drilling programs of several large oil companies.

So suddenly was this change brought about that no long-range plans have been developed either to soften the effect of such development on the natural environment or even to record the progress of these effects. Yet the absence of a plan provides an inadvertent potential advantage in that there has been no history of increasingly firm Federal policy which, in other places, has often made it difficult to take newly conceived action in line with the increasing societal interest in environmental preservation. The lack of firm Federal policy provides here a unique opportunity for the application of new rules and investigative

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techniques aimed at minimizing the adverse effects on the environment while, at the same time, not unduly hindering the development of the natural resources.

But the speed with which the changes are being wrought makes it imperative that the principles applicable here to environmental protection or preservation be enunciated immediately and that from these principles flow farsighted regulations which reflect the new interest in combining resource development with environmental protection.

The present report constitutes a brief summary of the conditions existing in northern Alaska in the spring of 1969, presenting some inferences on the environmental changes which can be expected in the future and offering some specific steps which, if taken immediately and positively, could greatly ameliorate the adverse effects of rapid development in the absence of positive steps for environmental protection.

In that regard, then, this report is ephemeral in character because the conditions in northern Alaska will surely change with great rapidity. Considering the fragility and sensitivity of the ecosystems existing there, the changes can be both harsh and permanent. Therefore, whatever value lies in the recommendations made here, the results of their application will depend on the promptness of their consideration, amendment, and application. Whatever form the actions might take for minimizing the harm to the environment, the urgency of the matter can hardly be overestimated.

### History of This Report

During the 1950's, at the request of the Department of the Navy, the U.S. Geological Survey was engaged for close to a decade in making a wide variety of hydrologic, topographic, and geologic studies in the Naval Petroleum Reserve No. 4, a large area north and west of the Colville River and extending westward approximately to the longitude of Point Barrow. Comparable studies have not been made in the land lying east of the Colville River, including the recently proven oil field in the general vicinity of Prudhoe Bay. The now famous well, Prudhoe Bay State No. 1, was brought in by Atlantic-Richfield Co. early in 1965. By April there were at least 7 companies and their 16 drilling rigs drilling in the area, mostly in the general vicinity of Sagavanirktok River south of Prudhoe Bay, and at least one a short distance southeast of Umiat near the Colville River some 70 miles to the west.

The office of the Director of the U.S. Geological Survey perceived the necessity of obtaining some general facts about the relation between present activities and the environment as a necessary prelude to more detailed studies and records of progressive changes. Recognizing the sensitivity of these Arctic environments to changes wrought by man's activities, it was deemed desirable to conduct at this early stage a field reconnaissance as an initial part of the necessary record. Consequently, the author was asked to make a field reconnaissance, talk to knowledgeable people, obtain photographs, and make whatever recommendations that seemed to flow from the facts and information collected.

The purview of the reconnaissance was to be as broad as possible and include estimates of the interrelation among the many physical, biological and social factors which might be affected. In other words, we were asked to look at as many aspects of the total environment as possible and to discuss not merely the physiographic and geologic factors affected, but the broader spectrum of environmental matters. Further, we were asked to make recommendations on administrative and on regulatory actions which might be taken for environmental protection regardless of jurisdictional boundaries now extant.

The reconnaissance was conducted during the week of April 3, 1969, operating by means of a light airplane out of Fairbanks and Bettles.

The author acknowledges the cooperation of persons too numerous to name, but including representatives of Federal and State agencies, the University of Alaska, and interested citizens.

#### Status of Development, Spring 1969

Prior to late winter in the year 1968 the number of persons other than the native population working north of the Brooks Range was small. Several small military installations, maintained for observational purposes, constituted the principal establishments. These were all served entirely by air transport for ingress, egress, and supply. The impact of such installations on the country immediately surrounding was limited because there was no heavy equipment or large vehicles operating over any distance away from the installations. A certain amount of scientific exploration and of hunting occurred on the North Slope and

in the Brooks Range itself, but most of this was accomplished on foot after initial transport to the work area by light airplane or helicopter. Such use, however, was necessarily limited owing to the fact that the distances are very large and supply bases for obtaining gasoline very few. For example, from the closest airport to the south, Bettles, it is about 340 miles to Point Barrow and more than 300 miles to Barter Island.

Within the first three months of 1969 the situation had completely changed. A winter road, the first to be constructed anywhere through the passes of the Brooks Range to the North Slope, was put through by bulldozer and heavy equipment from Fairbanks through Bettles, up the John River, and across Anaktuvuk Pass to Prudhoe Bay, a distance of nearly 500 miles. Over this road, during March and April 1969, a very large number of pieces of heavy equipment, including road building carriers, flatbed trailers, caterpillar tractors, semis with trailers, road graders, and other machines were plying their way from Fairbanks to Prudhoe Bay on a day and night schedule. At the same time, it was estimated that on every day, when weather permitted, there averaged 40 flights of large aircraft, especially Hercules "flying boxcars", transporting goods from Fairbanks north to a series of new landing strips near the drilling rigs. At the beginning of 1969 there were only two airstrips on the North Slope. In April there were 15 new airstrips. Another indication of the extent of air transport to the North Slope

The net result of this is that there is a non-vehicle route extending all the way from Fairbanks to the North Slope and consisting of two such routes from routes numbered. Because of the permanence of any bulldog trail in this type of country, the Brooks Range has already been split not by one but by two transportation routes.

#### Immediate Prospects for Development

Owing to the fact that the Fairbanks-Bethel leg of the pipeline route has apparently already been surveyed, it is probable that the pipeline will actually be built in the near future. Considerable reticence in discussing such plans is encountered in northern Alaska. Actual construction plans are apparently known only by a few. It is believed by many people that the actual construction of a 48-inch pipeline will begin by the fall of 1959.

There seems to be a definite intention to make the present winter road from Fairbanks to Prudhoe a permanent all-weather road. Engineers in the State Highway Department believe that the State officials will seek Federal funds for the upgrading of the present winter road to an all-weather road under the usual procedure of requesting Federal highway aid money from the U.S. Bureau of Public Roads. Under the terms of such a request, the all-weather road would be constructed under State supervision and the Federal contribution would be of the order of 98 percent of the total cost. It is estimated that that portion of the road consisting of the 150 odd miles through the Brooks Range itself would cost on the order of a million dollars a mile to make the present winter track an all-weather highway.

Recreational values.--In recreational values we include two aspects which may at times be incompatible of existing simultaneously. These values to society are, first, those obtained from recreational use by people for a variety of sporting and associated activities such as hunting, camping, fishing, skiing, walking, and the like. Another sometimes incompatible recreational value comes merely from the existence of stable and original ecosystems enjoyed intellectually by people even when the area is not "used" or visited. The private citizens' donations to save a sample of the redwoods clearly includes a large number, perhaps even a majority of donors, who have never seen and may never see the redwoods they wish to save.

Economic values.--The economic values considered here include the natural resources occurring on and in the ground, such as minerals, oil, and timber, the monetary values of waterpower, the monetary benefits associated with recreation, such as travel, lodging, sporting supplies, and tourism.

