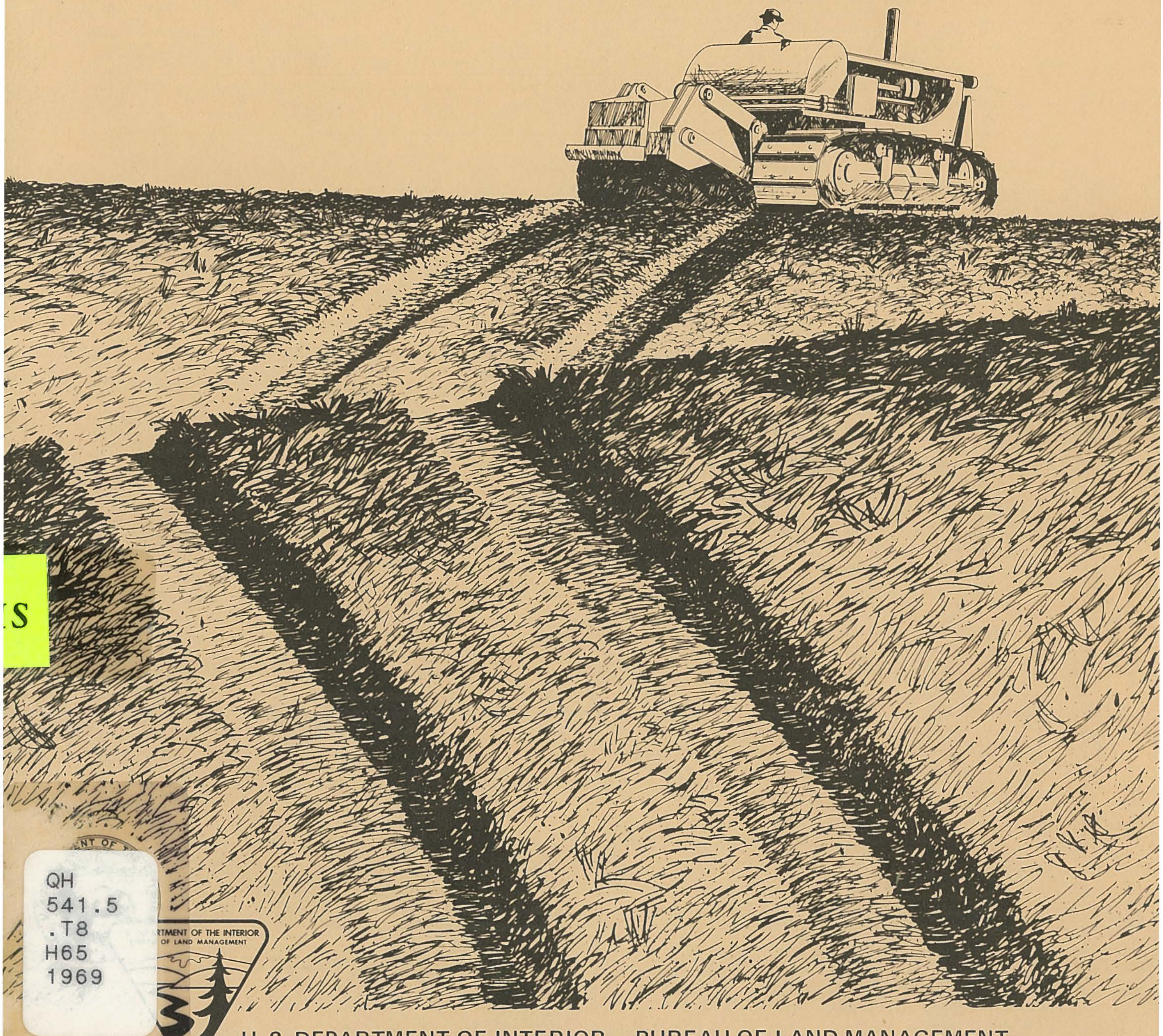
A RECONNAISSANCE OF TRACTOR TRAILS AND RELATED PHENOMENA ON THE NORTH SLOPE OF ALASKA

JEROME R. HOK
RESOURCES CONSERVATION TECHNICIAN
1969



U. S. DEPARTMENT OF INTERIOR – BUREAU OF LAND MANAGEMENT

FOREWORD

"A Reconnaissance of Tractor Trails and Related Phenomena on the North Slope of Alaska"

Jerome Hok, on the basis of one summer's reconnaissance, has provided both factual information and an easily understood primer for use by anyone interested in the tundra-permafrost environment of the North Slope of Alaska as well as much of the land surrounding the polar basin. The report emphasizes the long lasting effects of the movement of vehicles across, or operations in, this environment. His illustrations show the importance and interrelationship of season, the degree of disturbance, the moisture content and topography and their effects on erosion and brings into focus many of the real culprits in the controversy concerning the development of the North Slope of Alaska.

Mr. Hok admits to bias since he could not discuss the effects of tractor trails and related phenomena unless he could find them. He has pointed out the results of errors made in the past, due to a lack of knowledge and/or regulation, the long lasting effects of these errors, and that man cannot move across the surface without leaving some trace. He has not discussed the successes that have occurred, particularly in recent years, nor was that the object of this particular study. Once presented with the evidence, the important question is what do we learn from it and how do we modify our activities so that we do not commit violence upon the landscape.

Max C. Brewer, Director
Naval Arctic Research Laboratory
Point Barrow, Alaska

ADDENDUM

A RECONNAISSANCE OF TRACTOR TRAILS AND RELATED PHENOMENA ON THE NORTH SLOPE OF ALASKA presents observation, _modus operandi_, and conclusions, by one observer, about the disturbance to the land surface from operation of power driven vehicles upon tundra-permafrost type terrain in Alaska.

This study of historical evidence was primarily undertaken to assist in the development of guidelines for use by all who have need or occasion to traverse the delicate terrain of the Alaska North Slope.

This report was written by Jerome Hok during the summer of 1969, while he was a seasonal employee of the Bureau of Land Management. Mr. Hok is now a graduate student at the University of Alaska at College, Alaska. The _Foreword_ (inside front cover) was written by Dr. Max C. Brewer, Commissioner of Department of Environmental Conservation, State of Alaska, formerly Director of the U. S. Navy Arctic Research Laboratory at Point Barrow, Alaska. Dr. Brewer is an authority on tundra and permafrost of the area described by Mr. Hok.

With the growing store of related environmental studies now underway, this publication contributes to the pragmatic knowledge required to function in the Arctic region of Alaska while preserving its more fragile physical qualities.

ERRATA: A Reconnaissance of Tractor Trails and Related Phenomena on the North Slope of Alaska

p. 6 should be captioned: Map 2

p. 23 should be captioned: Map 3

p. 23 in title, GUBIC, should read: GUBIK

p. 23 on map, place name, Gubic, should read: Gubik

p. 32 line 1 ...naval camp..., should read: naval petroleum exploration camp

p. 40 should be captioned: Map 5 (upper)

Map 6 (lower)

p. 49 should be captioned: Map 7

p. 56 numbers insert on Photo 69, should be:

#70, should be: 66

#69, should be: 65

#72, should be: 68

#68, should be: 64

#67, should be: 63

p. 58 line 23 "Hickle," should read: "Hickel"

END

A RECONNAISSANCE OF TRACTOR TRAILS AND RELATED PHENOMENA ON THE NORTH SLOPE OF ALASKA

JEROME R. HOK
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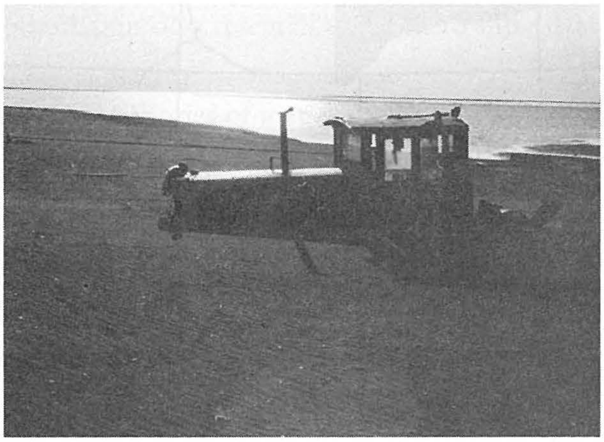

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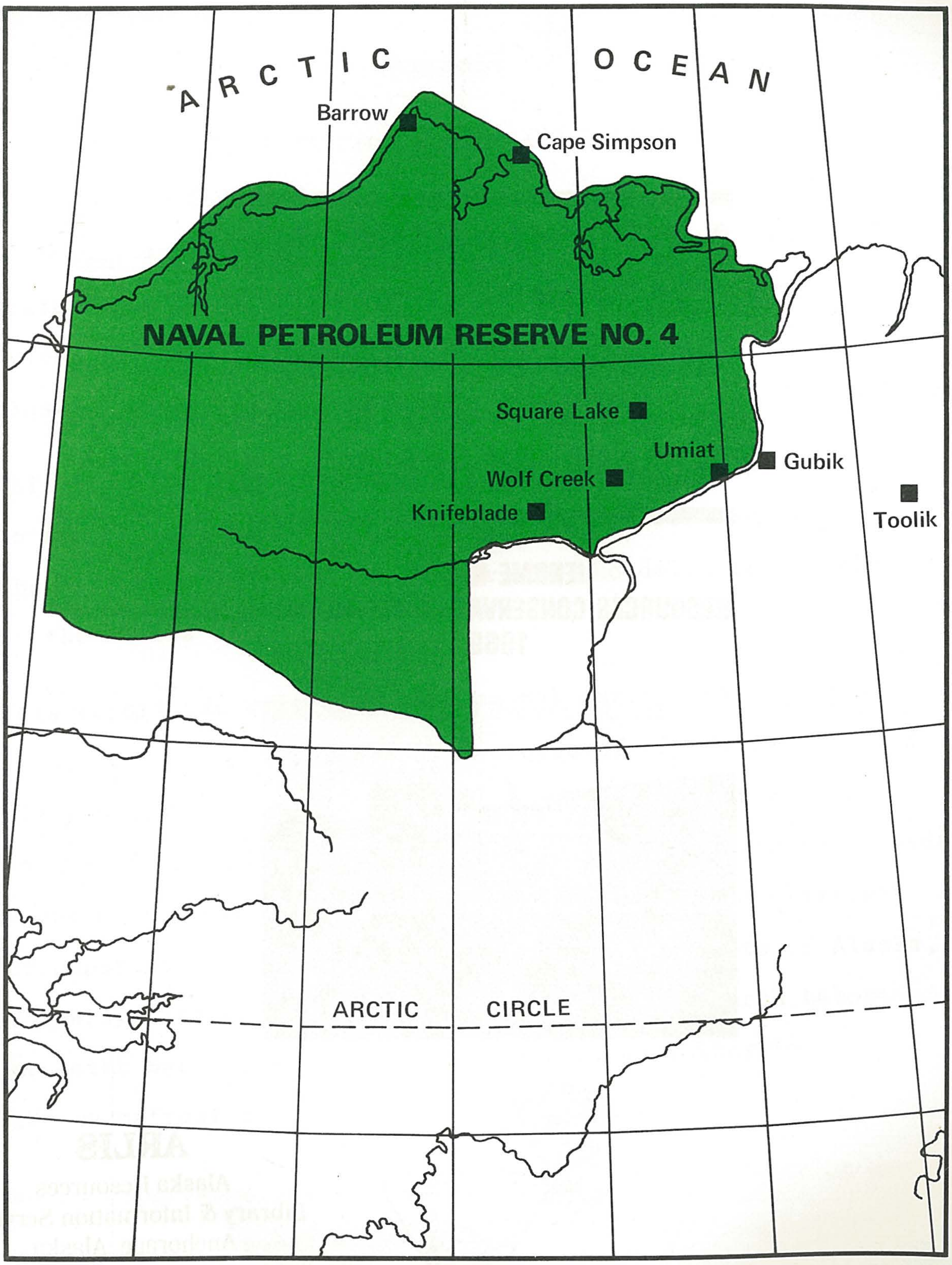


Map 1: The North Slope. Pet. Res. No. 4 and sites included in this report are indicated

INTRODUCTION

During the summer of 1969 a broad reconnaissance of the long-range effects of tracked vehicles on arctic tundra landscape was conducted under the joint sponsorship of the Bureau of Land Management, U. S. Department of the Interior, and the University of Alaska's Department of Biological Sciences. The goals of the project were:

1. To obtain broad preliminary observations of tundra vegetation recovery upon tracked vehicle trails of known history.
2. The compilation of a bibliography of studies on this subject.
3. The development of working hypotheses about the effects of vehicles on tundra vegetation, and the formulation of a research program to intensively study specific aspects of the problem.

Regions with documented histories of man caused surface disturbances were selected in representative areas of the North Slope. These areas were visited, and any lasting effects of past vehicular disturbance were described in relationship to the topography of the region. The exploration of Naval Petroleum Reserve No. 4 (Pet. 4) was well documented by Reed (1958) and others, and has remained largely undisturbed since the end of naval operations in 1953. With only a few exceptions, disturbances dating from this exploration provided the basis of this reconnaissance.

Varying and often contradicting opinions about tundra disturbances have been expressed for some time.

To achieve a separation of fact from opinion, each area that was investigated is described independently and illustrated with numerous photographs. Opinions, comparisons, and hypotheses are presented in a separate section. This manner of presentation enables the unfamiliar reader to "tour" a great deal of country in a brief span of time and provides the better acquainted reader with numerous documented, and relocatable photographs, on which to base his conclusions

Grateful acknowledgement is made of the experience and technical knowledge which were made available to this project by Dr. Max C. Brewer, Director of the Naval Arctic Research Lab; and Dr. Bonita J. Neiland, Professor of Botany, University of Alaska, Department of Biological Sciences. The procedures followed for this study were originally suggested by the late Don Charles Foot, Geography Department, McGill University, Montreal, who was on a leave of absence to the University of Alaska at the time of his death in 1969.

Photo 1: A bladed summer trail with distinct berm of sod and vegetation (Cape Simpson).

GENERAL INFORMATION

For this survey of "environmental response to disturbances" to have positive value as a management tool, it was necessary to know the cause of the disturbance as well as its age. Accordingly, three questions were raised for each trail inspected:

1. Was the trail cut and/or used in winter (while the surface was solidly frozen) or during summer?
2. What was the trail's mode of construction . . . eg. bladed, cut down to permafrost (summer), packed snow surface, heavily used and worn down in winter, etc?
3. What sort of vehicle was most significant in producing the disturbance?

Documentary background for the above detail was not always available, and in many cases decisions rested on interpretation of on the ground evidences. For example: If the margins of

Photo 2: A recent winter trail with berm of vegetation only and little surface disturbance (Umiat).

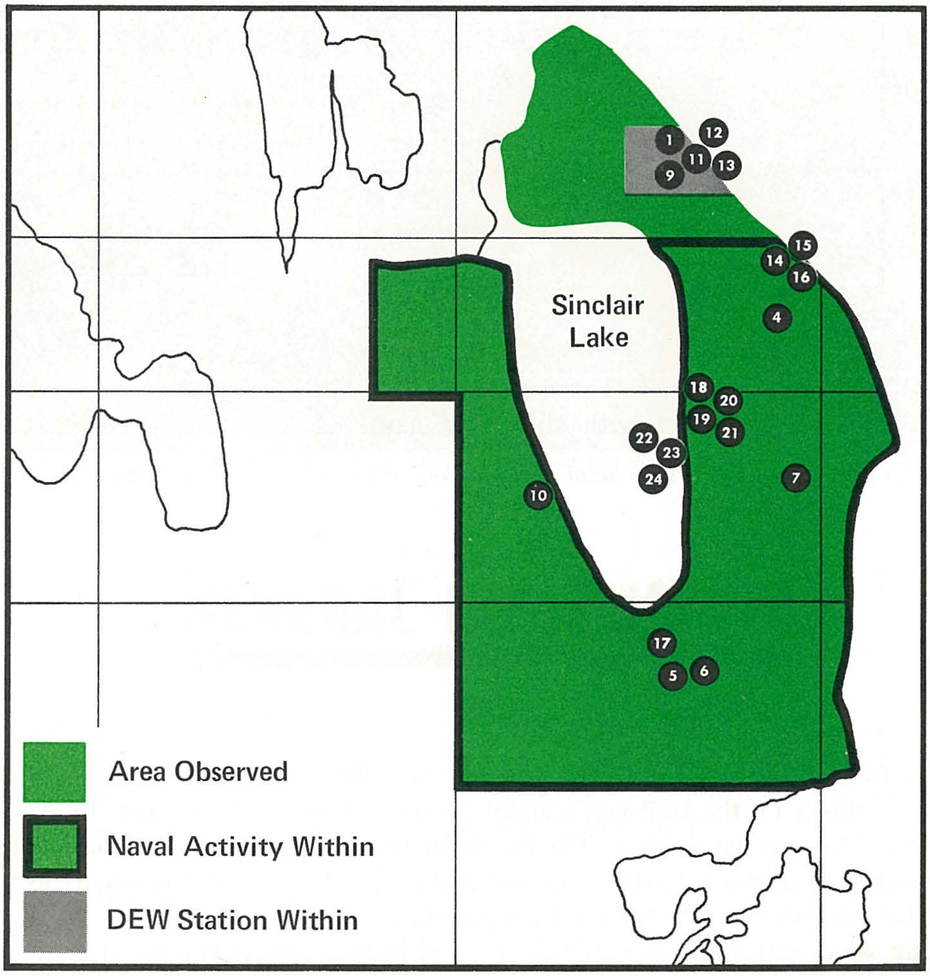
the trail were formed by two conspicuous berms consisting of a peeled-back layer of sod and old vegetation (photo 1), the trail was usually considered to have been made by down-blading to frozen ground during the summer. On the other hand, if no appreciable berm was present, or if an existing bern contained little or no sod and peat (photo 2), it was usually assumed that the disturbance was made during the winter when the active layer was frozen.

