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BEDROCK SOURCES OF HIGHWAY MATERIALS

INUVIK TO TUK HIGHWAY

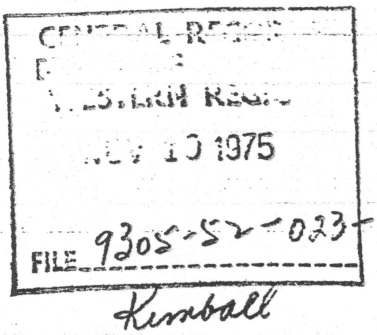
TERRAIN ANALSIS AND MAPPING SERVICES LTD.

Terrain Analysis and Mapping Services Ltd.

(613) 836-2594 PRES. - VERN RAMPTON, Ph.D. Box 92, Fringewood Village
Stittsville, Ontario

21113

October 30, 1975



Mr. F.E. Kimball
Project Manager, N.W.T. Roads
Western Region
Department of Public Works
P.O. Box 488
Edmonton 15, Alberta

Dear Mr. Kimball:

Enclosed is a report discussing "Bedrock sources of highway materials, Inuvik to Tuktoyaktuk Highway". I hope you find the report to your satisfaction. If you have any further questions regarding this subject, please feel free to contact me.

As we were limited in the field by weather and my previous commitments, no time was available to examine present borrow pits south of Inuvik. No attempt, therefore, has been made to evaluate the quality of the bedrock between Inuvik and Parsons Lake as borrow material. Discussions with your engineers, however, lead me to believe your primary concern is to find ice-free materials. Thus, the report confines itself to commenting on the presence of Tertiary and Cretaceous strata that have a high probability of being ice-free.

In addition, I have some doubt to the desirability of the poorly consolidated Tertiary sands as highway fill in this environment. I do not feel qualified, however, to comment on this engineering matter and have avoided the subject in the report.

Finally, I would be pleased to be of service on any other matters requiring geologic input in your northern highways program.

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My final invoice re this project will follow shortly.

Sincerely yours,

Vern Rampton

Vern Rampton,
Ph.D., P.Eng.

P.S.

If you plan to do any drilling in the area, please contact Dr. D.K. Norris of the Geological Survey of Canada at Calgary. He would be very anxious to get some cuttings for purposes of geological correlation, which in the end may be of some benefit to your work.

BEDROCK SOURCES OF HIGHWAY MATERIALS,

INUVIK TO TUKTOYAKTUK HIGHWAY

for

Department of Public Works
Western Region
Edmonton, Alberta

by

Terrain Analysis and Mapping Services Ltd.
Box 92, Fringewood Village
Stittsville, Ontario

October, 1975

Terrain Analysis and Mapping Services Ltd.

tel: (613) 836-2594 PRES. - VERN RAMPTON, Ph.D. Box 92, Fringewood Village, Stittsville, Ontario

October 28, 1975

Mr. F.E. Kimball
Project Manager, N.W.T. Roads
Western Region
Department of Public Works
P.O. Box 488
Edmonton 15, Alberta

Dear Mr. Kimball:

In this report I have outlined areas where Tertiary or Cretaceous strata are either at the surface or near-surface. Cover thicknesses are based on extrapolations of geologic stratigraphy and interpretation of geomorphic forms; some drilling will be necessary to confirm estimated thicknesses of cover. In addition, it is not the purpose of this report to comment on the quality of the different Tertiary and Cretaceous units as highway fill.

I hope the report fulfils your requirements.

Sincerely yours,

Vern Rampton

Vern Rampton
Ph.D., P.Eng.

VR/hd

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Bedrock Sources of Highway Materials,

Inuvik to Tuktoyaktuk Highway

1. INTRODUCTION

1.1 General

The objectives of this paper are to outline areas of bedrock or near-surface bedrock that might be utilized as borrow for the proposed highway between Inuvik and Tuktoyaktuk, to propose a program to further determine the feasibility of developing the outlined areas, and to comment on possible problems in development.