Indigenous population values.--The indigenous population values are of two kinds: One is the ethical value to society derived from its efforts to maintain a native culture to support the aspirations of the people and thus, by inference, maintaining the ecosystems on which such native populations depend. The second is the responsibility of any society to provide conditions of health and education to all of its citizens, taking into consideration their own desires for maintaining whatever distinctive religious, social, and livelihood systems which they may choose.

Fish and wildlife values.--Fish and wildlife values are those separate from recreational use as objects of hunting, but refer to the inherent right of species to maintain themselves on the earth. This inherent right of living creatures is the conservation ethic of an advanced society which produces a high order of intellectual, scientific, and aesthetic benefit through either observing such species in their native environment or merely knowing that such an environment is being maintained. But the fish and wildlife values depend not merely on protection but on the maintenance of the ecological conditions under which they can survive.

Aesthetic values.--Aesthetic values are those nonmonetary benefits accruing to an ethical people from observing or merely knowing that there exist pieces of the earth which are essentially natural and wild. Reaping these aesthetic benefits may take the form of observing, photographing, or otherwise enjoying Nature on the spot, but, as in the case of fish and wildlife values, may accrue to a society merely in the knowledge that it is there for those who wish to see it firsthand.

These brief definitions are provided here in order to indicate what we will refer to in this report as the various benefits and costs to society and the scope of our attention to what is more briefly called the environment. We are cognizant of the fact that various segments of society have different preference patterns and certainly do not give similar weights to any one of these mentioned values when a choice

among alternatives is presented. We assume, however, supported by the trends in public opinion expressed as an increasing concern for the nonmonetary advantages of a decent environment, that the environment includes all these factors even though they may not at present be considered by all persons to be important. They represent aspects of the world which must be given consideration now if they are to exist at all for a society only gradually learning to appreciate them.

Present and Projected Effects of Environmental Impact of North Slope  
Development

Ecological Factors

One hears often that the Arctic vegetation is sensitive and fragile. The truth of this statement is written on the Arctic slope in the multitude of vehicle tracks, many as old as 20 years, which fail to heal and be restored to original condition. These tracks often markedly deteriorate through deepening by erosion and marked change in vegetation. Some general facts about the nature of the surface, its landforms and vegetation, and factors determining its stability might profitably be reviewed here briefly.

The salient fact about much of Alaska north of the Yukon is that it is underlain by permafrost, an inheritance from glacial times. The part of Alaska about which this report is concerned was generally not glaciated except in the highest mountains. The glacial climate impressed on a very large area conditions of frozen ground extending from the surface to a depth of many tens of feet and, in places, hundreds of feet. Except for the alluvial materials of the river valleys, the subsurface maintains this deep layer of frozen water and the vegetation and landforms are, for the most part, determined by the fact that summer melting affects only a few inches to a few feet of the surficial materials. So thin is the zone of summer melting that the native vegetation has adapted itself to this condition of a permanently frozen subsoil and to the resulting actions of gravitational movement, frost heaving, ice wedge formation, and near saturation of the surface melt.

zone of summer. Until the drying action has proceeded well into the summer, the initial melting creates nearly everywhere a thin zone of soil and organic material which is subject to gravitational movement over the slick, frozen surface beneath. The large diurnal temperature range allows this free water to be drawn up into a large variety of physiographic features, the form and vegetational covering of which are closely related to the conditions of moisture and of freezing-thaw.

This being the case, changes in surface vegetation, even of a minor sort, can materially alter the albedo, the heat balance and thus the stability of the underlying frozen material; buildings, or any structure which alters the surface radiative exchange tends to prevent complete refreezing in winter and, as a result, the average level of the frozen layer recedes downward. Loss of moisture in the increasing thickness of unfrozen ground causes contraction which leads to surface lowering, slumping, and a consequent topographic depression. In such topographic depressions, meltwater accumulates.

In the case of vehicle tracks across the taiga (subarctic forest) and tundra (Arctic low plants), the topographic depression may extend long distances and thus forms a natural watercourse as accumulated meltwater in summer begins to run off. Some vehicle tracks then become gullies in a few years. A single traverse of a tracked vehicle is known to result in a few years in a gully 50 feet deep.

The effects on slumping and erosion are exacerbated in those areas especially prevalent along the bluffs of the Colville River where the geologic materials are high in unstable clays.

population pressure and the accompanying increased incidence of uncontrolled fire becomes an ecologic hazard of great importance. As in other ecosystems, the balance among various elements is sensitively dependent on the maintenance of each element. The caribou range is highly dependent on lichens. A grizzly range requires large areas free of heavy human use pressures. Thus the stability of these sensitive ecosystems is affected not only on the physical destruction of the vegetation by roads, trails, and mechanical disturbances, but depends on the mere existence of blocks of country of sufficient size that wide-ranging mobile animals can be free of constant interruption as well as free from modern hunting pressures.

#### Recreational Factors

Recreational uses of the Brooks Range and the North Slope have been primarily by hunters and secondarily by mountain climbers, fishermen, and the hiking visitor. Access is normally by light airplane landing on natural gravel bars and based on scattered airstrips in the bush. The common argument about wilderness recreation applies here in Alaska as well as elsewhere; that is, to reap the benefits of recreational use, the recreationist has to have access to the land. One of the inherent facts about wilderness landscapes of northern Alaska is that the ordinary tourist, accustomed to camping in or near his car or at hostels or motels, would find the Brooks Range and the North Slope to be brutally inhospitable even were the usual facilities of food and lodging available. The mosquitoes and other bugs of Alaskan summer are well known. Winter weather is cold if not otherwise uncomfortable. Yet the scenery of the Brooks Range, for those who appreciate mountain grandeur, is of a high quality and even the monotonous character of the tundra can be grand in its own way. Therefore, the physical location and characteristics of the

north country is not likely to provide recreation to large numbers of people even under drastically improved conditions of access and accommodation. Hence, the recreational use of the Brooks Range and the North Slope will probably continue to be only for the big game hunter, the avid fisherman, and the wilderness hiker and photographer. These recreational values depend primarily then on the maintenance of ecosystems which can functionally produce the trophies of camera, rod and gun. Without the wildlife, recreation, even for the hiker-photographer, would be much less valuable than it is today. Tourism in the usual sense of mass recreation is much more possible to develop in central and southern Alaska than in the Brooks Range and the far north. Even with marked improvement in access and accommodations, it is unlikely that recreation in this part of Alaska would develop any large economic benefits for the State from tourism. Compared with the many other places in Alaska of less harsh climate, easier access, and equally beautiful scenery, the Brooks Range and the North Slope are not as suitable for mass recreation as many areas farther south.

#### Economic Values

The economic values of the Brooks Range and the North Slope are primarily related to the development of minerals and oil. The proven oil field of the North Slope is unquestionably the largest economic resource of the area and, comparatively, the geologic conditions indicate that other mineral development is likely to be of a much lower order of magnitude. Reliable estimates of the total economic worth of the oil, including that of the Naval Petroleum Reserve No. 1, have not

been made, but knowledgeable people believe that it is one of the really large oil resources on the entire continent. One estimate places the possible quantity as 100 million to 10 billion barrels. In addition, there is the possibility of oil shale developments, the complete extent of which is as yet unknown.