In deciding what sort of vehicle or vehicles had been involved in a given disturbance, the physical dimensions of the trail were important. For example, the tread marks of the old military LVT are only 10 inches wide, but are 8 feet apart. Those of a D-8 cat have a much wider tread yet are separated by a lesser distance. Marks which could be identified as those of light personnel carriers such as the weasel and the bombardier were rarely seen.

There was no hard, fast formula by which the cause of a given disturbance was identified. Often, the details of such decisions are given in context with the descriptions which follow.

CAPE SIMPSON OIL FIELD

(1949-1953)



CAPE SIMPSON was visited during the last week of June. All observations reported here were made during that time and within the area indicated in black on map 1.

In general, the Coastal plain around Cape Simpson is flat as far as the eye can see, with relief rarely exceeding 25 feet. The plain is dotted with lakes which range in width from a few dozen feet to over a mile. With the exception of a few major rivers, well-defined surface drainage channels do not exist.

Human disturbances in the Cape Simpson area can be traced to two different time periods. These disturbances are also separated geographically. Petroleum exploration was carried out by the Navy during the years of 1949 to 1953 within the area outlined in red on map 2. More recently a DEW-line station, POW-A, was constructed, operated, and abandoned. Activity associated with this station occurred between 1955 and 1963 (area outlined in green on map 2).

In addition to surface disturbances resulting from human activity, the Cape Simpson region also has distinct elements of natural instability. Two notable examples of this are parts of the coastline and some lake margins (photos 3 and 4). The question of oil pollution on Cape Simpson, associated with the early naval exploration of the area (photos 5 and 6), is complicated by the presence of near-by natural oil seeps (photos 7 and 7A).

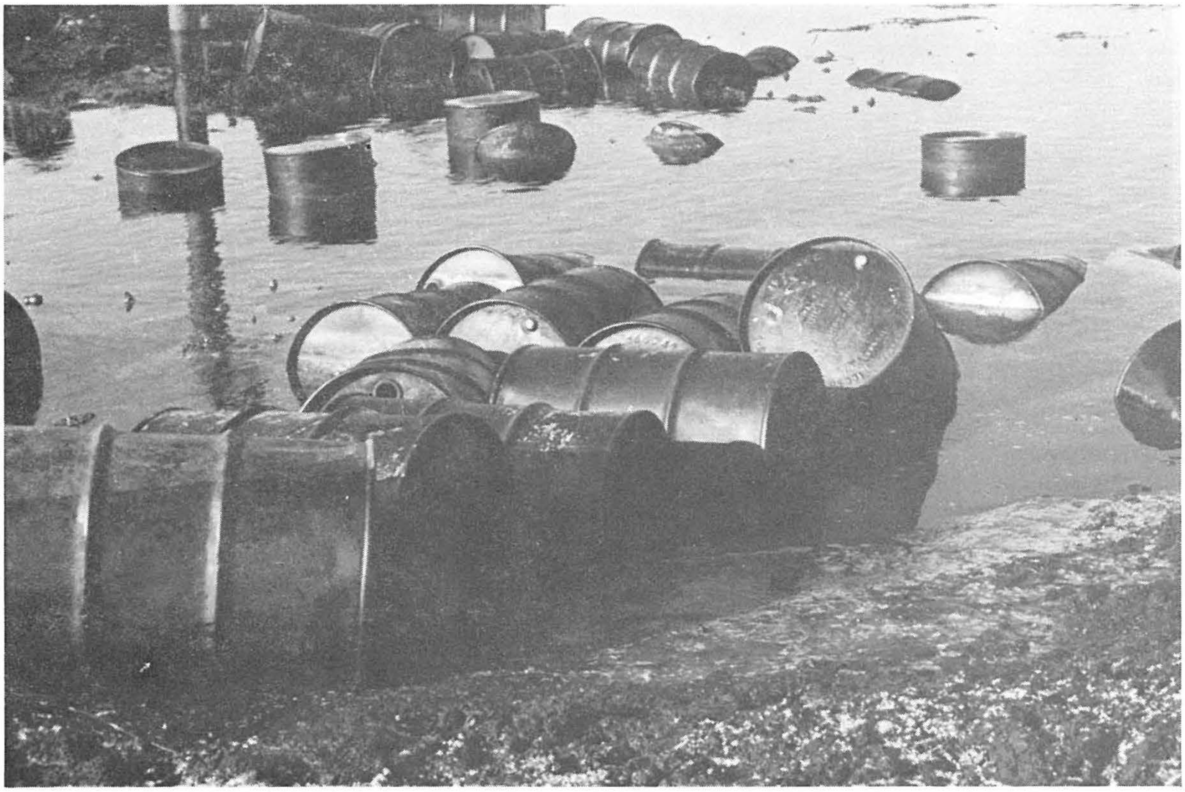
This section includes a selection of trails that illustrate the effects of several types of disturbances on each of the major land features of the area. The observed trails are divided into three broad groups: flatland trails, slope trails, and lake margin trails.

FLAT LAND: By far the most numerous trails are those that cross flat land. Most of these trails were made during the summer by blading back the tundra surface to permafrost.

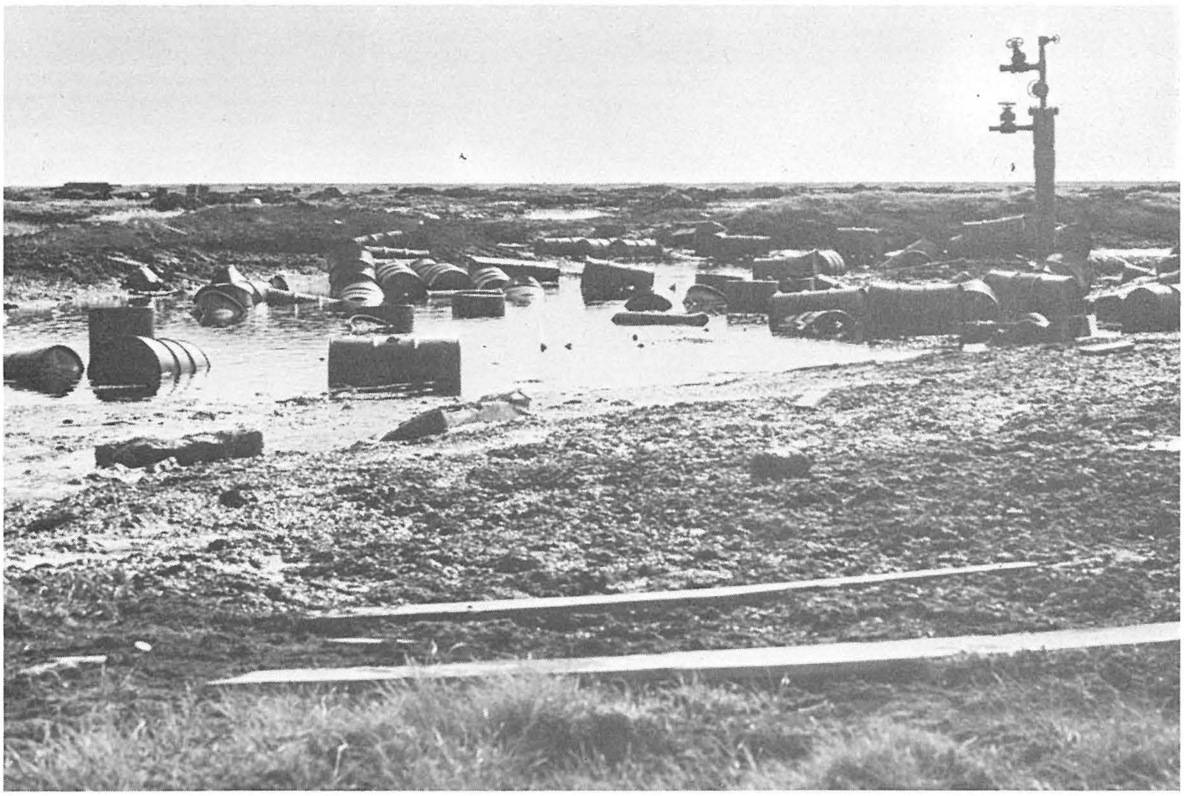
Photos 8 and 9 illustrate typical extremes in water saturation of bladed flatland trails: dry bed and submerged bed, respectively. In the dry bed trail, the return of ground cover is complete and appears quite similar to that of surrounding areas. In the submerged bed trails, however, no rooted plants have returned.

Photo 3: Ice cliffs on naturally unstable coastline of the Beaufort Sea (Cape Simpson).

Photo 4: Slumping lake margin (natural) near Sinclair Lake (Cape Simpson).



Photos 5 & 6: A man-made oil seep at Cape Simpson.



Photos 7 & 7A: A natural oil seep at Cape Simpson.

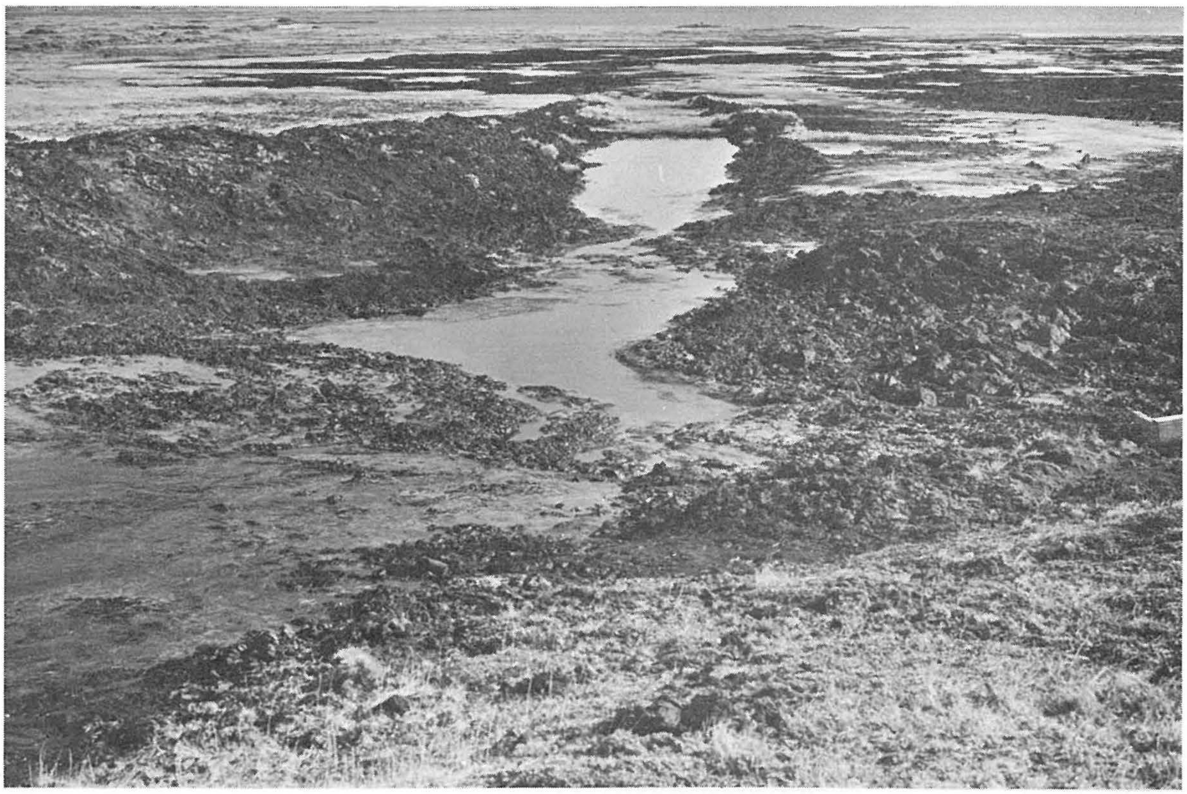


Photo 8: A dry bed summer bladed trail. 16-20 years old.

Photo 9: A submerged bed summer bladed trail. 7-14 years old.

Photo 10 illustrates a 16 to 20 year old trail which is intermediate between the extremely wet and dry trails. In this case the new vegetation in the trail bed is typical of a wet meadow with the rooting portions of the plants submerged in free water. The areas immediately adjacent to the trail are dry underfoot and support a more varied assemblage of plants.

All of the trails except the one shown in photo 9 were created during exploration of Pet. No. 4 and illustrate the conditions which have resulted after the passage of 16 to 20 years' time. Examples of more recent bladed trails are found in photos 11, 12, and 13, all of which were taken within the area indicated in green on map 2. In each case, vegetative cover is far from complete. This condition is probably due, in part, to the comparative youth of the trail. Ground cover where these newer trails are located is also less continuous in its undisturbed state than the ground cover around the older trails described earlier.

Without exception, the 16 to 20 year old trails seen on flat land appear stabilized. No extensive areas of bare, unrevegatated ground were noted nor were any signs of continuing instability such as active erosion or subsidence detected. The condition of slope or lake margin trails was more variable.

SLOPES: In this extremely flat region only two trails were found on distinctly sloping ground. These trails provided examples of situations in which moving water was or was not present.

The first trail collects water at the base of a low hill as it slopes gently down to the Beaufort Sea. The bed of this trail is completely revegetated with semi-aquatic plants and seems quite stable. However, the banks of the trail have remained active, and are still slumping into the channel (presumably as support is lost as permafrost thaws along the exposed bank). Photos 14 and 15 show the inclined position of this trail. Photo 16 illustrates the track left by a single blade-up, tractor pass along the bank of the main trail at a point seen at top center on photo 15.

The second trail (photo 17) has its origin on a dry hillslope and contained no moving water. Like the dry flat land trails, it is fully stabilized with cover very similar to the adjacent undisturbed areas. These two trails suggest that moving water is highly significant in determining the long range effects of disturbances on sloping ground.

LAKE MARGINS: Two significant conditions were observed on a lake margin trail.

The first occurs where a typical submerged-bed trail (photo 18) traverses a wet meadow and skirts the narrow head of a small lake (figure 1). Photo 19 shows where about 100 yards of this trail has now been cut off by the encroaching northern margin of the lake. The situation is further illustrated in photos 20 and 21. As this was a summer trail, the original route could not have crossed the expanse of water as it does at present.

The probable past location of the trail is drawn on photo 20.

The second occured within ½ mile of the first at a different point on the same trail. The trail presently ends at the margin of Sinclair Lake, but there is no sign of a turn-around area, nor of an end to the berm (photo 22-23). The trail may have originally continued along the lake margin, but has since been eroded away.

Photo 10: Bladed summer trail wet sedge meadow vegetation in bed; adjacent areas dry. 16-20 years old.

Photo 11: A bladed summer trail. 7-14 years old.

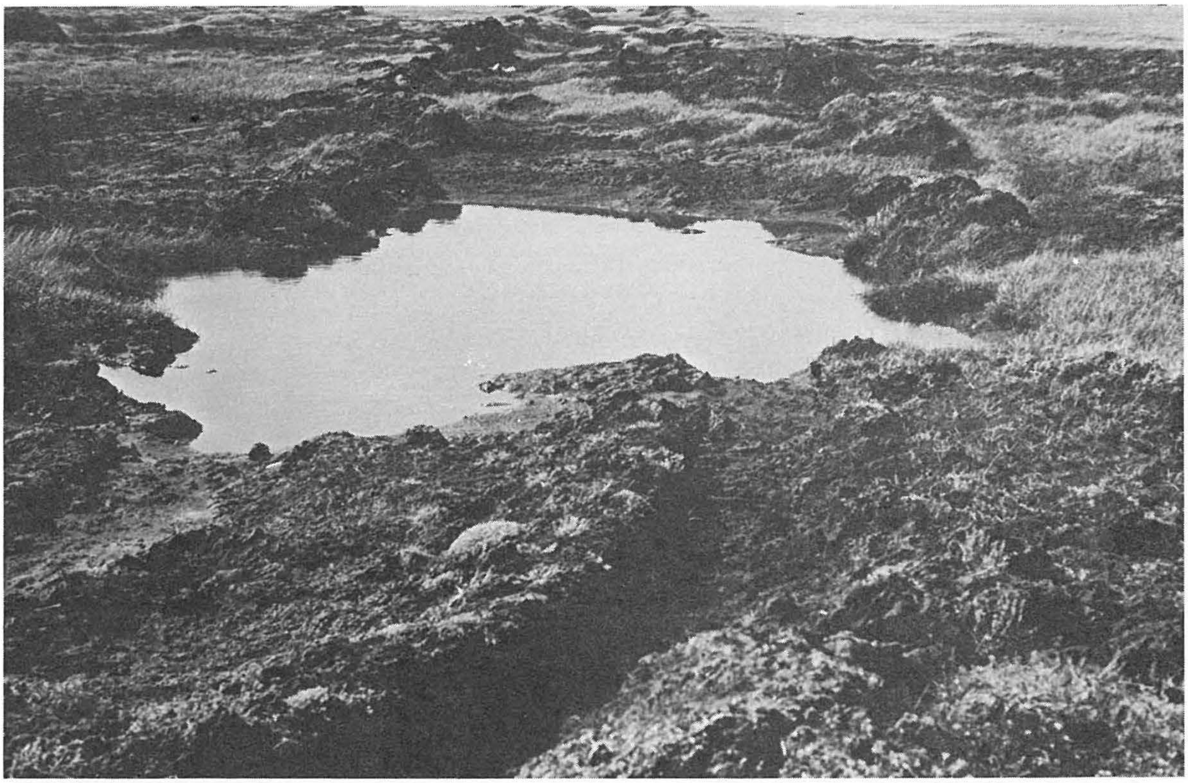


Photo 12: A bladed summer trail. 7-14 years old.

Photo 13: A close-up of a 7 to 14 year old bladed trail bed. Subsidence at center.