1.2 Methods

A field reconnaissance was conducted (1) to examine bedrock exposures near the highway alignment in order to identify the bedrock lithologies, (2) to examine escarpments whose slopes were covered by weathered bedrock in order to determine lithologies and continuity of strata, and (3) to examine the landscape in general to establish if near-surface bedrock could be determined from geomorphic expression.

Office studies included a review of geologic maps, a brief review of geologic literature, examination of shothole logs provided by DPW and from other sources, discussion with goverment officials familiar with the geology of the area, and airphoto interpretation.

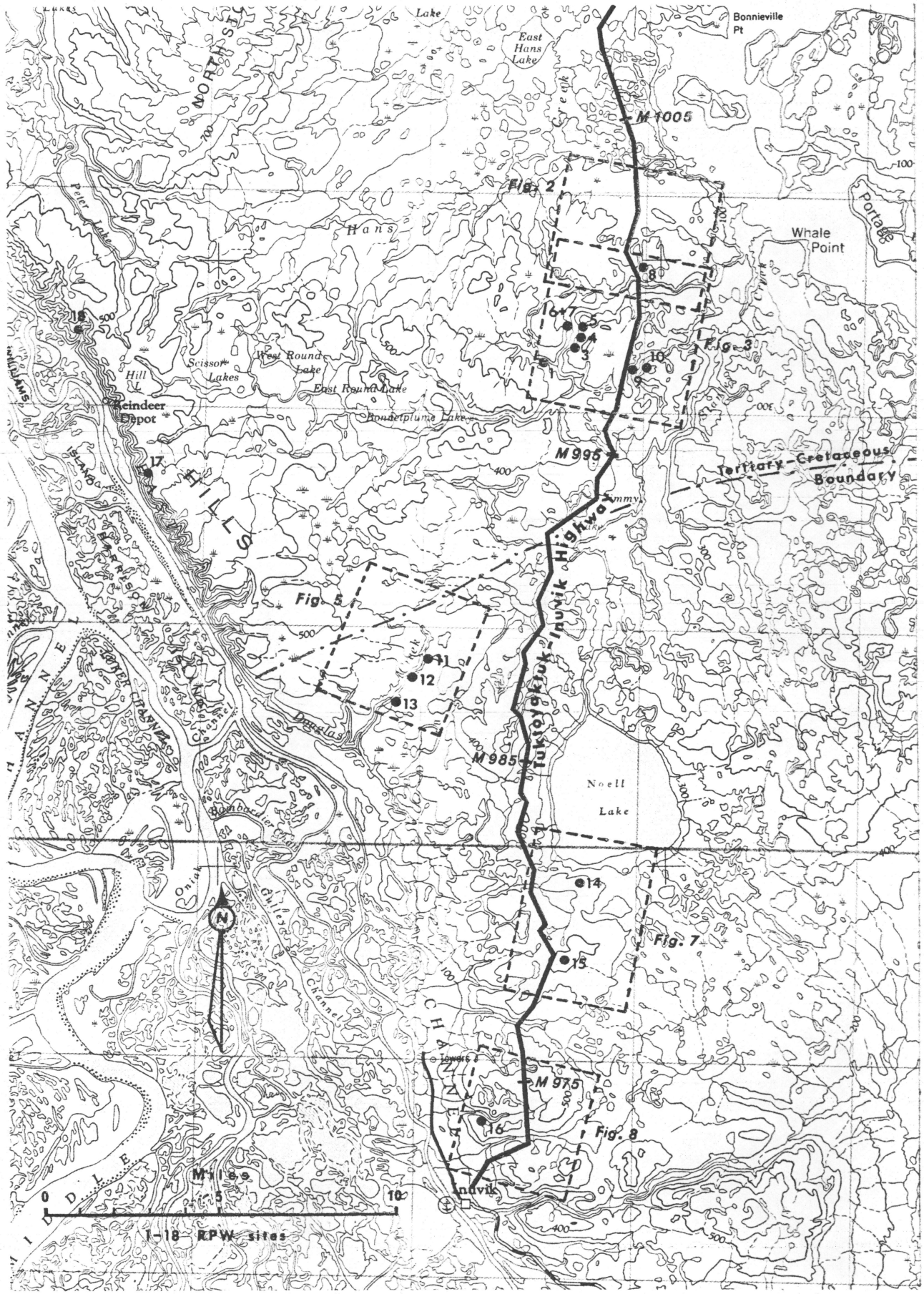

Figure 1 Location map.