The economic values associated with travel, trucking, airlines, housing, food, and services in the Brooks Range and the North Slope would all flow primarily from the development of North Slope oil. Each of these can be considered subsidiary effects of the oil development, except for the money which will be paid to the State and the Federal Government through the leasing of the oil-rich lands. Oil development, of course, will require a large financial outlay both by the State and by the Federal Government. For example, the State of Alaska has carried the costs of the development of the present winter road from Fairbanks north to Prudhoe. The highway engineers expect that, if this winter road is turned into an all-weather road, something like 98 percent of the total cost will come from Federal funds. There already has been a large private investment on the part of the oil companies even to prove the oil fields, and if the oil pipeline is built as expected, the investment will be even greater.

It is difficult to estimate the number of individual citizens in Alaska who are presently and potentially to reap benefits from the oil development. The activity in the last several months has caused a large expansion in several local airlines, of airport and road construction companies, of trucking firms, and of a variety of allied services. There has been a considerable influx of working forces into the Fairbanks area

as well as into the oil field itself. However, there have been compensatory social costs to a much larger portion of the population through rapid inflation. Certainly in the Fairbanks area costs of living have increased considerably especially for food, housing, and lodging. One hears many citizens complain that the North Slope oil development has not only failed to benefit them, but has worked to the disadvantage of the rank and file of citizens through increased costs and shortages, especially in food and housing.

The economic benefits from increased employment have affected a small percentage of the population of the State despite the fact that there are hundreds of workers employed on the North Slope and in transportation to and from. Most of this labor force, however, came not from the local area, but represents an influx from southern Alaska and from the other States.

The major profits derived from North Slope oil development will go, therefore, to stockholders outside of Alaska itself. The main economic gains to the State will be the increased activity in services, the development of new industries, in travel, docking facilities, petroleum refinery, and power generation. Probably the largest direct benefit to Alaska as a State will come in the form of the payments for land leasing. It is the plan of the developers to sell an important part of the oil abroad, especially to Japan.

### Indigenous Population Values

The indigenous people, mostly Indian and, to a lesser extent, Eskimo, will be affected through influences causing change. Oil development is providing and will provide much broader opportunities for cash work to indigenous people. However, they will derive few other benefits except those associated with improved transportation and therefore probably improved educational and health services. There will be concomitant losses or disadvantages owing first to the simple disruption of accustomed ways of life. Cultural attributes will be under great pressure for change, the final results of which may be variously assessed as advantageous and disadvantageous. The indigenous people will be affected by changes in wildlife on which they have depended. Such changes, being ecologic in character, can, as usual, not be computed in detail, but general trends or tendencies can be expected by analogy to most other ecologic situations in formerly wild areas. The ecologic changes are nearly always disadvantageous, rather than the opposite, by disruption in both numbers and stability of native members of faunal and floral communities.

The Eskimo village of Anaktuvuk, for example, through which the winter road now passes, has a population of 120 persons. All the members of this village who are able or willing to work have been provided employment in one way or another related to North Slope oil exploration.

It is estimated that the total native population of the North Slope, Brooks Range, and interior Alaska is about 8,600 persons of which 4,600 are male and 4,000 female. Of the available labor force 16 years old or older, it is estimated that before North Slope development there were about 2,800 individuals unemployed, 1,800 male and about 1,000 female.

The villages most likely to be affected by North Slope oil development, however, are only a modest part of the total native population. The population of the villages on the North Slope potentially affected by its development are listed below:

Barrow	2,000
Wainwright	300
Barter Island	150
Anaktuvuk	120
Arctic Village	90
Bettles	5
Allakaket	130
Alatna	25
Wisman	2
Rampart	40

It thus appears that even if North Slope development were to be a net benefit to native populations primarily through employment, the benefit would accrue to less than 3,000 out of a regional native population of 8,600 persons.

Instability or disruption of the range and migration of large animals, especially caribou, would adversely affect the same people.

### Fish and Wildlife Values

As indicated in the brief definitions given above, fish and wildlife values are here treated separately from the economic values associated with recreation. Recreation has both its economic and its aesthetic or experience side. Similarly, fish and wildlife have an economic value of the take itself, but also an aesthetic or intellectual value to society from the mere existence of ecosystems which support native fauna. The effect of North Slope development on fish and wildlife values is, for the most part, going to be a large net loss despite some increase in benefits in the form of take or harvest. Especially vulnerable are three species, caribou, grizzly, and wolf. In the Arctic slope region, it is estimated that caribou number about 450,000, of which the average yearly harvest is 15,000 and the estimated value of the harvest is three-quarters of a million dollars. Grizzly is considered common and the average harvest low, but even a rough numerical estimate of the population is not available. It appears to be certain, however, that the grizzly has approximately the same density of animals per square mile over the whole tundra area of the North Slope as in the mountain environment of the Brooks Range. This is an unfortunate distribution for the species because during the seasons that the bears are not in hibernation, an individual roaming over the nearly featureless tundra tends to be spotted easily from an airplane. The same is true of wolf, but because wolf does not hibernate as does a bear, the vulnerability from aircraft spotting is much higher.

The winter road to the North Slope goes up the John River and over the Aniakchuk Pass directly along one of the favored migration routes of one of the important caribou concentrations. The oil pipeline will presumably either follow this winter road or go up the middle fork of the Koyukuk and Dietrich Rivers. As far as the relationship of the road to caribou migration is concerned, one can only imagine that an all-weather road would materially affect the use of the John River valley as a continuing migration route because vehicle traffic at certain times of the year would be meeting thousands of animals concentrated on the same route. The effects might be several: a greatly increased hunting pressure; an environmental pressure due merely to constant harassment, interruption and disturbance by sight and sound. Such interruptions could easily lead to splitting the herd, to new habits of migration, choice of calving areas, and alteration of the necessary habitat.

It can hardly be doubted that caribou need a large area in which to migrate in order to maintain their viability as a biologically reproducing herd. Confining them to a small area, say the size of the Arctic Wildlife Refuge, would tend to reduce their only natural defense against their natural enemies. These enemies include wolf, bear, flies and mosquitoes. One thing that they need is room to outdistance predators such as wolf partly by maintaining a nearly continual movement. Confinement or restriction of natural habitat would also prevent the caribou from gaining access to the diversity of habitats they need to provide food during the highly variable succession of Arctic winters.

As for grizzly bear, two influences are surely going to be important, both additional. According first that northern Alaska represents the last place in the United States where grizzly occurs in anything like their original population density, it best this density is not great for one may fly many hours over grizzly range and never see an individual.

Being a large animal, this is relatively mobile and, although the cruising radius is not well-known, it is commonly measured in miles. Also, the grizzly is a territorial animal and in any given season tends to remain within a restricted geographic zone. Once spotted, therefore, by a hunter in a light airplane, it is usually possible to land on a nearby gravel bar and proceed to the area where the bear was seen for the actual hunt. This, in fact, is the principal way that bears are hunted in the mountains. The same thing applies to the broad, flat areas of the North Slope except that there the bear is more easily spotted in the first place.

Being a highly prized game animal, the mere existence of a large number of airstrips, a greatly increased traffic of persons who might be looking for bear, and a larger number of places to land and fuel airplanes, can be expected to increase greatly the hunting pressure on grizzly.