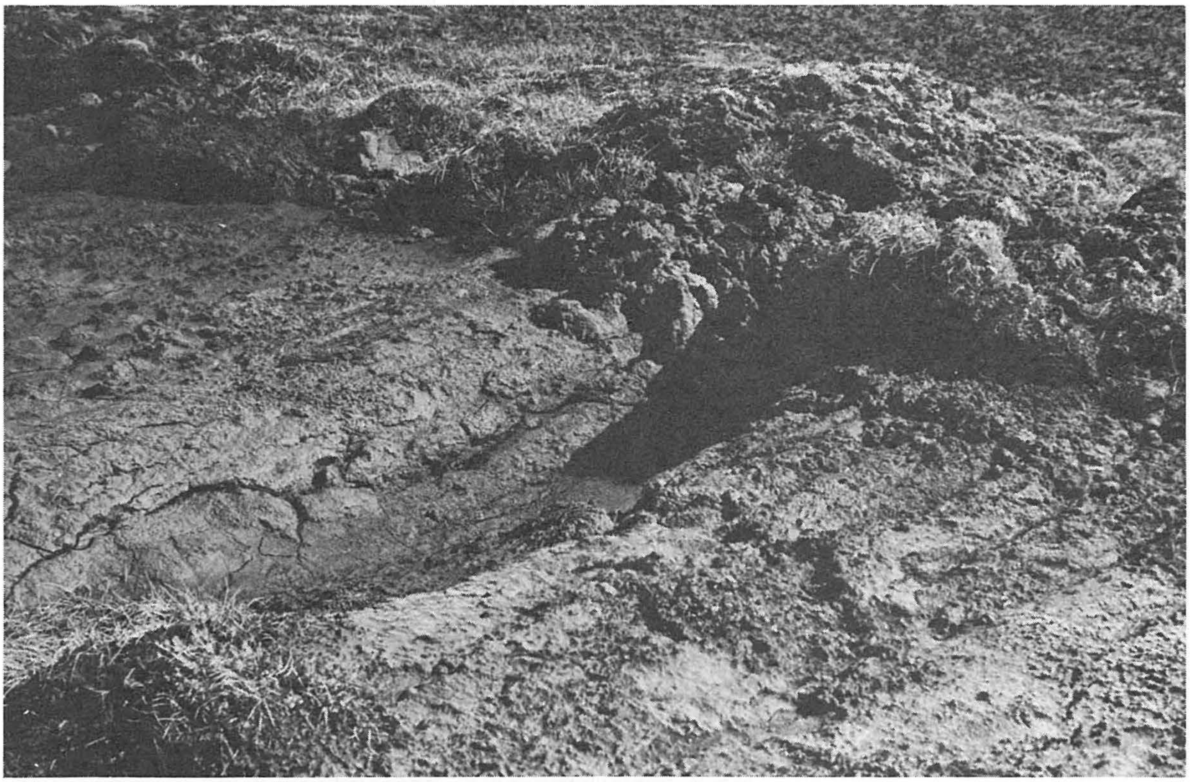


Photo 14: Bladed summer trail on gentle, wet slope. Sides are continuing to slump. 16-20 years old.

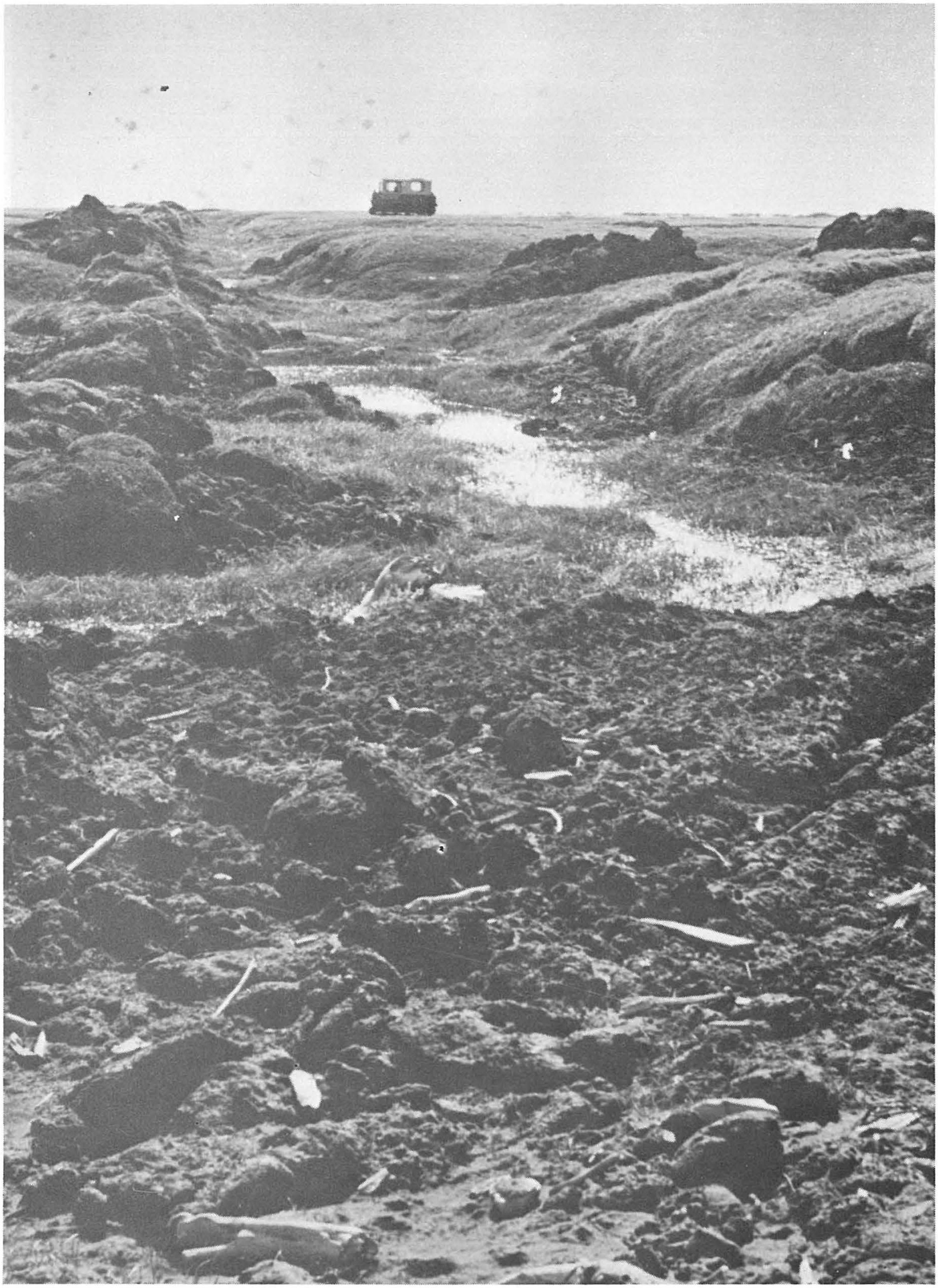


Photo 15: The same trail as shown in photo 14 seen looking uphill.

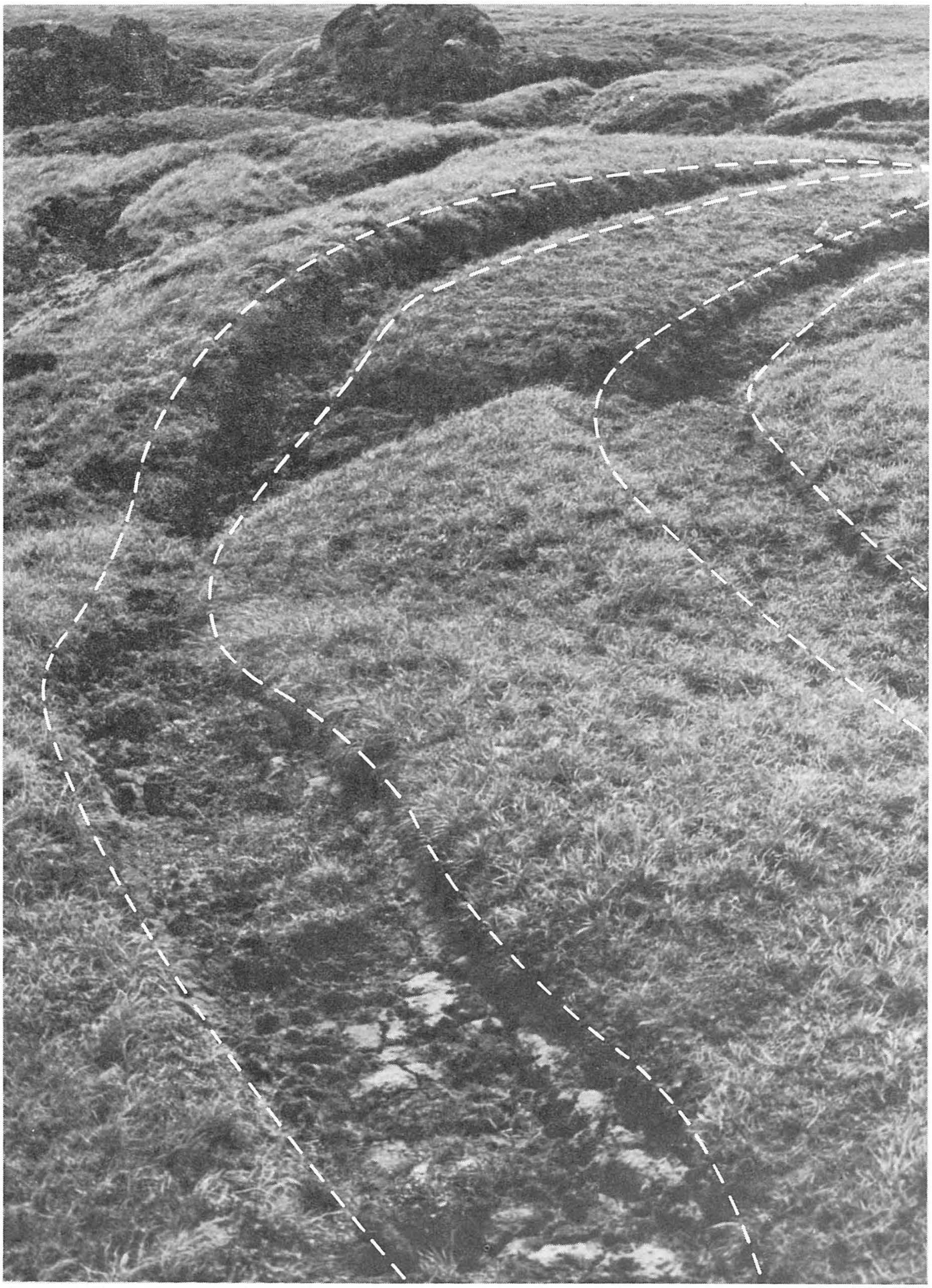


Photo 16: The mark left by the tracks of a heavy tractor on the bank of the trail as shown in photos 14 and 15.

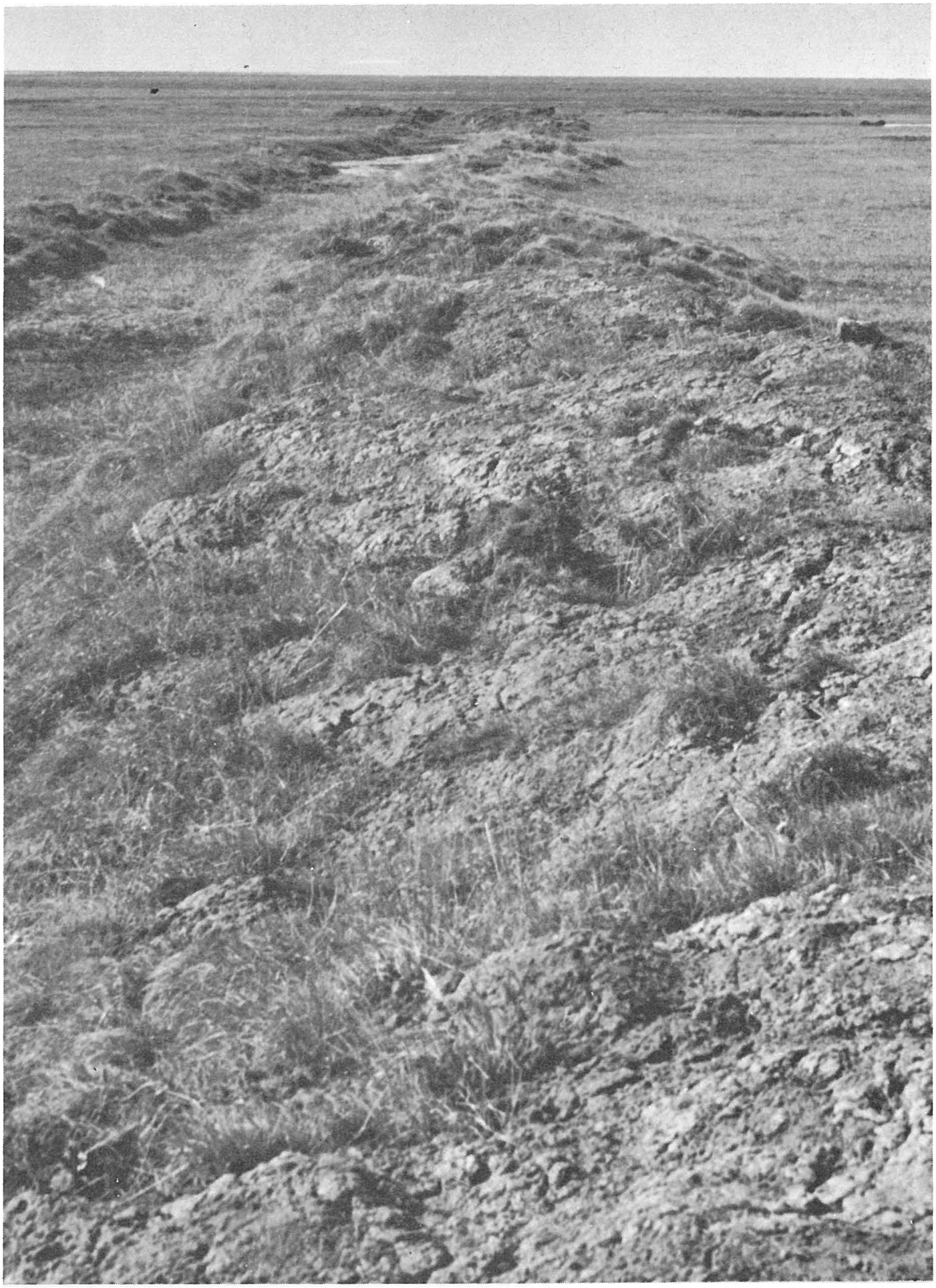
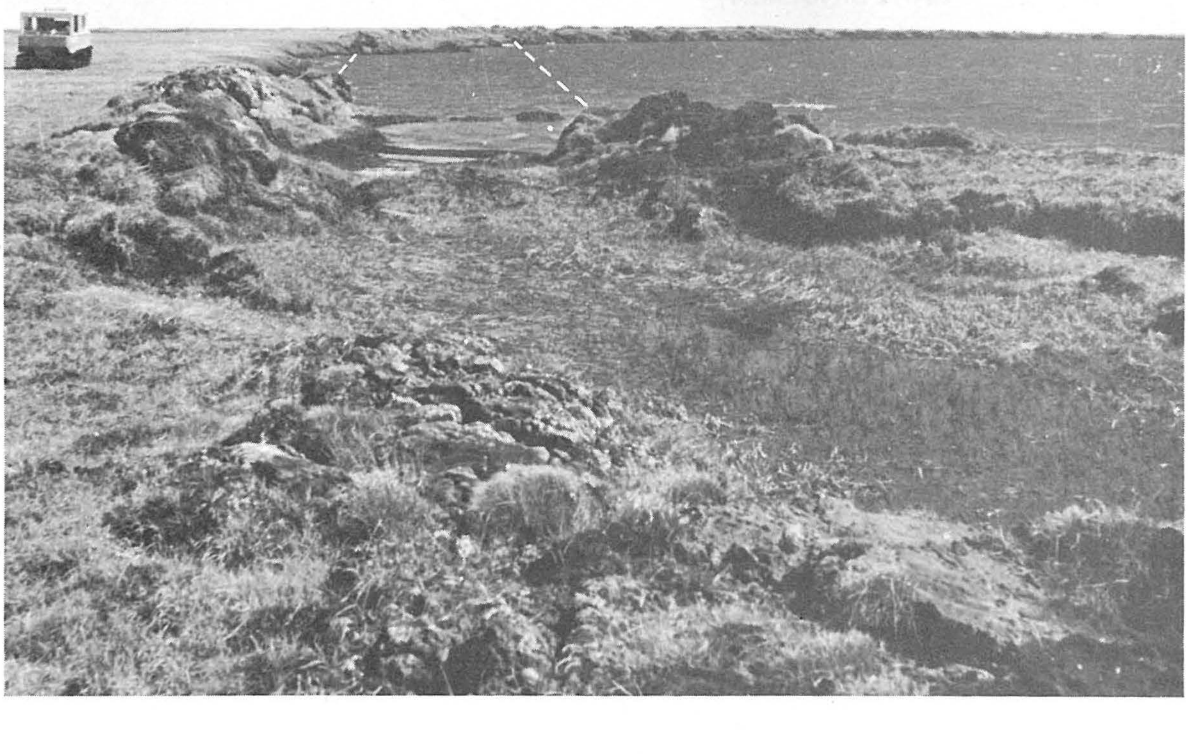


Photo 17: A bladed summer trail on a gentle, dry slope. 16-20 years old.

Photo 18: A bladed summer trail across wet sedge meadow. Lake is at upper right.

Photo 19: Trail shown in photo 18 where it intersects the lake margin. 16-20 years old.