2. TUKTOYAKTUK - MP1005

2.1 General geology

Just north of MP1005 the highway alignment crosses the boundary between the Caribou Hills and the Pleistocene Coastal Plain. The terrain north of this line is underlain by Quaternary sediments[1] well over a hundred feet in thickness and containing abundant ground ice. They consist of a complex of interbedded glaciofluvial, morainic, fluvial, lacustrine, marine, organic, and thermokarst sediments. Glaciofluvial, morainic, lacustrine, organic, and thermokarst sediments are the most common surficial materials.

2.2 Near-surface bedrock

Bedrock in this area is nowhere within a 100 feet of the surface and is not considered a viable source of highway borrow.

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1 The phrase "Quaternary sediments" is used throughout this report to describe what in most engineering reports is called unconsolidated materials, for the Quaternary sediments are in a frozen state and, as such, are hardly unconsolidated. Also, the underlying Tertiary strata are often no more consolidated than the overlying Quaternary sediments (or unconsolidated materials).

3. INUVIK - MP1005

3.1 General geology

Between Inuvik and MP1005 the highway alignment crosses the Caribou Hills. Tertiary and Cretaceous strata form the core of these hills. The boundary between the area directly underlain by Tertiary strata and that underlain by Cretaceous strata runs from the north end of the Reindeer Hills to Jimmy Lake. Although the Caribou Hills are covered by Quaternary sediments, much of the relief is a direct reflection of the bedrock surface.

The Quaternary sediments consist of varying thicknesses of morainal, glaciofluvial, lacustrine, and organic deposits. They contain abundant ice including massive icy beds. The hummocky nature of parts of the area is probably due to a combination of glacial depositional features and thermokarst activity.

3.2 Near-surface bedrock

Shothole logs, field examinations, and airphotos indicate that Tertiary or Cretaceous strata are near the surface in four areas: (a) an eastward extension of the Caribou Hills that the alignment crosses between MP995 and MP1005, (b) flat areas adjacent to Douglas Creek, (c) the higher hills south of Noell Lake, and (d) on benches adjacent to the rims of canyons just northeast of Inuvik.

4. EASTERN CARIBOU HILLS AREA

4.1 General geomorphology and geology

Between Hans Creek and Jimmy Lake much of the terrain is about 200 feet higher in elevation than areas to the north and south. This rise reflects near-surface Tertiary strata, which can be seen in many exposures. This broad ridge has been glaciated. During some stage of deglaciation, this broad ridge would have stood at the general level of glacial ice in surrounding areas and would have been subjected to scour and erosion by meltwater flowing east and northeastward parallel to the general glacial gradient. When terrain to the east and northeast became free of ice, the meltwater cut large spillways that dissect the ridge.

A variable thickness of glacial till, which forms a flat to gently rolling morainic plain, covers the Tertiary strata on the uplands. Some poorly drained depressions on the morainic surface contain peat. The Quaternary materials commonly contain excess ice in the form of ice lenses, ice wedges, and massive ice. In some cases where icy materials have been exposed and ice slumps (retrogressive-thaw flow slides) have developed, terraces or depressions have formed, i.e. the melting of the ice results in a depression of the surface.

The spillways that dissect the area have been partially filled with alluvium from small tributary streams and colluvium from erosion of the bordering escarpments. During postglacial time, the small creeks flowing in the spillways have incised and terraced their bottoms.