Finally, the splitting of grizzly range by a road tends to cut the normal range and thus alter importantly the possibility of redistribution of an inherently light population. It is characteristic that when a formerly wild range becomes populated by the construction of a road, the local grizzlies are sufficiently curious that they tend to concentrate near the new construction looking for easy food and interesting objects.

During this time they are peculiarly subject to hunting pressure. Within a short time, however, those that do not get shot tend to move back away from the area of human use, apparently merely to avoid the scent and interruptions of man. A road, therefore, becomes a wide swathe of grizzly-free range.

The wolf is in a peculiar situation for slightly different reasons. The most important reason is that in the American mythology of the wilderness, the wolf has a bad name and everyone has always felt it a civic duty to shoot any wolf he could find. For this reason and because their natural habitat and prey have been altered, the wolf has been extirpated from nearly the whole of western United States and now exists only in a few restricted areas possibly limited even to one near the Canadian border in the north-central States. Alaska, therefore, represents the last of any large range where wolves occur. Unfortunately, there is also a local mythology in Alaska that the \$50 bounty on wolf represents an important way to increase the cash income to the indigenous population. The other opportunities offered to native populations, especially in light of North Slope oil development, strongly argues that such a need for a bounty on wolves has disappeared. In contrast, greatly increased air traffic and availability of landing strips for light aircraft means a large and immediate increase in hunting pressure on wolf. We are told that one of the pilots of the transport planes operating between central cities and the North Slope maintains his own light plane on a nearby airstrip. When he spots wolf on his regular transport route, he then takes off in his own plane and returns to the spot where he saw the animal. It is this kind of increased pressure on wolf which puts the animal under a heretofore unequalled pressure.

We learned of one man, hunting wolves from light aircraft, who bagged some 240 wolves in the last year. This is an indication of the severity of hunting pressure.

Under the hunting regulations of the Department of Fish and Game of the State of Alaska, the taking of game is prohibited from helicopter or airplane. However, wolves and coyotes may be taken by use of aircraft (except helicopter or rotorcraft) under terms of a permit which may be issued by the Department. The regulation further states that it is illegal to take big game by aircraft "in Alaska in any manner as an aid in taking brown or grizzly bear except for transport to a pre-existing camp."

Thus, it is illegal to shoot bears from moving aircraft and wolves may be shot from aircraft only with a special permit.

One of the problems is that at least some of these regulations are very difficult to enforce. Though the law states that aircraft can be used only for transports to a pre-existing camp for hunting bears, it would be very difficult to prove that the regulation is being broken when a hunter spots the game from a plane, makes a landing, and then walks into the brush for the hunt.

Also indicating the tenuous nature of these regulations, there had been in the spring of 1959 a temporary ruling allowing wolves to be shot from hovering helicopter. This ruling was later rescinded. In any event, it ought to be clear that the wolf population cannot stand up under the double jeopardy of a bounty and an increase over the present already heavy hunting from airplanes.

The roads and pipeline pose environmental change in environmental conditions to fish in at least some rivers. The John River especially is likely to be greatly altered, especially in its sediment load.

Before development, the John was moderately clean even under high flow conditions of snowmelt. Its channel, though braided in certain portions and generally meandering in the lower reaches, appears to be stable. In the development of the route for the winter road, the advice of a local homesteader in the John Valley, Mr. Bill Fichtus, was apparently completely disregarded by the construction men. He had shown them the possibility of choosing a route to the upper reaches of the John River which would have eliminated nearly every crossing of the river. Rather, for temporary convenience, the construction men crossed and recrossed the John a total of about 14 times between Chavice Creek and Anaktuvuk Pass. Each crossing was marked with a considerable amount of gravel bulldozed from nearby river bars as well as grading of the river bank to provide a usable ramp. The winter road, of course, crosses the John River, as in the case of the Yukon, on the ice.

Highwater conditions will see these crossing materially altered by erosion and deposition as the river attempts to re-stabilize the banks disturbed by bulldozing. The engineers of the State Highway Commission visualize that were the winter road to be constructed, millions of cubic yards of gravel would be excavated from the river channel for the construction of roadbed. Experience with such roads in remote areas also suggests that the disturbance of the river channel and its banks will, no doubt, lead to a major change in the amount of sediment carried by the stream especially during the construction stage. This increased sediment load will have an unknown but probably detrimental effect on fish in the river and may lead to sediment instability which could last long after the all-weather road is finally completed.

#### Aesthetic Values

Any of the changes discussed in preceding sections will have an adverse effect on aesthetic values, particularly near the road location and along the route of the pipeline. The aesthetic changes are of many different sorts. They include the unhealed scars of the native vegetation; the scars of presently uncontrollable timber cutting associated with providing logs for construction piles; the gradual loss of the ability to see wild game along the routes of travel and an associated degradation in the aesthetic environment merely from the recognition of the alteration of the original landscape; the great accumulation of trash and debris along the roads and near the airstrips.

The 500 miles of winter road has accumulated in the two months of its existence an incredibile variety of trash and debris including waste paper, plastic containers, oil drums, scarred vegetation, and just plain litter. Although generally throughout Alaska litter is a major problem near towns, villages, and along roads, it is especially important in the far north where degradation by ordinary weathering processes is slow and incomplete. Old oil drums can be seen scattered in many places on the North Slope which have rested there with little or no rusting or deterioration for a quarter of a century. Even bits of paper do not weather and disappear in these climatic conditions.

The problem of disposal of sanitary wastes is not yet a hazard to health but may rapidly become a factor markedly degrading the aesthetic value of the landscape. Pollution of streams or even the fear of pollution means that native waters, which might appear perfectly clear, cannot necessarily be drunk with impunity.

Air pollution can be a serious degradation of the environment in portions of the far north during winter when the temperature inversion near the ground is so strong that the air is extremely stable and little or no mixing occurs. In Fairbanks, for example, during portions of the winter when the pressure gradient is weak, even the burning of trash can result in a cloud of frozen microscopic particles which can hang only a few yards above the incinerator for hours without ever moving away. Under such conditions, the air pollution can be sufficiently serious at the airport that at times local airplanes have been lined up along the field with the propellers all facing the same way in order to try to create

concerns the construction of roads and occurrences additional variations may develop due to varying susceptibility to frost heaving resulting from different altitudes. The effects of these strong inversions of temperature variation if so different from our experience in temperate latitudes than the intensity of the effects is simply beyond our usual experience.

#### Immediate Needs for Policy and Regulation

##### Formation of Road Construction

It can be conveniently assumed that the planned pipeline will indeed be built in initial stages probably beginning in the present calendar year. The winter road on the way across the Brooks Range to the North Slope is an existing fact.

Most of the land traversed by the winter road is part of the public domain. The procedure to obtain permission to build any sort of track or road over public lands is minimal. For a temporary road anyone can build a track with impunity and with no advance permission. For a more important, even though seasonal road, such as that represented by the present winter road, the procedure is as follows:

The general location is presented to the Bureau of Land Management which agency then will usually reclassify the status of the lands involved. In the case of the winter road, the BLM reclassified a corridor of considerable width within which the final location of the road could be determined on the ground with flexibility. Apparently the BLM has no extensive administrative powers to control construction methods and uses. Only after the construction is complete and it can be shown

the unusual or unnecessary damage to the environment and causing  
costs which they require resources to settle such. Since this is  
already too late to prevent such damage, it appears that the minimum  
powers of the BLM needed to minimize environmental impact of road  
development on public lands need to be strengthened.