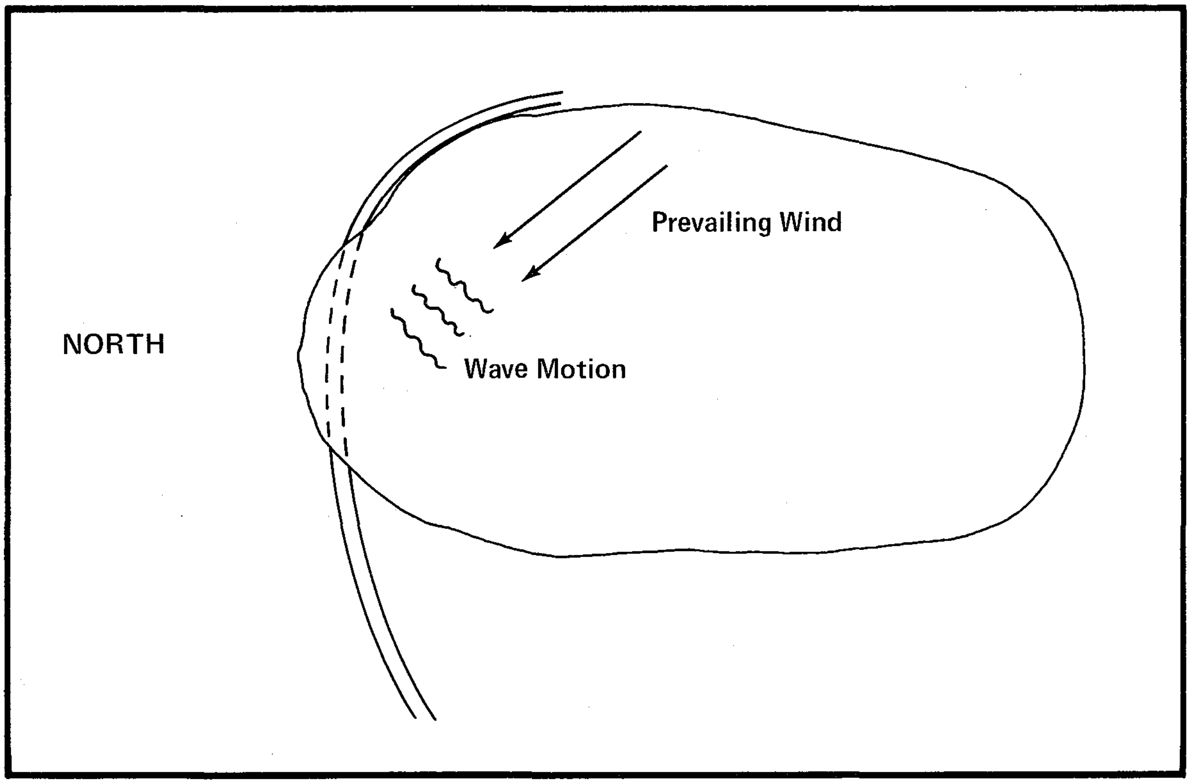
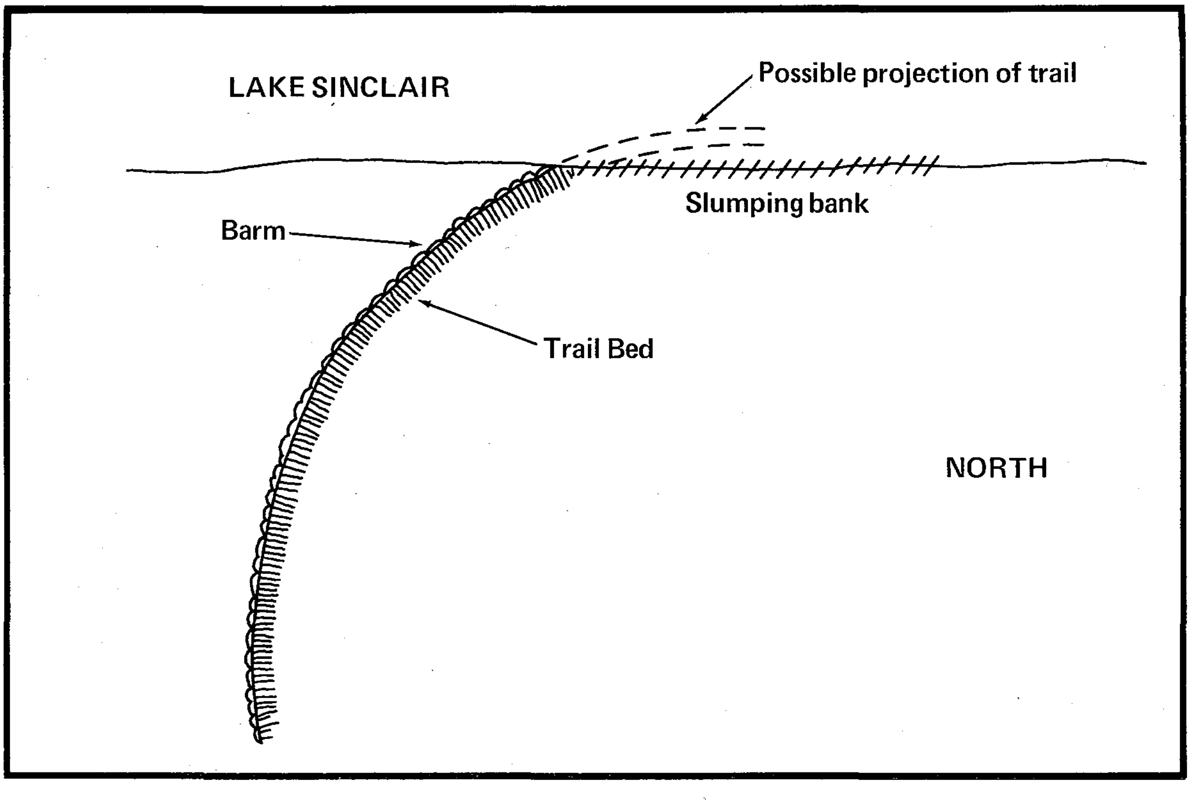
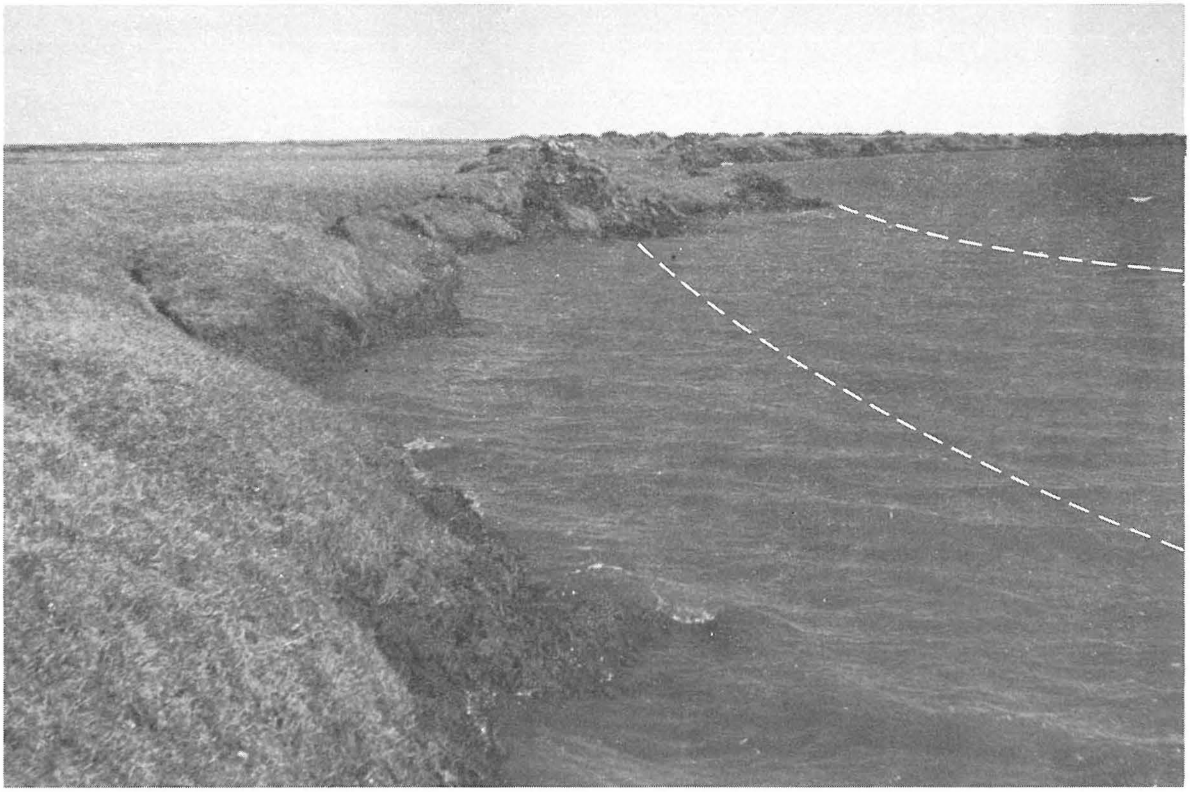


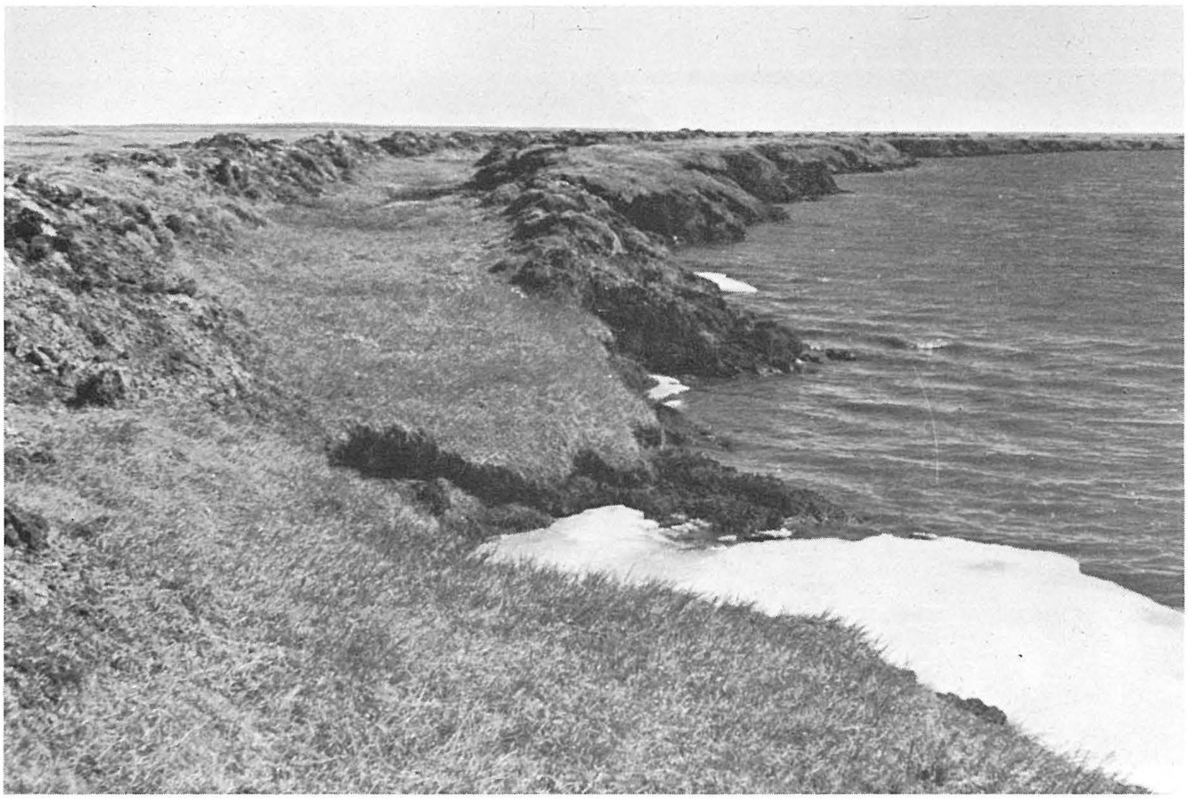
Figure 1

Figure 2





Photos 20 & 21: Bladed summer trail which skirts a lake margin (seen also in photo 19). 16-20 years old.



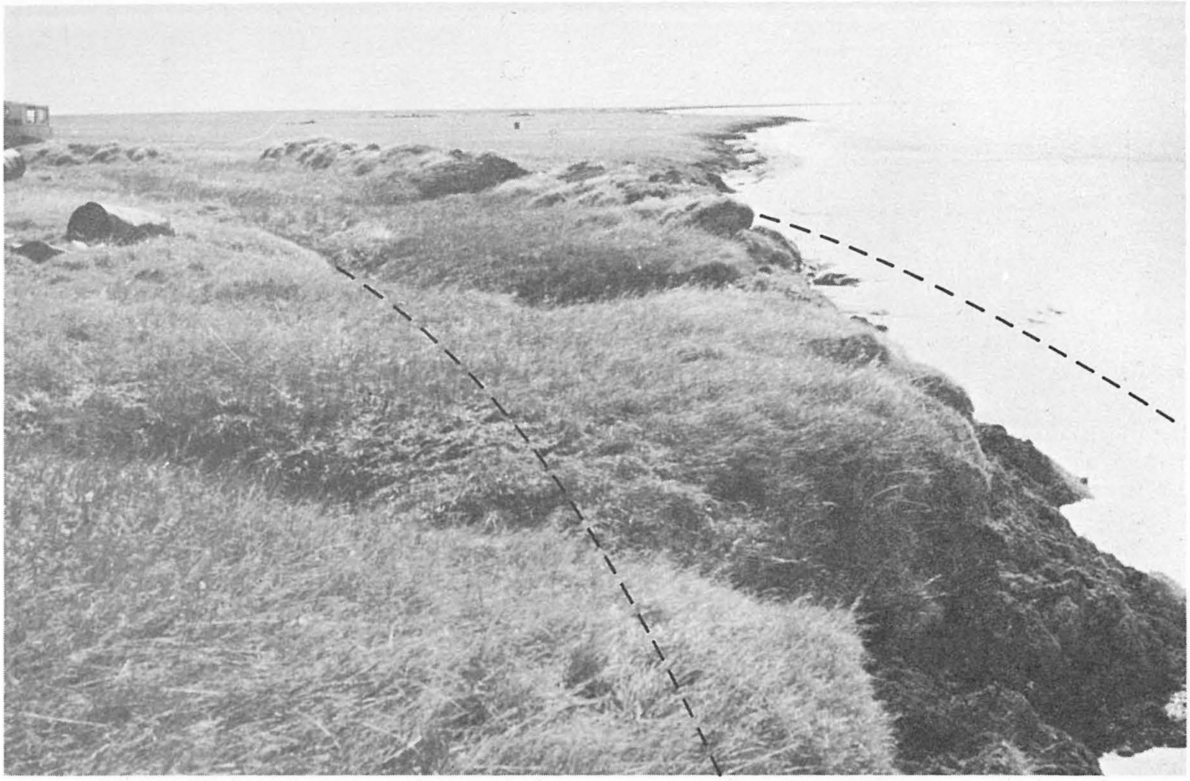
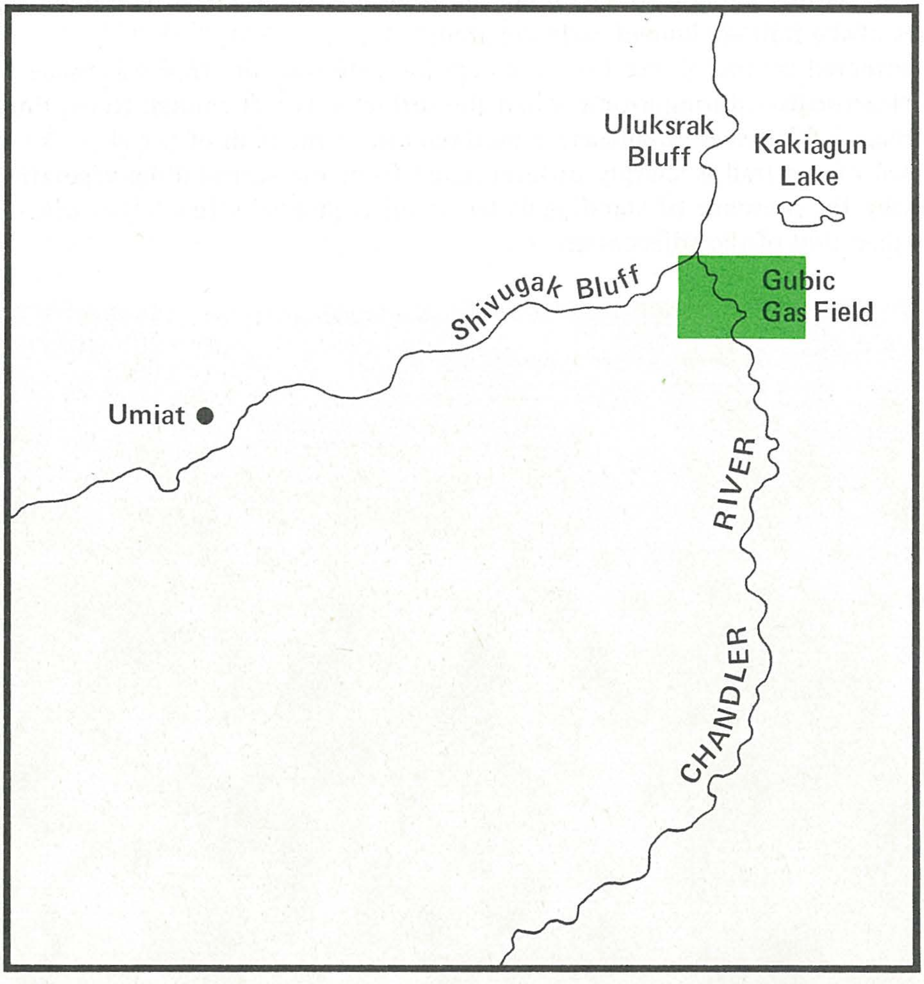


Photo 22: Bladed summer trail which intersects the shore of Sinclair Lake. 16-20 years old.

Photo 23: Lake margin in opposite direction as seen in photo 22.

GUBIC GAS FIELDS

(1951-1963)



The Gubik Gas Field is located 16 miles east of Umiat near the mouth of the Chandler River (map 3). Drilling of the first test well in this area began on May 20th of 1951. A second hole, started Sept. 10th, 1951, was abandoned after it caught fire on December 5, 1951. During May of 1951 a private company moved two more drilling rigs into the area. One of these rigs was never used, and stands abandoned at its original location (photo 24). The second rig was operated in the summer of 1962. At that time a test well was drilled on the old floodplain about one mile east of the river. The hole was plugged and abandoned in the summer of 1963, and the rig has since been moved out of the area (Brewer, 1971. Personal communication).