4.2 Bedrock

In this area the term "bedrock" has been applied to all Tertiary strata regardless of its degree of induration or consolidation. Localities that were visited in this area (RPW-1 through RPW-10) all indicate that unconsolidated and weakly consolidated sandstone is the most common sediment type in the area adjacent to the highway. Although no sections were found that were exposed sufficiently to examine the near-surface sequence in detail, clayey beds appeared to be interbedded with the sand under the colluvium at some localities. Also on some spurs along the edge of the spillways, such as at RPW-4 (Appendix 1; 32214-12), thin bands of iron-rich siltstone chips are present on the surface. RPW-7 (Appendix 1; 32214-10, 13) has interbedded clayey beds in its mid and lower parts. Covered intervals at RPW-7 in the lower part of this exposure also seem to be the source of large ironstone concentrations.

Large thicknesses of shale, siltstone, mudstone, and conglomerate are present in some sections along the western edge of the Caribou Hills along the East Channel of the Mackenzie River and on the eastern slopes of the Caribou Hills west of Parsons Lake, but they are a rarity in this area.

Although a shortage of time in the field and the poor exposures did not allow determination of local structural trends, the Tertiary strata is known to have a regional northwest dip. Glaciation, slumps, and the buildup of ground ice may have caused local flexures that are present. Regional trends indicate that the beds present along the western edge of the Caribou Hills along the East Channel north of Reindeer Depot would project above those that the highway traverses. Obviously they have been eroded away from the area that the highway traverses.

Continuity of beds within the Tertiary sequence is likely limited, which would explain the variations in the sequences from locality to locality. The degree of induration and consolidation probably varies even within unique stratigraphic units. The relatively well indurated sandstone present at

RPW-1 appears to be a rarity as no other outcrops of indurated sandstone could be located in the area. The possibility exists, however, that the Tertiary sediments are more highly consolidated and indurated some distance back from the surface exposures. The amount of ground ice that may be present within the sand no doubt depends in part on the porosity of the Tertiary strata, which is inversely related to the degree of induration and consolidation of the strata. Although massive ice has been found within the Tertiary strata of the Caribou Hills, the fact that exposed sandy units show no signs of thermokarst activity and that the well exposed upper sandy units at RPW-7, although not well indurated, appear free of excess ice, indicates that large volumes of near-surface Tertiary strata may be free of excess ice.

4.3 Nature and thickness of cover

Quaternary sediments in the area consist of peat and till on the uplands, and colluvium and alluvium on the sides and in the bottoms of the spillways. All contain variable amounts of ground ice.

Two areas exist where the thickness of the Quaternary sediments over Tertiary strata is probably negligible or shallow: (1) escarpments and (2) benches adjacent to the spillways (areas labelled as unit 2 on Figures 2 and 3). The benches owe their existence to one of two processes: (a) scouring of broad areas across the Caribou Hills by meltwater before the streams began to incise themselves and form the spillways or (b) removal of ice from the ice-rich sediments through thermokarst processes along the edge of the spillways.

On parts of the uplands having little or no relief, cover over the Tertiary strata can be expected to be between 10 and 20 feet, but may be thinner in some areas. Unfortunately, this cannot be determined simply from surface examination.

LEGEND

1A Escarpments; negligible to thin cover (0-10 feet) of colluvium on weathered Tertiary strata.

1B Escarpments; variable thickness (2-20 feet) of colluvium over weathered Tertiary strata.

2 Veneered Tertiary strata; cover of 0-10 feet of Quaternary sediments (till, colluvium, alluvium) on weathered Tertiary strata.

3 Quaternary sediments; 10-20 feet of till, outwash, colluvium, alluvium, or peat over Tertiary strata.

4 Quaternary sediments; 20 feet plus of till, outwash, colluvium, alluvium, or peat over Tertiary strata.

0 Peat; 5-15 feet

Figure 2 Airphoto of northern part of Caribou Hills area, showing expected thicknesses of Quaternary deposits.

LEGEND

1A Escarpments; negligible to thin cover (0-10 feet) of colluvium on weathered Tertiary strata.

1B Escarpments; variable thickness (2-20 feet) of colluvium over weathered Tertiary strata.