Though the BLM has prepared a set of guidelines hopefully to be  
followed by the construction firms regarding trail and road location  
associated with North Slope development, these guidelines have no  
effective force. Though they are presumably dictated by the construction  
companies, the latter are under no legal or enforceable pressures even  
to follow the suggested guides.

The BLM should be immediately given by the Secretary or by legis-  
lation much greater powers to specify the details of road location and  
construction, including such matters as: the nature of river crossings;  
deviations from the original track permitted for any purpose; the location,  
size, and construction of borrow pits; and general specifications for  
roads of different types.

The BLM, as part of the guidelines agreed to by the developing  
companies, has specified that seismic exploration be conducted generally  
from helicopter in order to eliminate the tracks of motor vehicles which,  
in places, criss-cross large areas of otherwise natural land.

It is recommended that the Bureau of Land Management should be  
granted by the Secretary or by legislation powers to regulate by statua-  
tory or executive authorization the resource exploration, especially by  
seismic methods, and be legally able to require the use of helicopter  
rather than land vehicles when environmental protection so dictates.

#### No-Shooting Corridors

The corridor for the road having already been granted by the BLM might well be used as the limits of a corridor to which new rules should apply. This seems logical from the administrative standpoint and imperative from the environmental one. A corridor of no-shooting is recommended to coincide with the corridor granted through the Brooks Range and across the North Slope for the winter road. The no-shooting zone could logically be specified as 2 miles on either side of the winter road within which zone no shooting or hunting with or without license would be permitted.

Recognizing that the "final" control of hunting regulations lies with the State rather than with the Federal Government, the necessary legal powers are unclear regarding how the Federal Government through the Bureau of Sport Fish and Wildlife could reduce the hunting pressure on wolves. However, in the case of Federal lands in other States, both the BLM and the Forest Service, as agencies administering the use of public lands, have certain powers which could be used for the control of hunting.

#### Regulation of Wolf Hunting.

It is recommended that the appropriate Federal departments take immediate action to eliminate the shooting of wolves from aircraft; to work toward an immediate cessation of paying bounty for wolves; and setting up regulations to reduce the indiscriminate and unlimited killing of wolves, such as requiring a license and specifying a bag limit.

### Control of Logging.

The need for large diameter conifer logs, especially for the construction of piling, already jeopardizes the small area of large timber near the Koyukuk River below Bettles. Though southern Alaska and portions of central Alaska have large amounts of merchantable timber, the appropriate Federal agencies should immediately set up regulations to prevent the cutting of the few small stands of large diameter white spruce along the winter road from the Yukon River north.

### Disposal of Debris.

When a road through public land has been constructed primarily to promote the development of resources by a relatively few corporations and despite the fact that various citizens gain some benefits from increased demand for services, it nevertheless can be counted the responsibility of the companies involved in development to guarantee that the landscape is not indefinitely subjected to uncontrolled littering and random disposal of unwanted debris.

Therefore, it is recommended that the appropriate Federal agencies set up regulations which would require that the principal contracting companies involved in North Slope development will be responsible for cleaning up debris along the existing winter road; for the permanent disposal in appropriate fashion of oil drums and other construction sites, and be required to adopt disposal programs and techniques aimed at concentration of unwanted debris at agreed upon sites, and the elimination of uncontrolled littering of the environment.

Policy for Environmental Protection.

The kinds of recommendations made above would still be a patchwork of unrelated and uncoordinated regulations in the absence of a generally stated policy aimed at environmental protection on public lands north of the Yukon. It is recommended that the Secretary of the Interior in a joint action with other parts of the Executive Branch and with appropriate committees of the Congress assure an interim environmental policy, especially aimed at limiting the impact of oil development on the North Slope of Alaska on the environment. Though a general Governmentwide environmental policy may later include in general language the Government's determination to protect the environment while at the same time allowing resource development to proceed, there is an immediate need for a clear environmental policy statement applicable now to northern Alaska. Such a policy would govern not only the actions of private parties engaged in resource development, but would also provide a policy within which all Government agencies could work singly and together for environmental protection, especially on the Federal lands.

Summary of Immediate Recommendations

- 1) A corridor of no shooting be declared by the Department of the Interior approximately coinciding with the corridor classified by BLM for the winter road route. The no-shooting zone would include 2 miles on each side of the winter road already constructed and should extend from the Yukon River along the winter road north to the ocean.
- 2) The BLM should be empowered by the Secretary of Interior to write and enforce regulations specifying details of road exploration and construction on public lands in Alaska, aimed at maximum protection to

the environment. These regulatory powers should include specifications for exploration, including exploring for seismic data, seismic surveys, and other transportation needs.

3) The Department of Interior should declare the spotting, harassing, or hunting of wolves and bears from moving aircraft illegal on all public lands, with provisions in the regulations carefully drawn to enhance effective enforcement.

4) The Department of Interior should cooperate with the Department of Transportation to make Federal aid for road construction contingent on acceptance of standards for exploration and road construction, and acceptance by the State of the elimination of bounty on wolves.

5) The Department of Interior should require exploration, drilling, and construction companies on public land to conform to standards on debris disposal, cleanup of sites, and environmental protection against uncontrolled waste disposal. Controls on waste disposal should reflect a cognizance of the peculiar environmental conditions typical of northern Alaska. The weathering and disintegration is extremely slow. Bears can dig into the ground deeply and do so persistently. Winds in the Arctic are strong and variable. Microbiologic activity is slow or absent.

6) The Department of Interior should cooperate with the Department of Agriculture in setting standards for the cutting of timber on Federal lands for road and pipeline construction.

7) The Executive Branch should issue a temporary policy aimed at protection of the environment in northern Alaska which would ameliorate the impact of resource development on the landscape.

## Immediate Need for Data and for Investigations

### Reconnaissance Study of Sediment and Streambank Stability.

One of the principal water factors which must be investigated as soon as possible is the present condition of the rivers with regard to their sediment content before and after the construction of the all-weather road and the pipeline. When the winter road was put in across various streams, construction machinery could move across the river on the ice. Many small streams, however, caused enough of a barrier to be crossed with equipment that the bulldozer operator scraped soil and gravel from nearby to reduce the angle of the gully banks and actually filled up the bottom of the channel with material brought in.

When melting occurs and water begins to move in these same channels, the material bulldozed will form an obstruction to the flow of water which will undoubtedly, in most instances, be washed away downstream and, as a result, there will be initiated new conditions of streambank stability, probably associated with local erosion and sedimentation. Also, the downstream transport of this bulldozed material will change the characteristics of the sediment load of the stream in the downstream direction.

A reconnaissance, therefore, should be carried out along the full length of the pipeline and along the full length of the present winter road location in order to assess the stability of the channel and the channel banks after the initial soil movement by the construction of the present winter tracks. Also, the reconnaissance should make a prognostication on the basis of the type of soil material, the preponderance of silt versus gravel, the existence of permafrost, and the type of vegetation of the future stability of the channel during the melt season.