Most of the Gubik field occupies a poorly drained river flood plain on which surface depressions readily become water-logged. The results, typical of concentrated human activity in this area, are illustrated in photo 24. The abandoned drill rig shown in this photo is the only one still standing in the area and provides a reference point for locating other photos.

One of the several longer trails present in this area was chosen for study. This trail is seen from the air in photos 25 and 26. (Its relationship to the drill rig may be noted on photo 27.) Two features of the trail are immediately apparent:

1. It is bordered by prominent berms, which indicate that the trail was made by a down-blade tractor pass during a time when the surface was soft enough to require movement of perhaps a foot or more of surface material out of the path of travel.
2. The bed of the trail is sharply differentiated from the surrounding vegetation, in some places by the presence of standing water, in other places by vegetation which is a darker green than that of the adjacent areas.

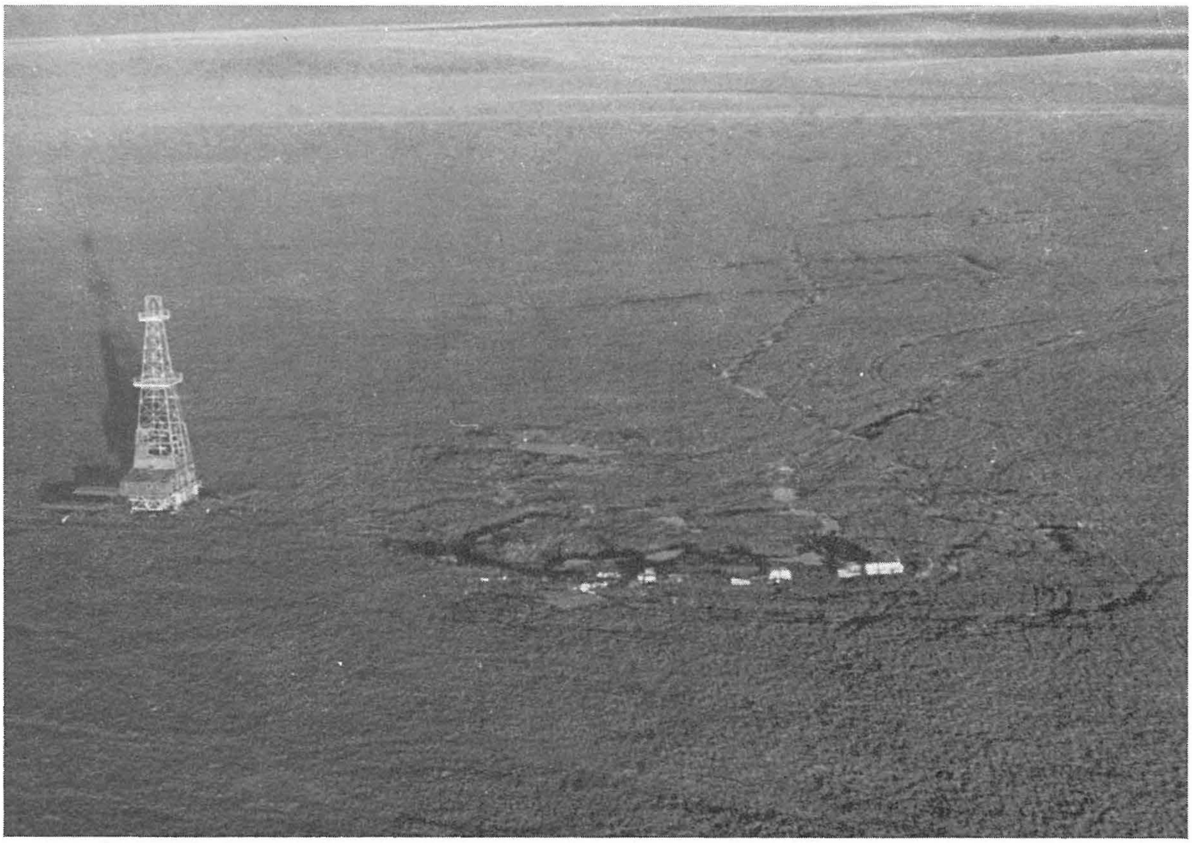


Photo 24: An area of concentrated activity. The abandoned rig is a landmark. 17-19 years old.

As was mentioned above, certain portions of the trail bed are distinctly greener than the surrounding flats. This condition is sometimes interpreted to mean that the greener vegetation is healthier. This is not always a valid conclusion. Photos 28 and 29 provide a close-up view of the rich green trail bed contrasted with the yellow-brown (darker green) areas which lie adjacent to it. The rich green vegetation in the trail bed is a nearly uniform stand of individual shoots of *Eriophorum angustifolium* rooted in a very wet habitat. Nearby are found tussocks and a mixture of other plants on a much drier surface. The richer green of the trail bed, therefore, does not necessarily indicate "healthier" vegetation.

Although the flat section of the trail had achieved relative stability, a portion of the trail that traverses a gentle slope (photo 25) was still rapidly eroding in 1969. The approach to this section of trail is shown in photo 27. Photos 30, 32 and 33 are taken in sequence beginning at the depositional area at the base of the slope and proceed up the slope. The trail has developed into a stream course. Subsidence at the head of the existing gulley suggests that erosion is continuing to encroach up the hill (photo 33).

The sloping portion of the trail, although 7-10 years old, has not yet begun to approach a stable condition. This is indicated by the slumping surface cover (photo 33), the deep, unvegetated water channel (photo 32) and the accumulating outwash (photo 30). A yellow flowering plant *Senecio congestus,* is particularly prominent as a colonizer of silty mud outwashes in active eroding areas (photo 31). This plant is not found in the immediate area other than in this active outwash habitat.

This particular trail is the only one in the Gubik area that traverses a slope. Conditions found on the flatland portion of this trail are found in many of the trails traversing the area.

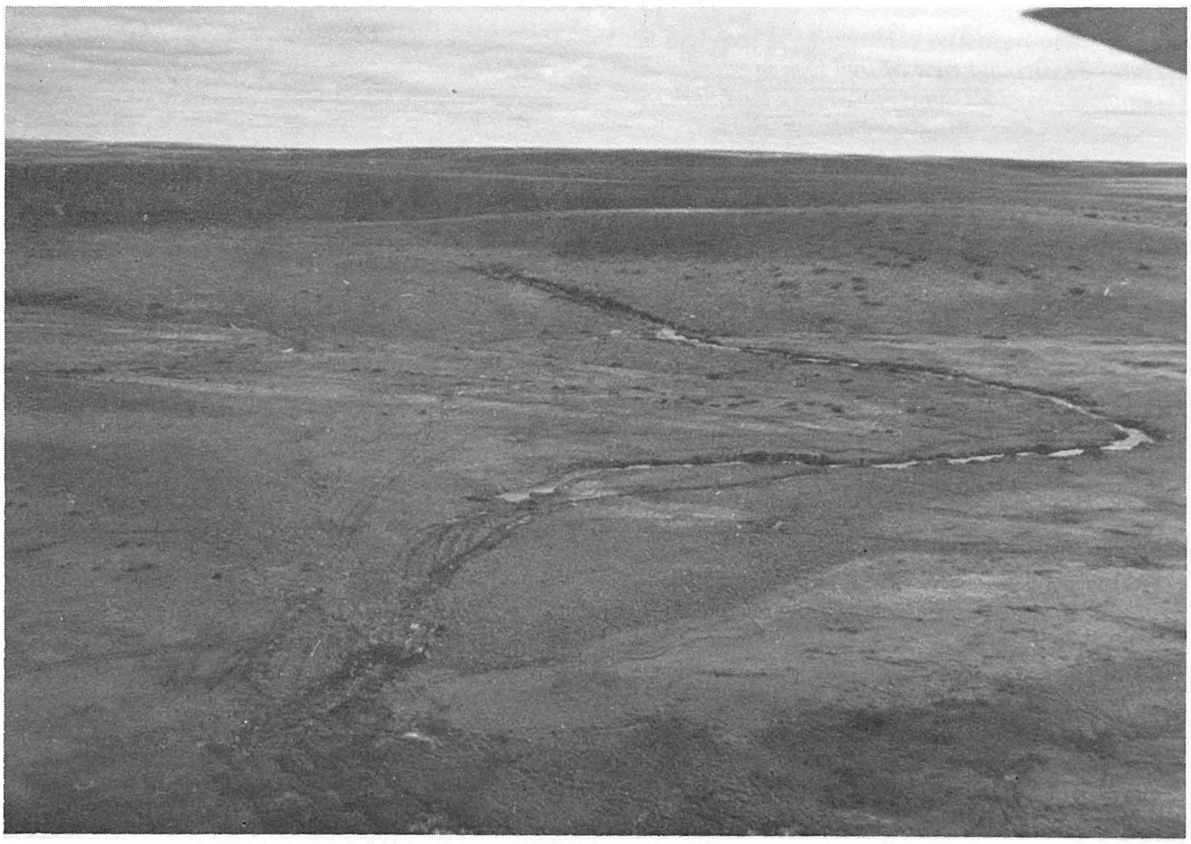


Photo 25: Aerial view of one of several extended bladed trails. 17-19 years old.

Photo 26: Continuation of the trail seen in photo 25. Airstrip is outlined as a landmark. 17-19 years old.

Photo 27: Ground view of trail seen in photos 25 & 26. Drill rig provides a landmark.

Photos 28 & 29: Ground views of a section of the trail seen in photo 26. 17-19 years old.

Photo 30: Silt outwash from eroding trail at base of slope. 7-10 years old.

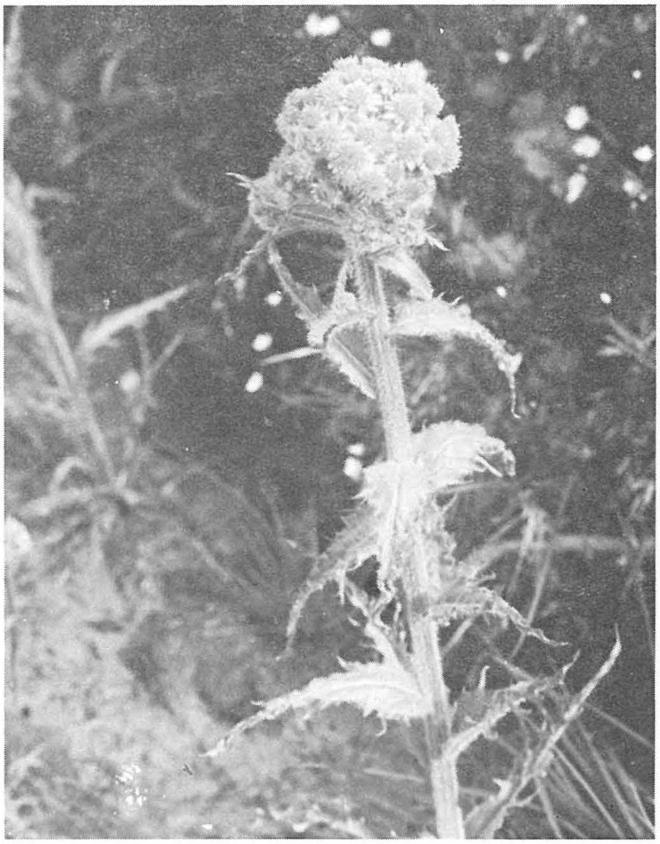


*Photo 31: The most prominent colonist on the above outwash (*senecio congestus*).*

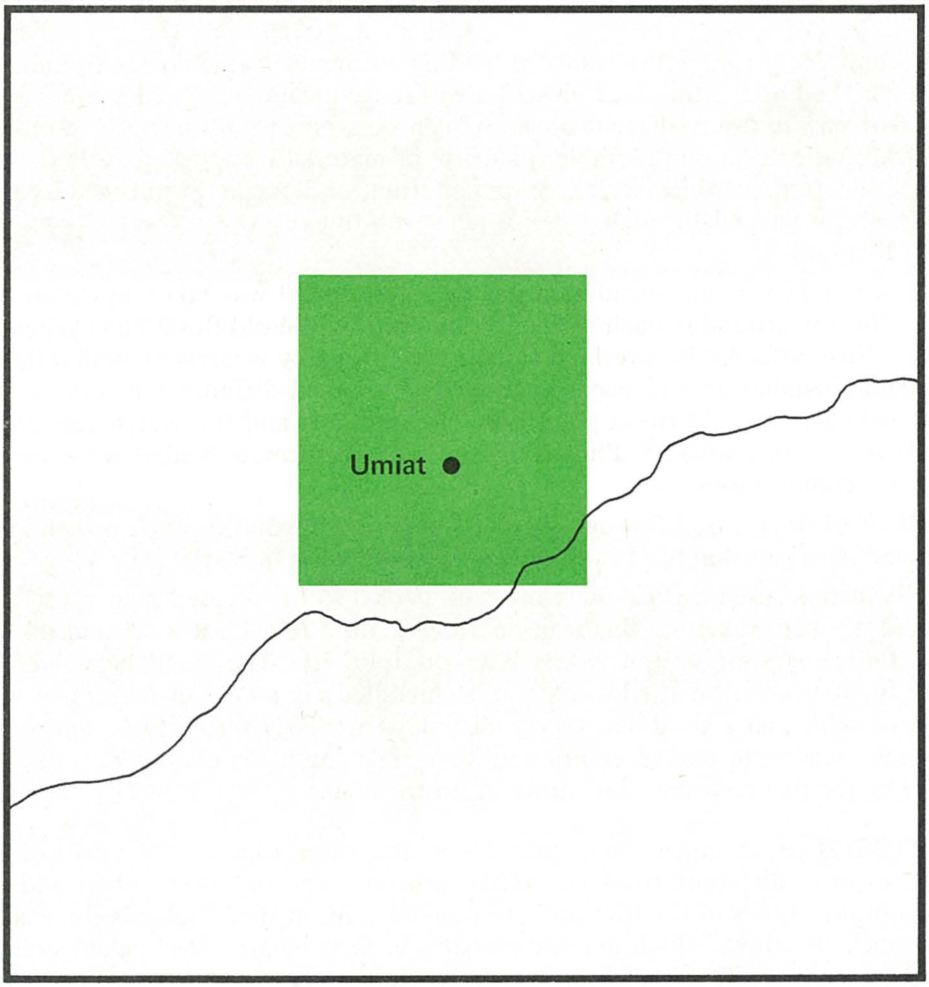
Photo 32: View downslope at the point of deepest erosion. Banks are far from stable.

Photo 33: Dish-like head of eroding portion of trail. 7-10 years since disturbance.

Photo 34: Outwash from eroding trail.

UMIAT OIL FIELD

(1944 to)



The valley bottom in which the semi-abandoned Umiat naval camp is located, and the ridges immediately to its north, were subjected to extensive disturbances which began in 1954 and have continued in some extent to the present (Map 4). The Umiat oil field is described as the most extensive discovered in Pet. 4 (Reed, 1958). A total of eleven holes were drilled during its exploration.

The history of disturbances is more complicated at Umiat than in other areas of Pet. 4. Umiat served as a major base of operations throughout the period of Navy exploration. It is presently being used to a limited extent by private companies as a base for exploration. Trails away from the immediate vicinity of the base camp were presumedly constructed during the Naval exploration, which makes them 16 to 25 years old at the time of this report. This age is assigned to the disturbances described below unless otherwise noted.

Umiat FLATS: The vegetation of the Umiat flats varies considerably from place to place. Two plant community types are common; (1) the old flood plain type; (2) the wet sedge meadow type (Spetzman, 1959). In several cases a trail passing through both of these communities provided an opportunity to see the effect on each plant community type by an identical disturbance.

Photos 35 and 36 illustrate the result of blading a summer tractor trail through a tall-shrub willow area. The bed of the trail is at present a wet sedge meadow ankle deep in water, sharply differentiated from the drier adjacent areas. As can be seen in photo 35, the berm on the left side of the trail indicates a considerable quantity of material was pushed aside (a backpack in the center of the trail provides scale). A similar situation appears in photo 37 where an old river crossing is approached through a dense tall shrub thicket. Only a few willows are present in the bed of this trail.

Photo 38 was taken at an abandoned gas well, photo 39 was taken along an abandoned electric line. The foreground in each of these is covered by the old flood plain vegetation type, which appears little affected by overland vehicle use (probably weasels or similar light carriers) once the original installation had been completed. A marked difference in vehicle use impact can be seen between the old flood plain type (foreground) and the wet sedge meadow type (background) is seen in photo 38. Photos 37 and 39 also show unbladed trails through these two major plant communities.

The result of blading a trail through the old flood plain vegetation type is seen in photo 40. Wet sedge meadow vegetation has become established in the trail bed.

A winter haul road used during the winter of 1968-1969 is located near these older trails. Photos 41 and 42 were taken of this trail on June 11th, 1969. Photos 43 and 44 were taken from nearly the same spot several weeks later on July 7th. The small berm which consists almost entirely of vegetation (little or no peat included) is a typical feature of winter haul trails. It can be seen that a good deal of vegetation, particularly shrubs, was removed from the trail bed. Some areas were bladed completely bare. The condition of this trail, if it is not used again, will be interesting to follow and study in future years.

NORTH RIDGE: The conditions encountered on the ridge tops to the north of the Umiat camp area are quite different from the valley bottom. The old flood plain and wet sedge meadow community types of the low land are non-existent on these uplands. Instead one finds extensive tussock meadows which are occasionally broken by willow-chocked drainage channels. Photos 45 and 46 illustrate bladed summer trails on level, tussock meadow vegetation. The richer green color of the trail beds is due to the predominence of individual shoots of an aquatic sedge which lack the brown component of the adjacent tussocks (a ground view of this is provided in photo 50).

The transverse channels which cross the ridge were left by ice wedges which thawed as a result of vehicle ice wedges disturbance of the surface vegetation.