This reconnaissance should consist of a water resources engineer and a sedimentation or river channel expert who would go from one channel crossing to the next, developing while doing so a method of both mapping and recording. They should record not only the original conditions of the stream, but the effect of the bulldozing to date with a prognostication of future changes, both with and without additional construction.

#### Reconnaissance of Engineering-Geology Problems.

With regard to the construction either of an all-weather road and the pipeline, it probably should be assumed that the location for both has already been determined. Geology has a role of great importance in that it affects the type of construction even after the exact location has been chosen. Ideally, of course, it would have been desirable to have a geological reconnaissance made of the general zone through which the pipeline and the road were to pass in order that the geologic factors as they affect location might have been taken into account. Clearly this was not done, however. The location was in detail actually determined not by an engineer, but more by the bulldozer operator himself.

Therefore, given the location as having already been chosen, the main geological problems have to do with the sources of road building material and the effects of choosing alternative sources in any given site. For example, if large amounts of gravel are to be used in the construction of an all-weather road, then geology plays an important part in where such gravel deposits are located, how large their amounts in various locations, and the effect on the stability of streams and

hillsides in choosing one location relative to another. It seems necessary, therefore, before final construction begins to have a geological investigation along the full length of the winter road and the full length of the route chosen for pipeline construction. This investigation should consist essentially of surficial geologic mapping, designating such things as location and amount of construction materials and their relative stability if mined.

The mapping should outline zones or areas having similar stability characteristics under the changes wrought by construction. For example, along the route the areas where permafrost is close to the surface and the vegetation is of a given type, such a zone marked on a map would have some influence on the manner in which the road construction might best be planned in that particular type of geologic and physiographic situation. On steep hillsides, for example, the relative instability of a certain kind of soil material would be indicated by the zonation shown on the surficial geologic map. Each mapping unit, therefore, should be conceived as not only a uniform area physiographically and geologically, but having a concomitant preferred construction method. An example would be a particular type of clay or finegrained till which would become very unstable when disturbed as a result of melting of the surface. This type of area might call for a minimum of cut by bulldozer blade and for engineering stability might require that the roadbed be made up primarily of gravel brought in from elsewhere.

The same type of precautions might need to be observed on flat, tundra area which becomes marshy and surficially wet during the melt season.

In other locations it might be better, for example, from the stand-point of road stability, to cut into solid dry material on the nose of a hill rather than to put the permanent road-in flat, marshy area at the base of the same hill.

This kind of engineering geologic mapping is work for specialists, not only in engineering geology, construction methods, and the occurrence of construction materials, but also men who have had experience in Arctic-type landscape where permafrost is a problem.

#### Study of Flood Potential and Road Construction Standards.

In order to have the all-weather road as stable as possible, it will be necessary to assure that the crossings of streams and rivers be related to the flood-flow possibilities of each individual channel. In most modern highway construction practice it is usual for the design engineer to have computed for his use the discharge equalled or exceeded at a 50-year recurrence interval in order to determine the size of culverts or the size of bridge opening necessary for stability of the road crossing.

North of Fairbanks very few river gaging stations are available, and northern Alaska has considerably different climatic and therefore discharge characteristics of its drainage basins than more southerly areas. It would be necessary to have, in the absence of direct measurements, studies made of the flood-flow characteristics of rivers typical

of those crossed by the pipeline and the all-weather road. These flood-frequency computations would initially be made by correlation methods using the flood characteristics of river basins for which measurements are available and estimating the relations which exist in unmeasured areas.

If, therefore, the highway crossings are to be stable from the hydrologic standpoint as well as from the standpoint of the losses which occur to the environment by washing away bridges and channel crossings, such flood-frequency studies should be started immediately. From them there should be drawn up regulations and instructions for the highway construction practice, issued by the Department of the Interior, to be followed by the construction companies.

This type of regulation and the establishment of standards for river crossings stands flows logically from the fact that the lands traversed by both pipeline and roads are for the most part Federally owned.

The same principles apply to pipeline construction as road construction except that, in the case of pipelines, different construction methods might be used, "but it is still necessary that the pipeline location provide sufficient freeboard for the passage of flood waters under the pipeline and through the pertinent culverts and associated construction features.

Study of Mineral Potential and Elimination of Noneconomic Exploitation.

Although the general rules for the establishment of mining claims on Federal lands are promulgated, the situation in northern Alaska, especially in permafrost areas, make the possibility of impairment of environmental values resulting from small-scale, especially marginal mining operations, exceptionally hazardous. For example, one has to build the same sort of access road even to make a reconnaissance for the possibility of establishing a minor or small minerals-claim as is necessary for the initial construction of an access road to a very valuable mineral deposit.

It seems, therefore, that the hazard to the environment is such that the regulations for the prospecting and development of small mining claims in the Arctic need to be revised in order to eliminate insofar as possible the proliferation of marginal and uneconomic mineral claims which have little or no promise of yielding to either the prospector or to the general public any reasonable return. The mining regulations, therefore, in the Arctic should be especially designed to eliminate insofar as possible the marginal and subeconomic prospecting.

This type of zoning and the drawing up of appropriate regulations may have to depend on the interpretation of the reconnaissance geology already available and might well include the specification that no mining claim may be worked until the projected area had been studied by competent economic geologists of the U.S. Geological Survey. Thus, the strengthening of mining and prospecting regulations on Federal lands could well depend on a much more detailed program of geologic mapping by Geological Survey personnel, concentrating on the areas in northern

Alaska which the presently available geological reconnaissance maps indicate might have some potential for mineral development. Prospecting, for example, might well be closed on all Federal lands until these areas already determined by reconnaissance methods to have some mineral potential have been studied in more detail by geologists of the U.S. Geological Survey.

Studies of Water Supply Potential.

As oil development proceeds on the North Slope, there will be increasingly a need for the development of water supplies both for industrial and for municipal use. No doubt the concentrations of people will lead to the establishment of small towns which will have special problems of water supply and waste disposal merely because of the type of climate, geology, and the presence of permafrost. It is therefore highly desirable that water-supply engineers of the U.S. Geological Survey, especially ground-water geologists, begin a study of the possible types of water sources on the North Slope which may have to be tapped for industrial and municipal uses.

The study of water supplies and water potential in the developing area is the only way in which not only will water be developed in the most economic fashion. The study would also help assure that the impact on the environment due to water development will be minimized.

The ground-water possibilities include the river gravel deposits, especially in the area just south of Prudhoe Bay along both the Sag River and the Colville. It would be desirable to have estimates of the extent of the river gravels, their relationship to the nearby permafrost areas, and the manner in which the contained water might efficaciously be developed.

### Study of Effects of Waste Disposal on Water Supplies.

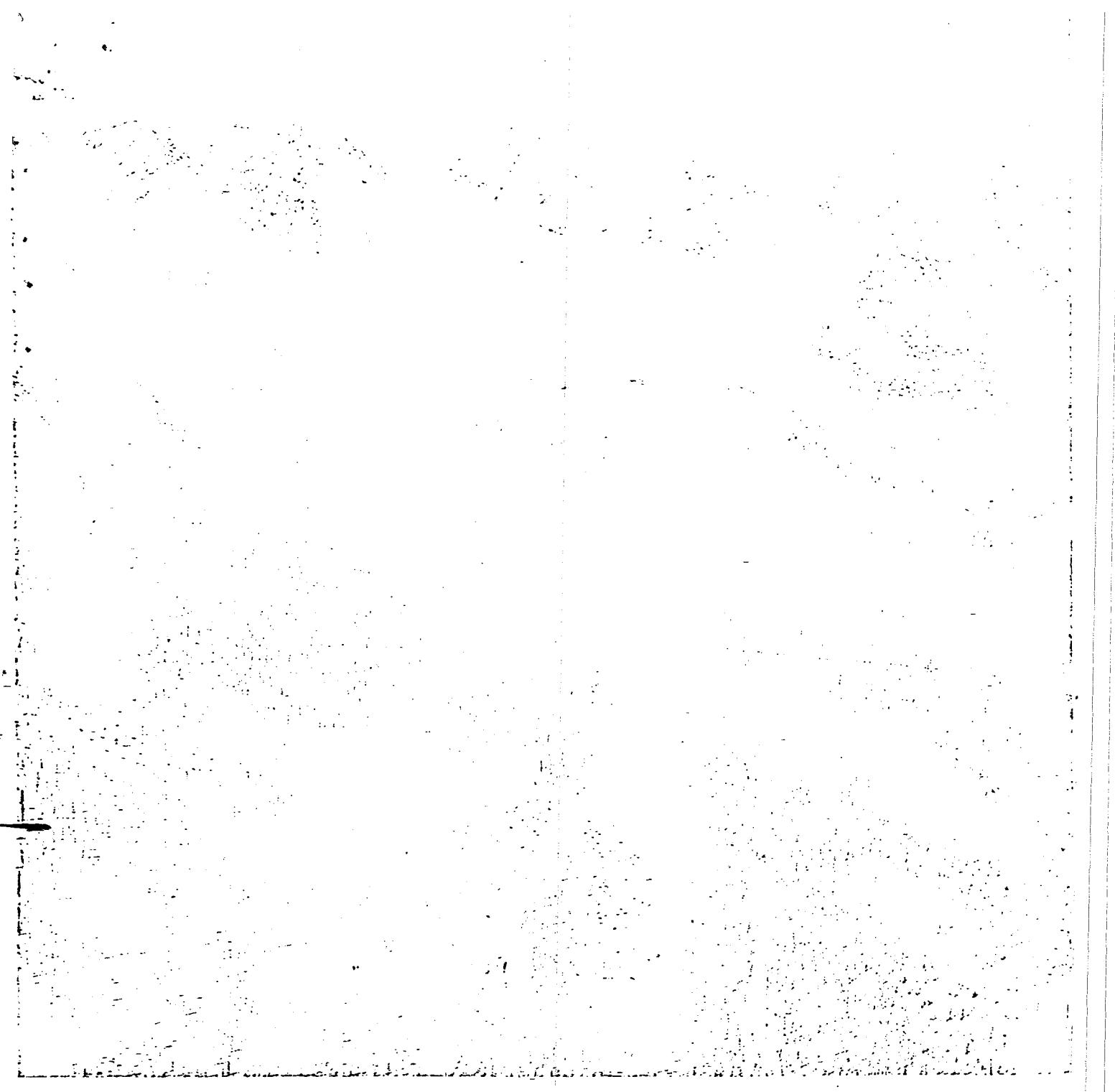
One of the effects of increasing the population on the North Slope in conjunction with oil development will be the possibility of contamination of local water supplies by the disposal of wastes. In connection therefore with ground-water studies of the availability of municipal and industrial water supplies, especially in the Prudhoe Bay area along the Colville and along the Sag Rivers, there should be also a concomitant study of the potential of different methods of waste disposal affecting adversely the quality of the available water supply. Generally, large supplies of water are going to be located in certain places, especially, as mentioned elsewhere, in the gravel deposits in the principal rivers. Therefore, since the available water is restricted in geographic location, the possibility of adverse quality effects of these water bodies by ill-considered waste disposal practices is a real problem.

### Summary of Recommendations for Immediate Study Projects.

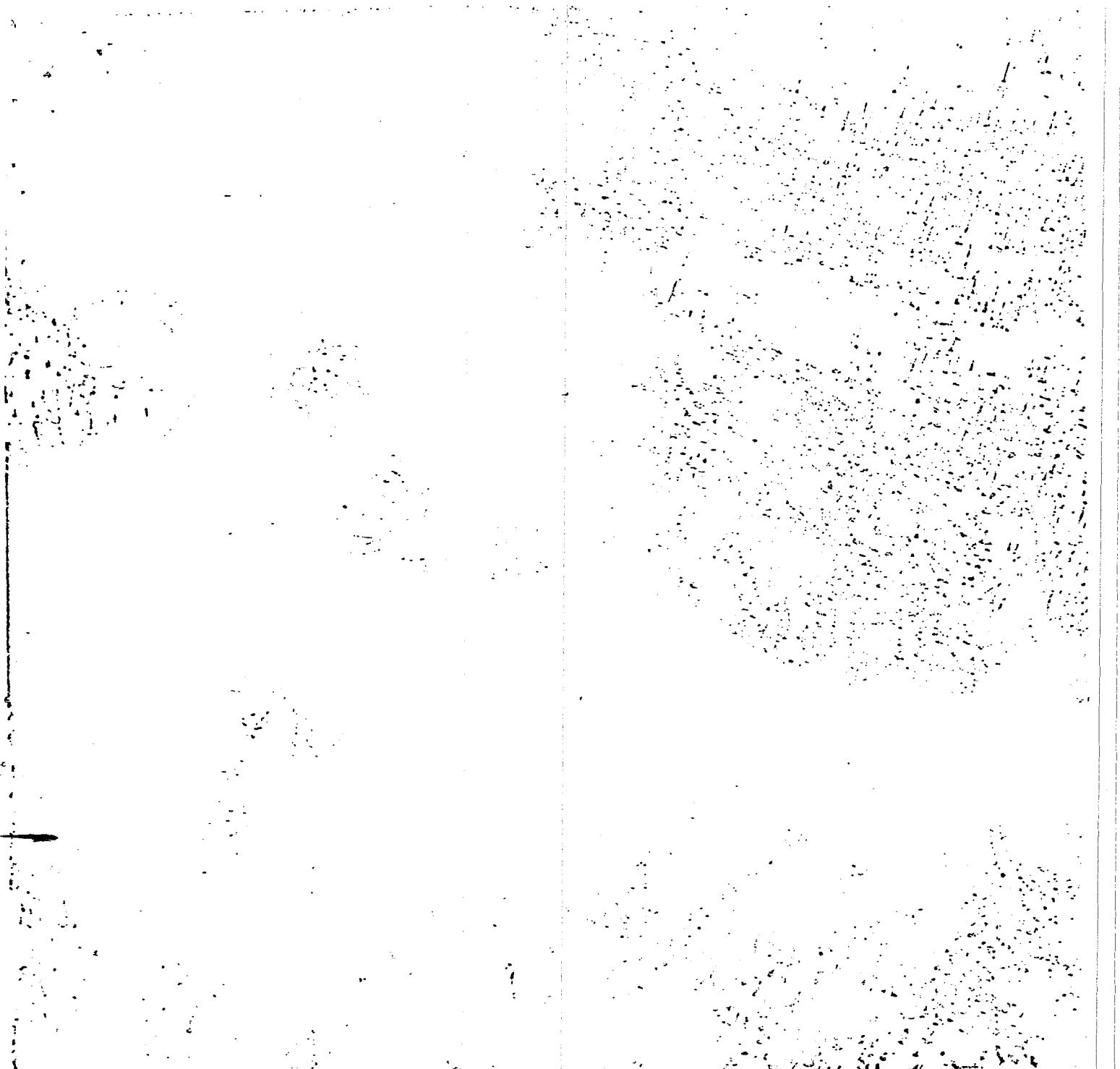
It is recommended that a geologic reconnaissance be conducted along the full length of the locations chosen for both the all-weather road and for the pipeline, in order to map the availability of construction materials and to show zones of recommended construction methods. The items to be mapped would include availability of materials, stability of the ground and soils, preferred types of construction to prevent sloughing, slipping, erosion, and instability.