Photos 35 & 36: Bladed summer trail through tall willow shrubs on flat land. 16-25 years old.

Photo 37: River crossing through tall-shrub willow community. Probably unbladed. 16-25 years old.

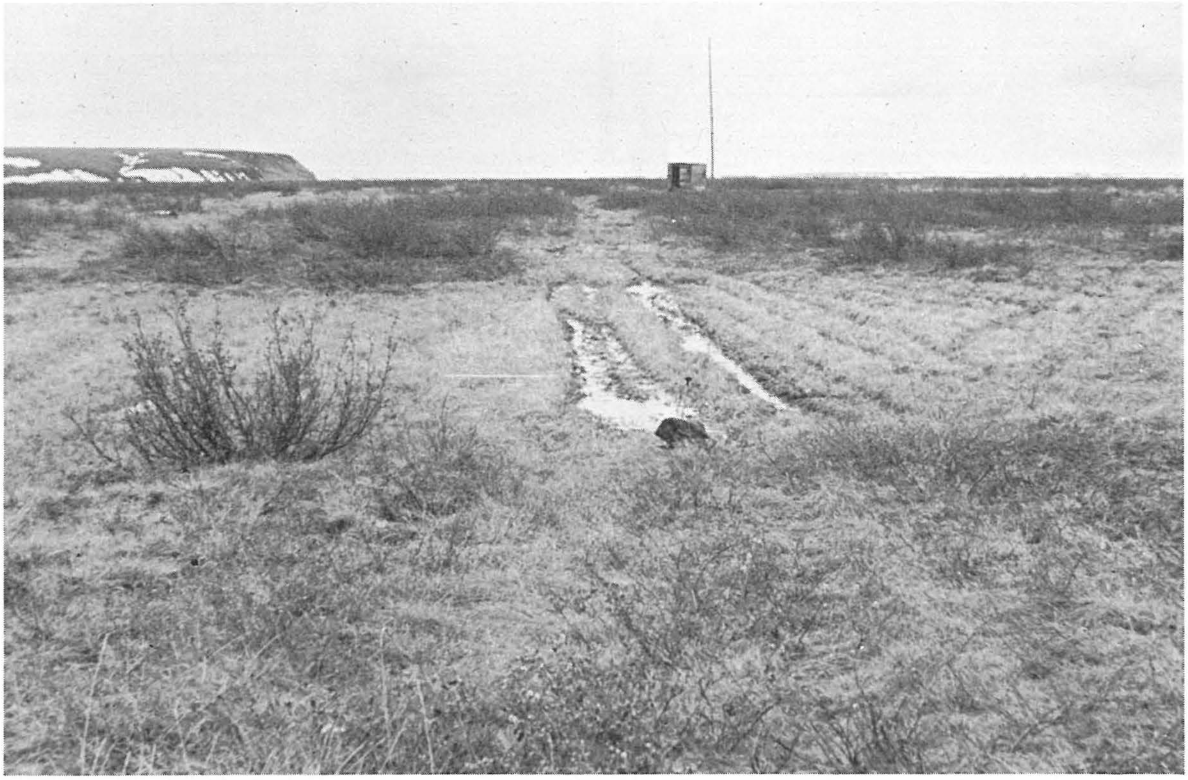


Photo 38: Trail to an abandoned gas well. The trail passes through three zones of vegetation. 16-25 years old.

Photo 39: Personnel carrier (?) trail along abnadoned electric line. 16-25 years old.

Photo 40: The result of blading a trail through a low-shrub floodplain community. 16-25 years old.

Photo 41: A winter haul trail seen on June 11th after use the previous winter. Looking south.

Photo 42: Same trail as above: North view.

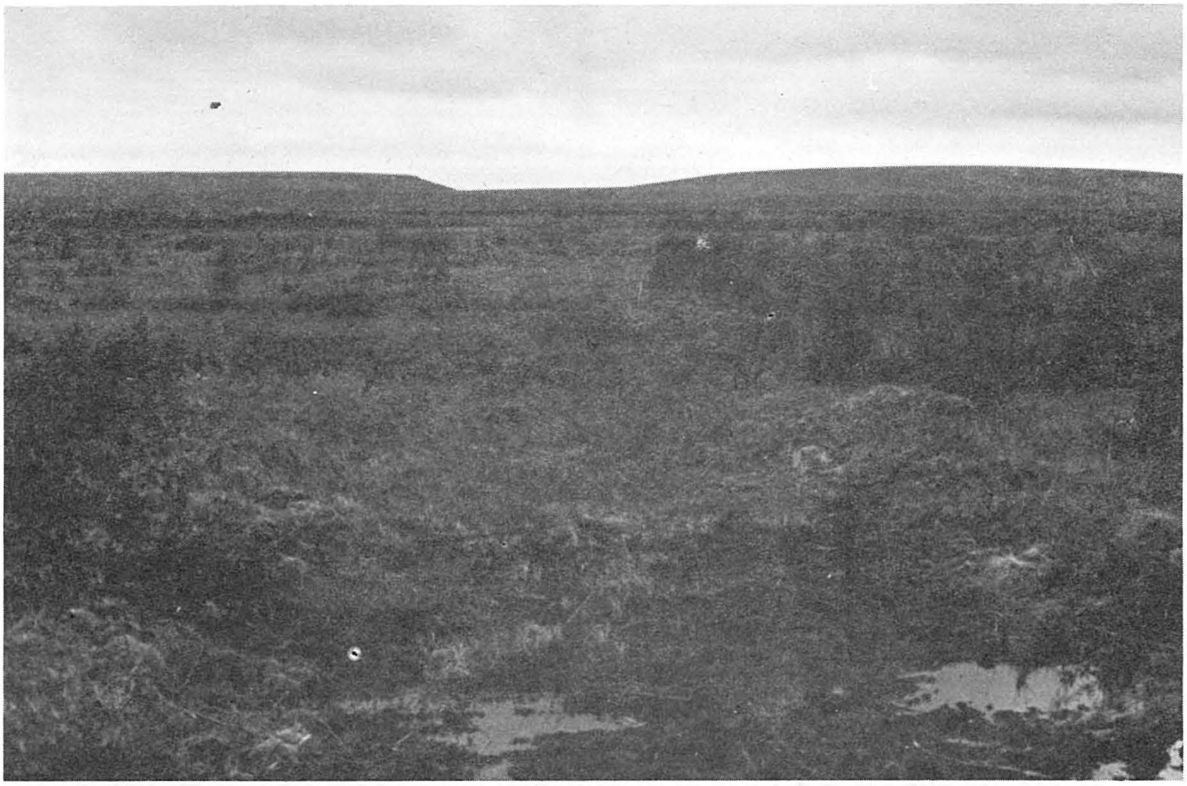


Photo 43: Same trail seen in photos 41 & 42 rephotographed on July 25th. Looking south.

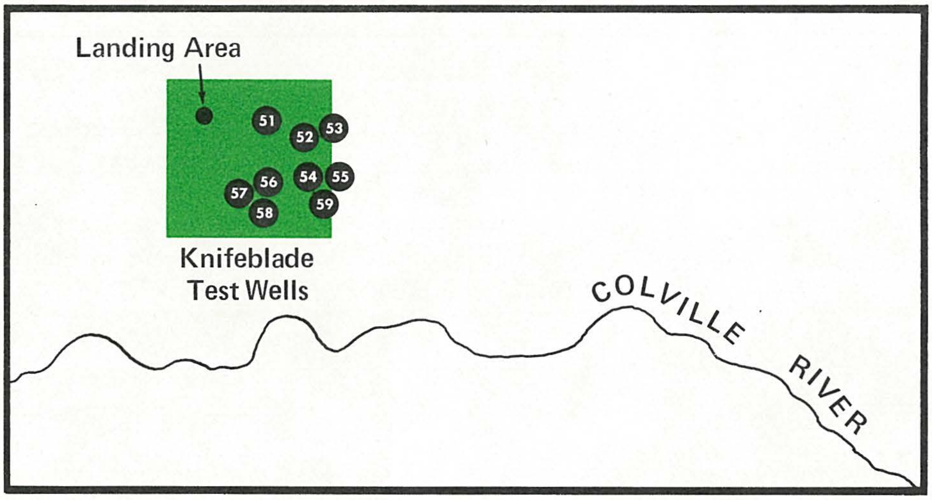
Photo 44: Same trail as above; North view.

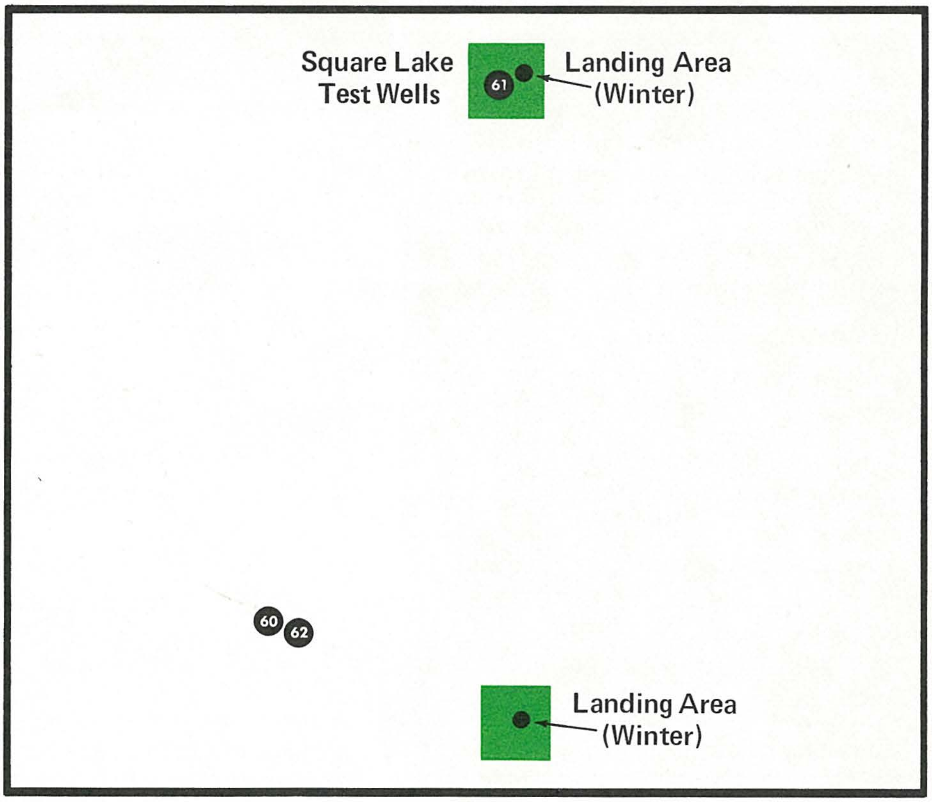
Photo 45: A bladed summer trail across tussock meadow, Umiat north ridge. 16-25 years old.

Photo 46: Bladed summer trails leading to an abandoned drilling site, Umiat north ridge. 16-25 years old.

KNIFEBLADE, WOLF CREEK AND SQUARE LAKE TEST SITES

(1951-1952)





Knifeblade, Wolf Creek, and Square Lake are three sites in the foothills, some 70 miles west of Umiat, where limited activity took place during the exploration of Pet. 4. The general location of each is shown on map 1, precise locations are shown on maps 5 and 6.

The Knifeblade site includes three well test holes, two of which were drilled within 30 feet of each other. Work began in the summer of 1952 and was completed on December 22nd of the same year.

The Wolf Creek site, slightly older than Knifeblade, involved only a single test hole. Work began on April 29, 1951, and was completed on July 3, 1951.

Square Lake was strictly a winter operation. The single well drilled there was spudded in on January 26, 1952, and completed on April 18th. No summer activity occurred in this area.

All of these sites lie in gently rolling hills which are covered by nearly unbroken tussock meadow vegetation.

Of the three, it was possible to land only at Knifeblade. One of the three test holes at Knifeblade, situated in wet sedge meadow between two hills, is shown in photo 47. The vegetation around this test well shows little evidence of disturbance. One major trail exists at the Knifeblade site. This trail begins at the drill site shown in photo 47, climbs a gentle north facing slope which is covered with tussock meadow vegetation, crosses the top of the hill, and descends a dry, south facing slope which is covered with grass, low shrubs, cushion plants, and herbs. The photo sequence illustrates varied conditions along this trail. Photo 48 gives an overall view and photo 49 a detailed view of the north slope traversed by the trail. Photo 50 shows the trail bed on a wet portion of the hilltop. Photo 51 shows the trail on a dry part of the hilltop just prior to its descent to the south. Photos 52 and 53 were taken at progressively lower points on the dry south slope. Photo 54 shows the trail bed near the base of the slope. An aerial view of this trail, where it crosses the top of the hill, is provided in photo 55.

The Wolf Creek and Square Lake sites were not inspected on the ground, but are seen from the air in photos 56 and 57 respectively. Several very prominent trails are present at Wolf Creek (photo 58) a summer operation, but none are apparent at Square Lake, a winter site.

Photo 47: An abandoned test site at Knifeblade.

Photo 48: Bladed trail on wet, tussock slope to test well. 17 years old.

Photo 49: A close-up of unstable spot in bed of trail shown above.

Photo 50: Trail seen in photos 48 & 49 where it reaches level hill top (wet portion).

Photo 51: Same trail on dry portions of hill top.

Photo 52: Continuation of trail seen on the preceding pages. Here seen descending a dry slope.

Photo 53: Same trail as above, farther down slope.

Photo 54: An upslope view of the preceding trail from the base of the hill. 17 years since disturbance.

Photo 55: An aerial view of an intersection of trails at crest of hill. 17 years old.

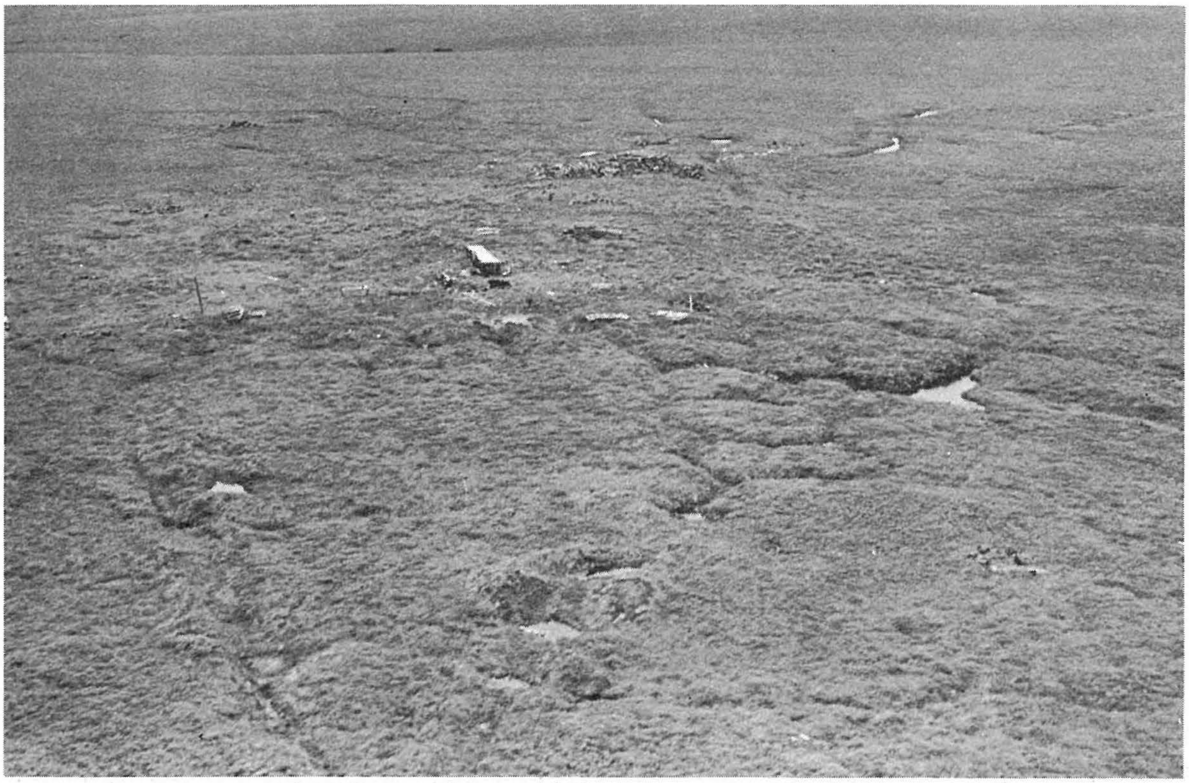
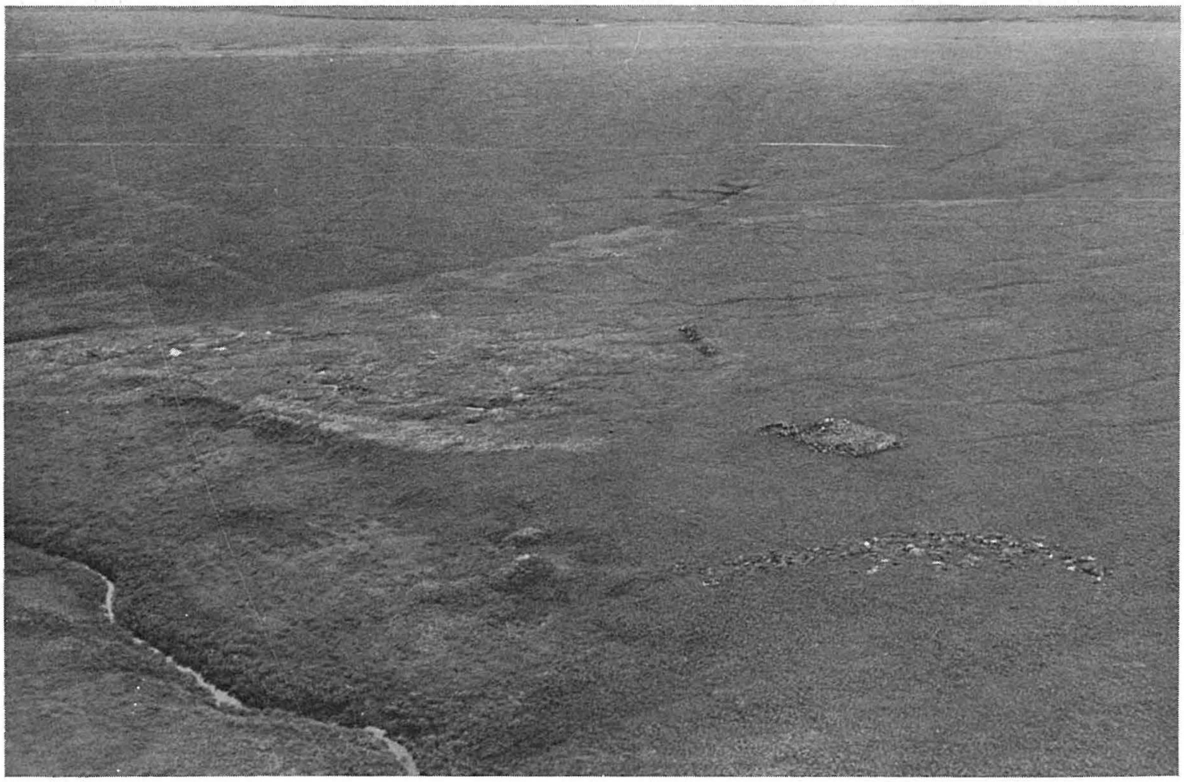


Photo 56: Aerial view of Wolf Creek test site. 18 years old.