New regulations should be written regarding the control of prospecting and small mining claim development in the Brooks Range and on the North Slope in order to limit the prospecting and utilization of marginal and uneconomic small mineral claims. The preparation of such regulations on Federal lands should be based on sufficiently detailed geologic studies to delineate those zones or areas where economic and practical mining developments might occur. This may lead to a cessation of the granting of permits for any prospecting or mining claim development pending the completion of sufficiently detailed geological investigations to assure that prospecting and mining development on a small scale is restricted only to those areas where a reasonable economic potential appears to exist.

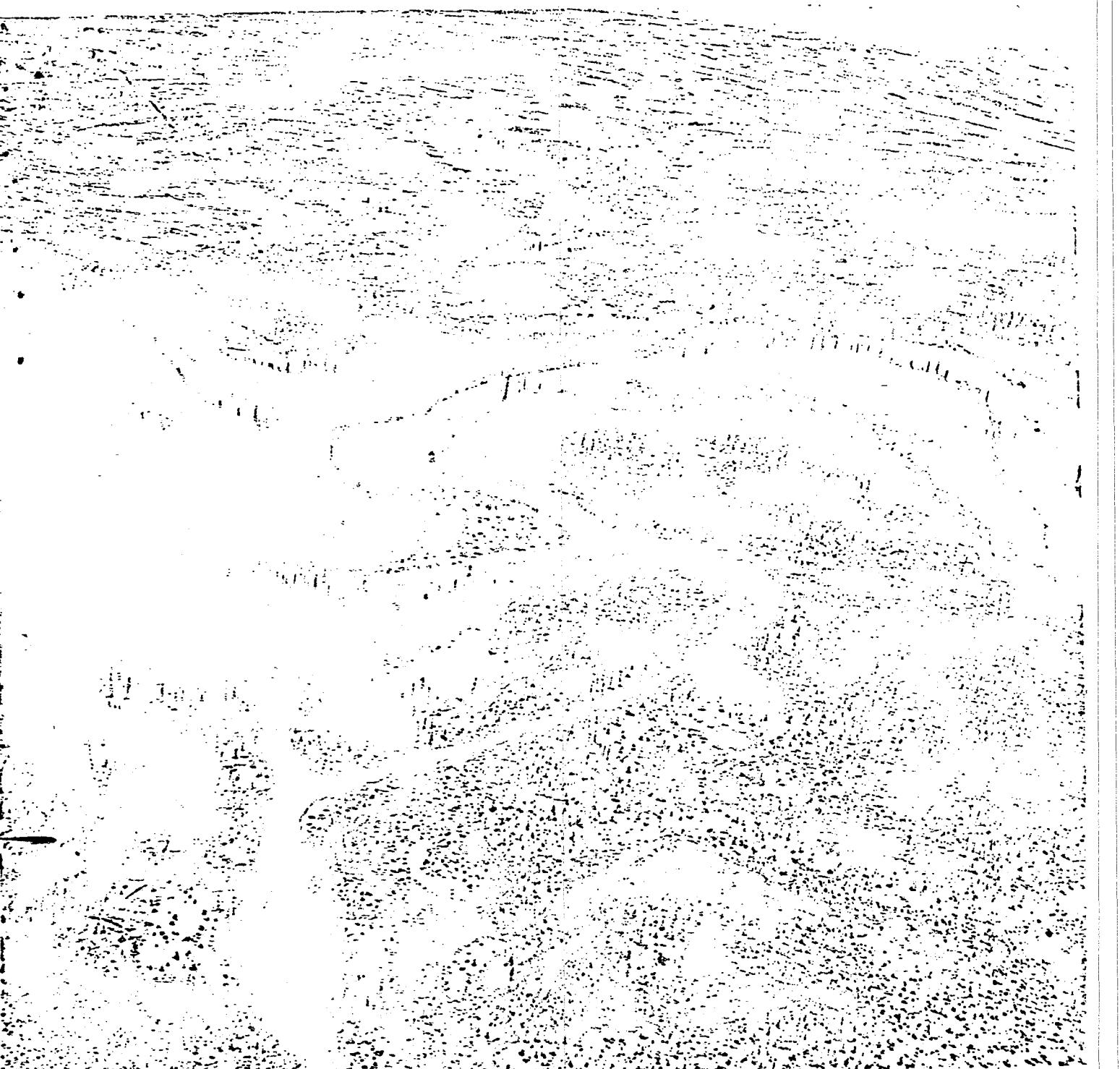
There should be initiated immediately a study of the road development and pipeline development on the stability of river channels and their associated deposits. One of the hazards both to road and pipeline structures is the utilization of improper materials and improper methods of construction which also can have adverse effects on the stability of rivers and streams. The investigation needed, therefore, is a reconnaissance of the types of stream channels, draws, rivers, and other watercourses over which the pipeline and highway must pass from Fairbanks all the way to Prudhoe Bay. New methods of mapping would have to be developed during this investigation because of the peculiar characteristics of the streams being fed primarily from high mountains in permafrost areas. The types of channel and sedimentary deposits are intricately related to both the geology and climate, and the stability of channels in these physiographic conditions is much more critical and less well known than in more temperate zones in the United States.



Hunt Fork of the John River Valley,  $67^{\circ} 45'$  North at northern limit of trees in the John River Valley system. Photo shows route error wherein route starts up the wrong fork of the valley, operator discovers error, circles back, and cuts back (right) to main valley - but not before completed widened road is finished with large graders behind him. Road is now abandoned. April 1969.



Winter road crossing small watercourse near Bonanza Creek, a tributary of the south fork of the Koyukuk River at the approximate latitude of the Arctic Circle. Note methods of road construction by bulldozing taiga vegetative cover down to the level of frozen ground and the filling of small watercourses with topsoil. April 18, 1969.



Winter Road crossing Bonanza Creek, about 5 miles north of the Arctic Circle, 4-18-69. Note subsidiary tracks and parallel use of the road beyond (north) of the Creek. Track fills with snow, packed by trucks, and areas adjacent to the road blow free of snow so the next convoy drives along side the main route until overall route is continually widened.

Pipeline road, southwest of Livengood, Alaska. View southward toward Fairbanks, April 1969. Note string-line straight route.