Photo 57: Aerial view of Square Lake test site. 17 years old.



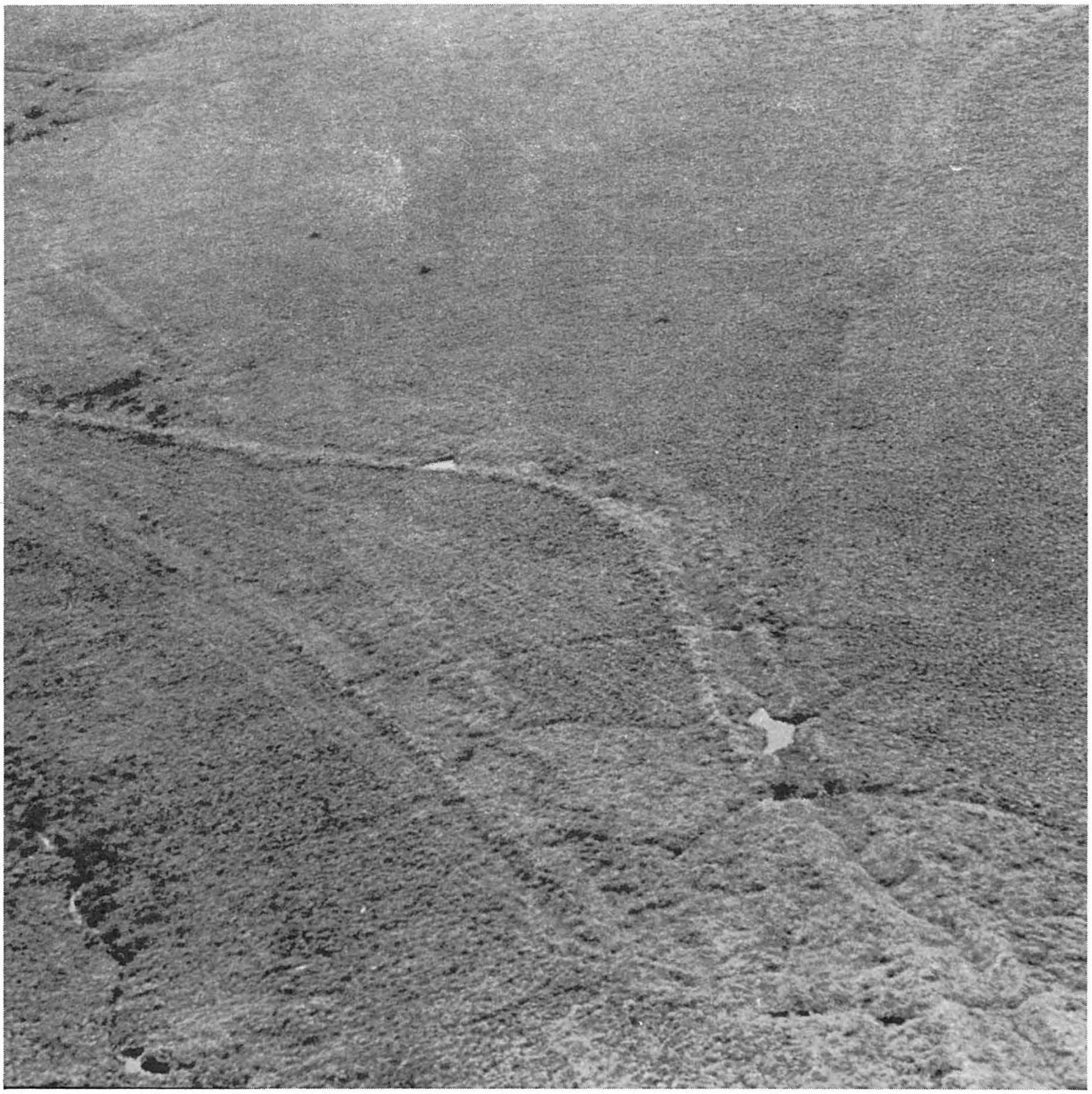
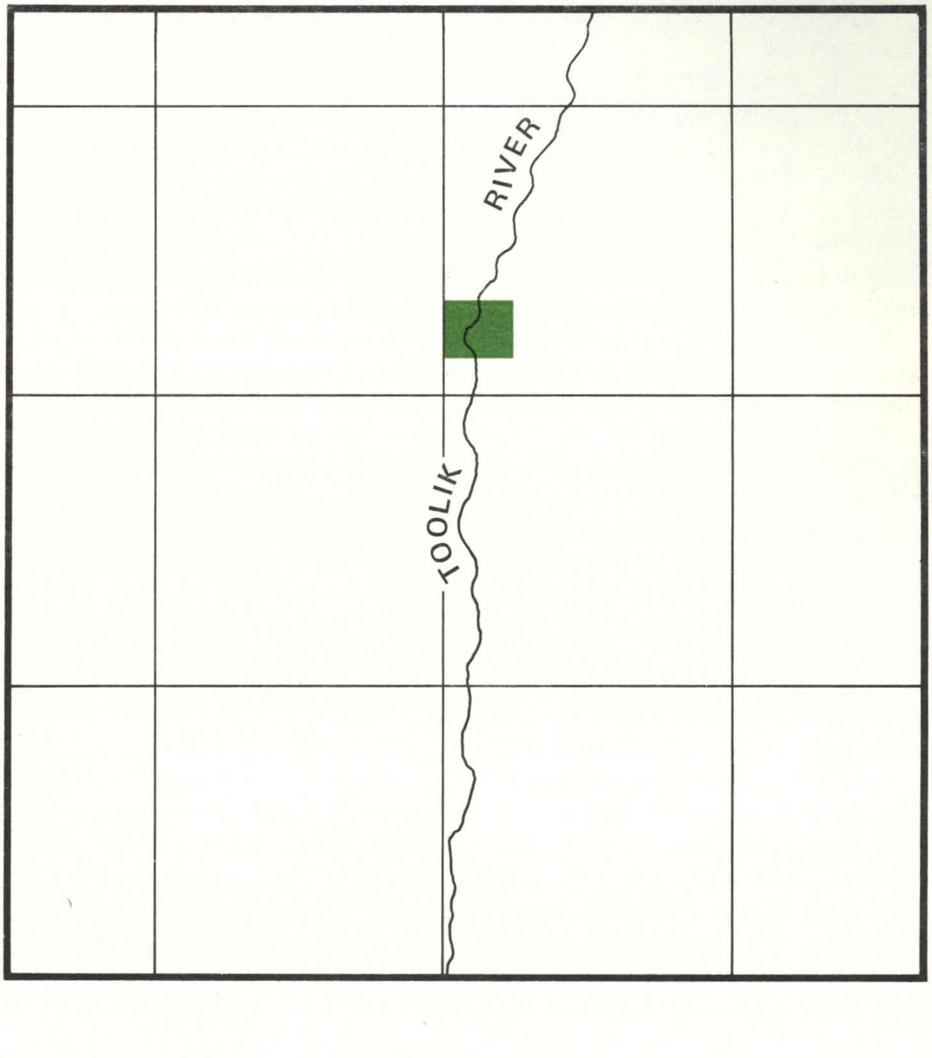


Photo 58: Trails at Wolf Creek test site. 18 years old.

TOOLIK RIVER TRAIL

(Dates Unknown)



Nearly all of the disturbances which have been described up to this point were specifically sought out on the basis of Reed's (1958) original records. However, once all of the selected sites in Pet. 4 had been visited, several excursions were made outside its boundaries. These observations ranged as far east as the Sagavanirktok River, and from a point about 20 miles north of Sagwon south to Elisive Lake at the foot of the Brooks Range.

Of the many trails observed, the one included in this report was selected for two reasons:

1. Within a short horizontal distance it traversed several types of terrain.
2. Its appearance from the air included several trail features which had repeatedly appeared elsewhere.

Two broad views of this trail are shown (photos 59 and 60) as it crosses a rolling tussock meadow, descends to the Toolik River, and continues on across a flat, well-drained flood plain. A cross section of the ice-rich slope which the trail descends, was viewed at a nearby natural slump (photo 61). At the upper center of photo 61 the thin layer of soil and vegetation can be seen covering frozen ground.

The effects of equipment-caused disturbances are most pronounced on this ice-rich, sloping ground. Note that it requires a close look to find the trail route on photo 60 where it crosses well-drained gravel.

Photos 62 through 66 were taken in sequence from a point where the trail leaves the dry, well-drained flood plain to a point on level ground near the top of a hill on the Toolik River's west bank. Photo 68 is an aerial view of the most unstable portion of the trail. Photo 67 gives a close-up view of this unstable bank as it appeared on the ground. Photo 69 can be used to locate ground positions of above photos.

This trail was a particularly useful find because of the opportunity it provided to follow a single track (and therefore an identical disturbing factor) across a dry gravel flood plain, up ice-rich sloping ground, and across a level tussock meadow.

Perhaps the best indications of what originally occurred can be seen (photo 66) where erosion has not obliterated the original trail. The trail margins are formed by two small but distinct berms. each consisting of dead vegetation and a small amount of soil. In the trail bed the scattered tussocks appear more youthful (little or no accumulation of dead basal material) than those of adjacent areas. Present information indicates that this trail was created during the winter of 1968-69 in the process of moving a drill rig. (Brewer, 1971. Personal communication.)

Photo 59: Bladed summer trail as it descends ice-rich, tussock covered slope. (Age unknown)

Photo 60: Same trail as in photo 59, but crossing well-drained floodplain. (Slope is at upper left.)

Photo 61: Exposed cross-section of tussock covered slope. Thin surface layer underlain by ice appears at center.

Photo 62: Summer trail as it leaves floodplain and crosses the Toolik River.

Photo 63: Depositional area at base of eroding slope where trail begins to ascend.

Photo 64: A veiw downhill of the unstable, sloping portion of the trail.

Photo 65: An uphill view at the upper end of the sloping portion of the trail.

Photo 66: The trail on nearly level ground above the previously seen sections.

Photo 67: A close view of the trail bank where active slumping is in progress.

Photo 68: An aerial view of the most active (and steepest) section of the trail.

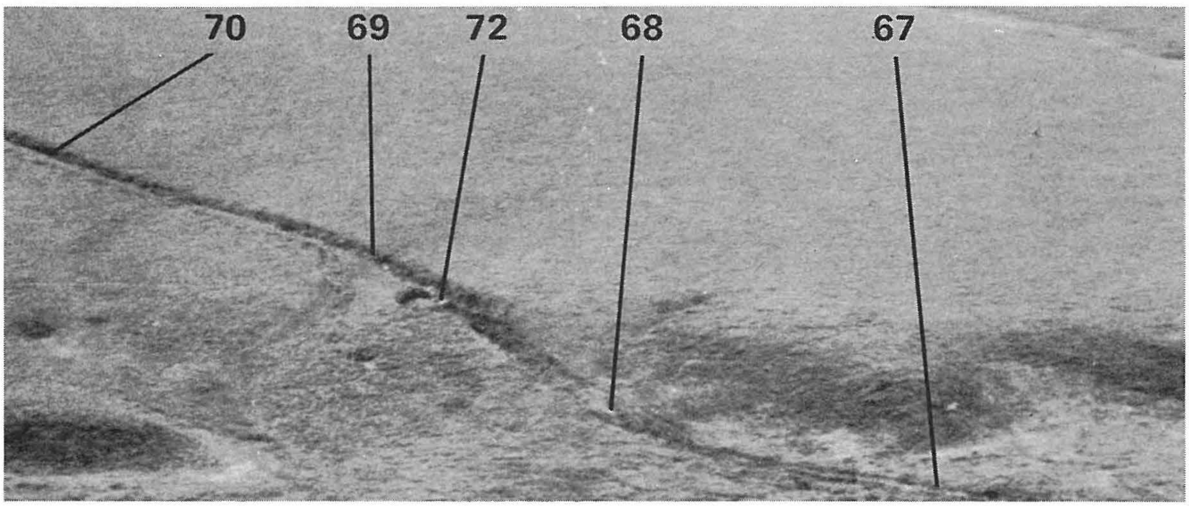


Photo 69: A section of photo 59 for locating the preceding photos.

DISCUSSION OF THE RECONNAISSANCE

The photographs and text presented up to this point have been limited as much as possible to provide the reader with an unadorned description of the sites which were visited during the course of the reconnaissance. In this section, an attempt will be made to establish a few broad patterns of "cause and effect".

Unlike the controlled experiment in which each variable can be manipulated by design, a field study requires one to view the evidence as it stands and make the most of it. The sample of disturbances which has been presented includes a high percentage of bladed summer trails made by heavy tractors. However, the records indicate that lighter vehicles and other modes of "cat" operation were widely employed during the exploration of Pet. 4. One reason for this bias lies in the truism that any marks which have completely disappeared by this time were not recorded. The extreme scarcity of tracks which could be recognized as those of the "weasel" or of the "bombardier" (both broad-tracked, light personnel carriers) suggests that limited use of these vehicles does not generally cause long lasting disturbances. This opinion is shared by others: Wiggins & Thomas, (1962 p. 29).

On the other hand, the use of heavier vehicles, particularly caterpillar-type tractors, often resulted in marked changes of disturbed surface. These changes were consistent with reference to four major variables:

1. The season (frozen vs. thawed ground) during which the disturbance took place;
2. The degree to which surface material had been bladed aside;
3. The water content of the substrate (ice-rich vs. well-drained);
4. The degree of slope.

The single most important variable in determining what changes will occur in the path of a heavy tracked vehicle is the season during which the operation was conducted. Surface movement of heavy* equipment during the summer months produced closely related disturbances that link the second, third, and fourth variables listed above.

**Probably better evaluated in terms of pressure per square inch of surface in contact with the ground than by gross vehicle weight.*

The three factors: degree of blading, substrate water content, and degree of slope interact to such a degree that it is difficult to discuss one without considering the others. This close relationship is evident when one considers that the degree to which the surface is disrupted determines the change in heat balance between air and substrate; the substrate in turn responds according to its composition until a new equilibrium is attained; but if slope permits the products of the thawing process to be continually carried away, exposing new frozen material, no new balance can be established. There are 8 possible combinations of use variables. Trails illustrating each of these combinations appear on the following pages.

A special case of a bladed summer trail across level, ice-rich terrain was noted at Cape Simpson. The trail's proximity to a lake margin may have stimulated slumping of the shore line (photos 19-23, Cape Simpson section). Such a possible connection between lake-margin instability and vehicle use was also suggested by Burns (1964: 81-82) as it pertained to destruction of mink denning areas on the Yukon-Kuskokwim Delta. The available evidence does not permit an evaluation of the rate of lake margin change in terms of natural and man-induced components, however.

Trails which were made during winter, while the ground was frozen, pose a different problem than those which were created by summer travel. Changes along winter haul routes, although more subtle than the effects of running a tractor across semi-solid ground, were none-the-less evident in a number of locations. Probably two major methods of construction for winter haul roads should be considered:

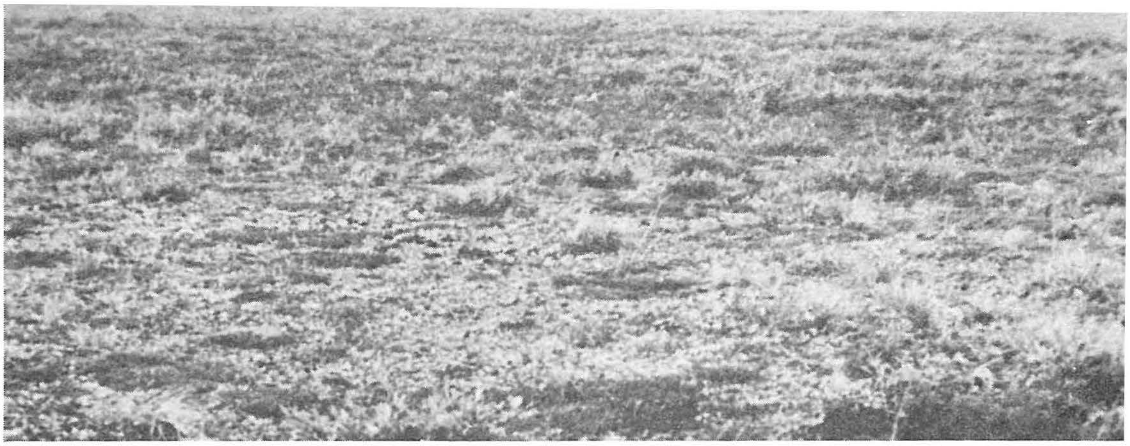
1. Those in which snow and surface irregularities are bladed away for use by heavy trucks;
2. Those in which snow is packed and smoothed for use by tractor-drawn sleds.

The first method was used for the construction of the "Hickle" Highway. When observed during the summer, this type of road generally consisted of a main track of black, soggy, exposed peat from which living vegetation has been worn away. A margin of dead vegetation extended some 10 to 20 feet on either side of this main track (photos 70 and 71). Old Navy trails made of packed snow generally did not break the tundra surface. These trails almost invariably followed the most gently contoured course which was available across the miles of rolling tussock meadows that separated the various foothill drilling sites. The vegetation in these winter sled trails was not scraped or worn away, but was killed and had not fully recovered by the time of observation. No opportunity occurred to observe any of these cross-country winter trails from the ground.

Some evidence of a packed-snow road will remain for many years (photos 72-74). Usually the lasting effects are not as pronounced as those resulting from exposure of the surface to direct contact with heavy vehicles. However, where slopes or other obstacles to travel promote surface disruption (e.g. Toolik River disturbance), the effects may duplicate those of summer travel.

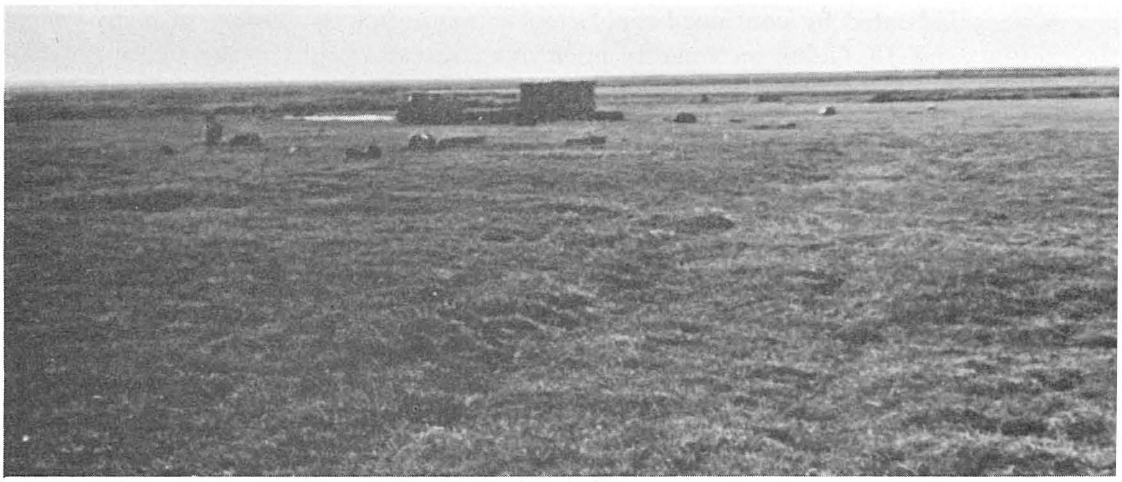
It is interesting to note in photos 70 and 71 (bladed winter trail) that the areas immediately adjacent to the actual road-bed, presumably where snow was heaped and packed while keeping the road open, have the same appearance as the packed-snow trail beds in photos 72 and 73. The cause of this phenomenon is probably a combination of mechanical pressure and shortened growing season (due to late melting of the packed areas). (Wiggins & Thomas – 1962: 28-29)

The published observations of several authors provide other examples of vehicle caused disturbances. Ferrians, Kachadoorian, and Greene (1969: 25), commented on a frequently traveled trail near Ogoyoruk Creek, N.W. Alaska: "The trail from the camp . . . climbs to the top of a ridge. The constant use of weasels on this trail compacted and destroyed the protec-

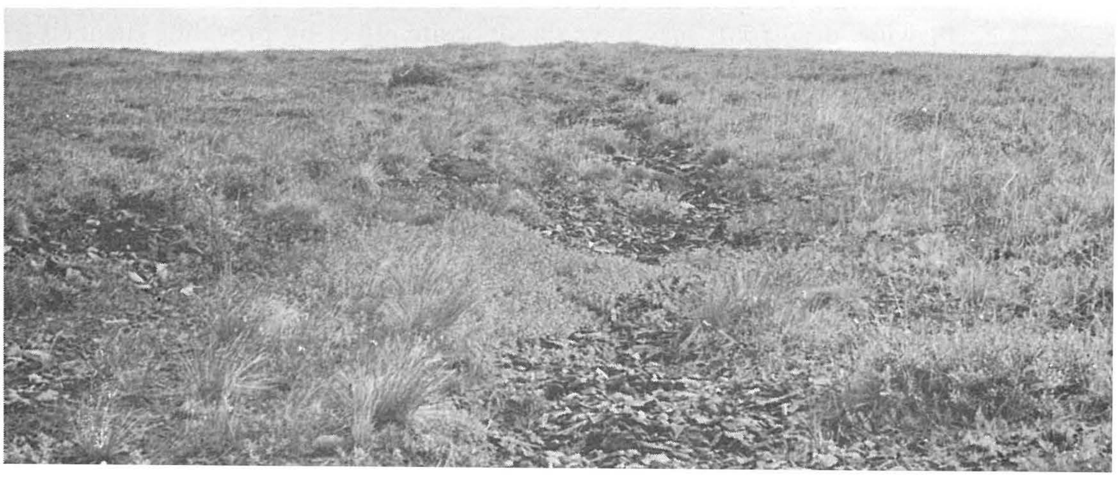


Blade up; well-drained; level.

Blade down; well-drained; level.



Blade up; well-drained; sloping.



Blade down; well-drained; sloping.

tive vegetation, causing the underlying permafrost (about 1 ft. below the surface) to thaw. This thawing was accelerated by runoff from rainfall, and by 1962 the gullies in the road were as much as 15 feet deep. In the area adjacent to the campsite the vegetation cover was completely destroyed, the underlying permafrost thawed, and quagmire areas formed."

An unusually detailed description of the changes which occurred in an abandoned summer "cat" trail during a summer three years after repeated travel, is given by Hopkins (1949: 122-124): "During 1945, a gentle hill slope had been crossed repeatedly by a caterpillar tractor. When first examined in 1948, the route of the tractor was marked by lone, swampy furrows indented 3-12 inches in the tundra. Later in the summer a series of sinkholes, 3-5 feet deep, connected by subterranean watercourses, was discovered beneath the tracks in areas where the tractor had traveled directly upslope. Still later, the roofs of the connecting caverns had collapsed, and the course of the tractor was marked by narrow gullies 3-4 feet deep." The condition described by Hopkins is probably similar to that seen in photo 75, taken at Barrow.

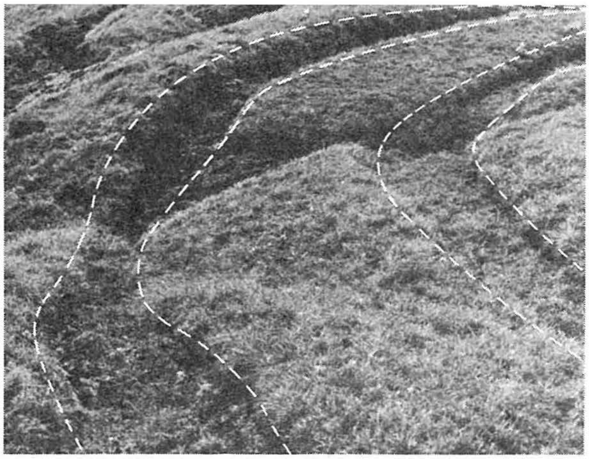
What can be done to minimize the adverse effects of vehicle operation on North Slope landscapes remains a subject of active debate. Included in a ten-point set of guidelines for minimizing the adverse effects of frost action, Ferrains, et al, (1969: 36) suggest: "Avoid the disruption or destruction of the vegetation overlying permafrost . . . Restrict tracked vehicles, trucks, and other heavy equipment to roads and do not permit them on the tundra or vegetation where they will destroy its insulating quality and cause the permafrost to thaw." This would seem the ideal approach wherever possible. At the same time, by recognizing the major factors involved (season, surface disruption, substrate, slope) and how they interact, it may be possible to rationally analyze the consequences of a given operation and act accordingly.

A more difficult question is: how to repair or minimize damage once a disturbance has been created? Unfortunately, where restabilization would be most valuable (on ice-rich slopes), the only impression gained was that the task was generally beyond the powers of vegetation, as indicated by continued rapid erosion even after the passage of many years (see photos 30, 32, and 33, Gubik section). In most of these cases some mechanical means will probably be necessary to permit vegetation to gain a foothold. Exceptions do exist, however. Photos 76 and 77 show a trail on ice-rich slopes along the Chandler River that have eroded and finally stabilized in a condition markedly similar to that of the natural drainages near it.

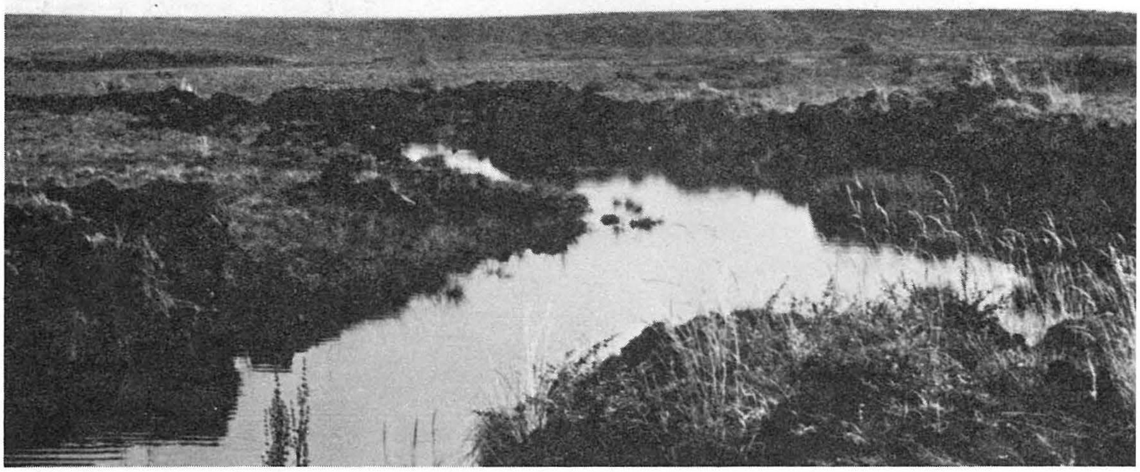
Attempts have been made to blade the berms back into the trail bed immediately after the trail is no longer needed. However, this treatment has met with little success, it is an oversimplification to consider the layer of peat and living vegetation as an inert insulating substance which can be removed and then replaced without significantly altering its properties. Benninghoff (1952: 38-39), citing the work of several Russian and American authors, discusses the active effects of vegetation on heat exchange and how they vary with changing conditions. For example, in addition to shading the reduction of air circulation, it has been demonstrated that, by retaining water during wet or humid periods and then releasing it by evaporation during warm, dry periods, mosses contribute an active refrigerating effect. It has been further noted that, while living roots in the soil tend to impede downward movement of water, thus reducing thawing, dead roots may have the opposite effect by providing channels for downward movement of water. (Benninghoff, 1952).

The most certain means for limiting damage to North Slope environment seems to be prevention rather than rehabilitation. In conclusion it may be said that once a decision is reached to proceed with surface movement of heavy equipment, one thing should be recognized: any marks, once made, will probably last for an indeterminate period of time; the nature and extent of these marks will depend upon the manner in which the operation is planned and carried out.

Blade up; ice-rich; level.



Blade down; ice-rich; level.



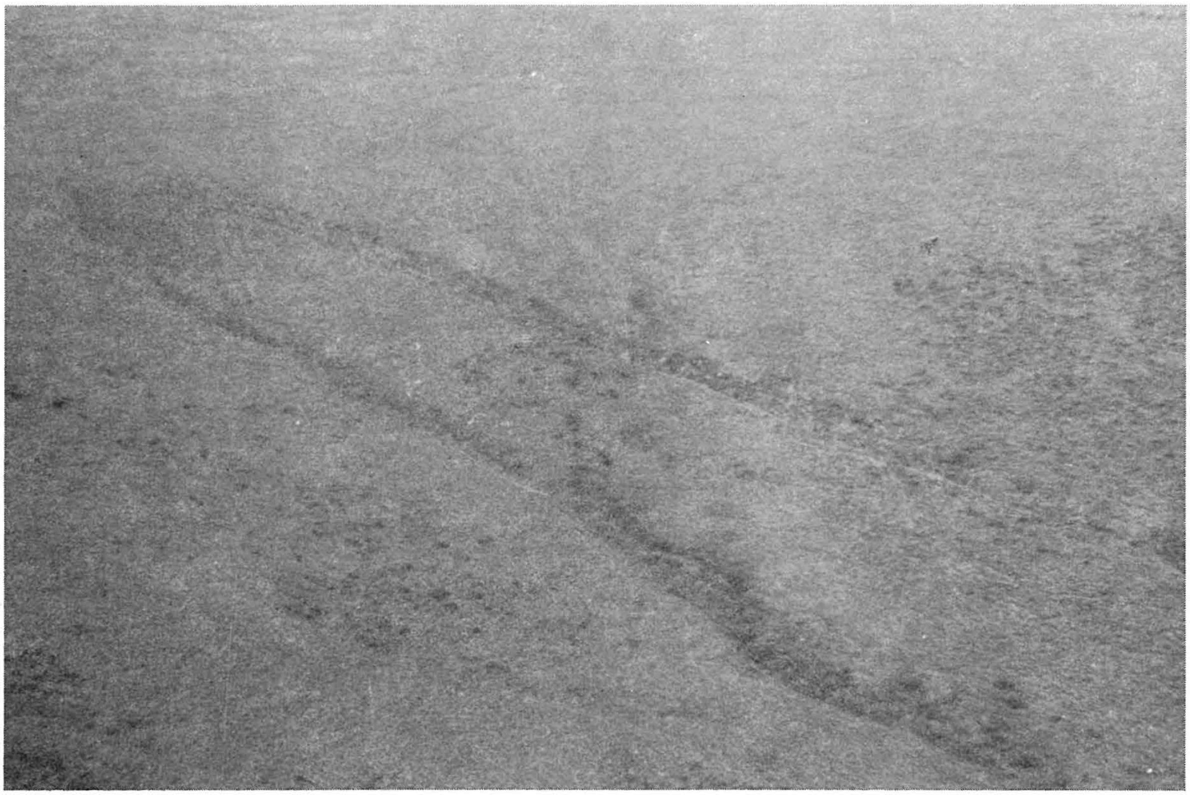
Blade up; ice-rich; sloping (several passes).

Blade down; ice-rich; sloping.

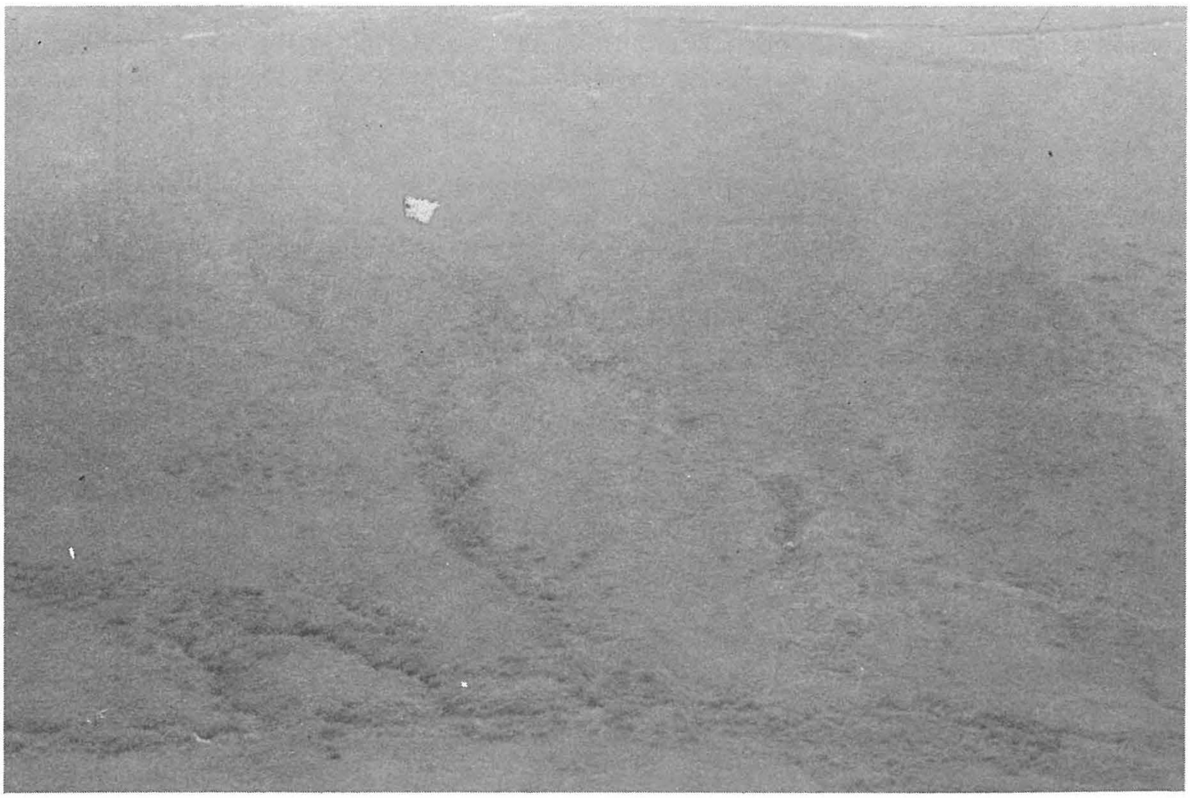
Photos 70 & 71: Bladed winter trail. Winter 1968-69.

Photos 72, 73, 74: Packed-snow winter trails. About 20 years old.

Photo 75: Result of repeated "cat" travel over thawed ground at Barrow.



Photos 76 & 77: An eroded summer trail now stabilized. Natural gully at left of trail.



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**Asterisk (*) indicates references which were cited in the discussion.*