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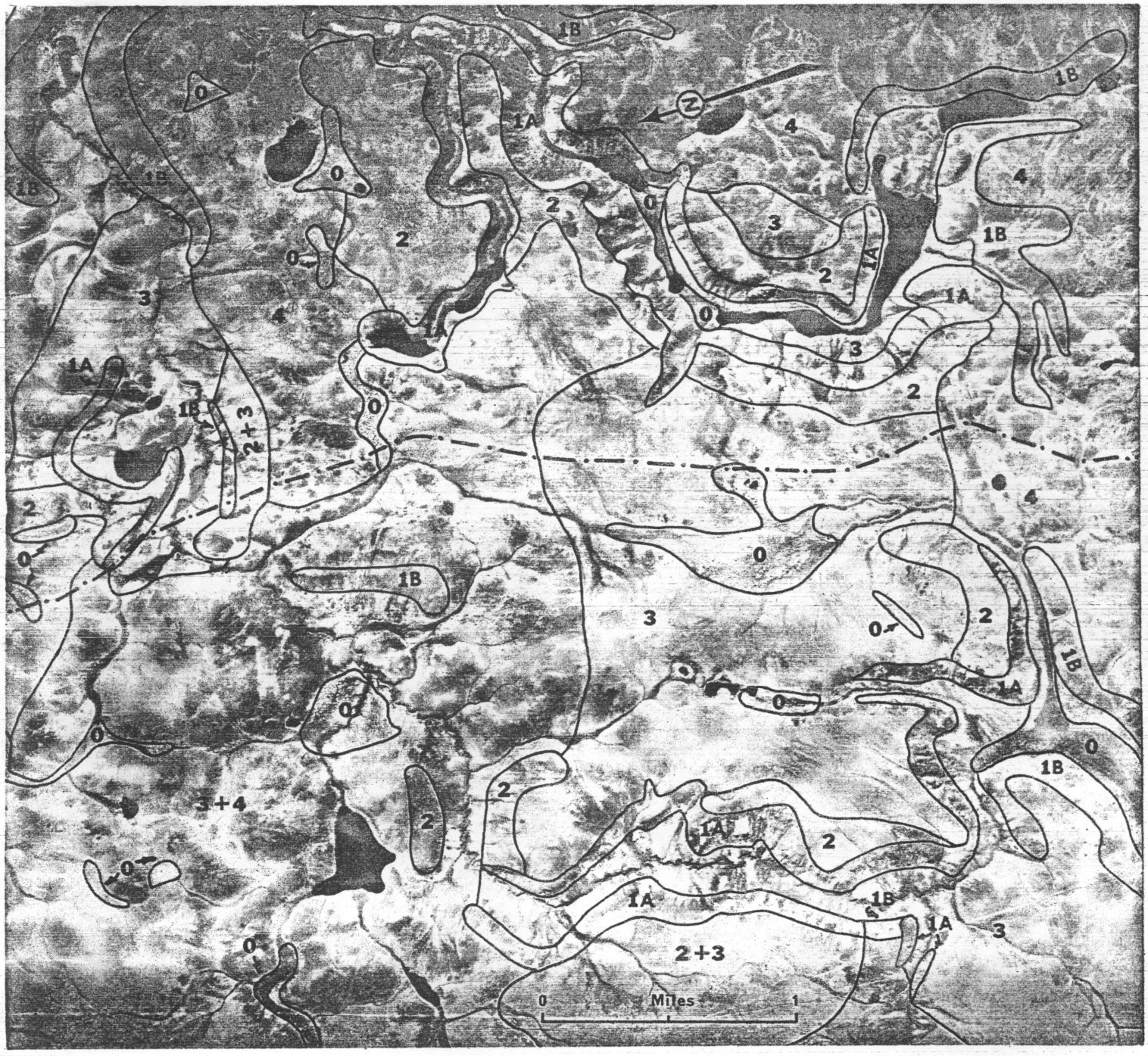


Figure 3 Air photo of southern part of Caribou Hills area, showing expected thicknesses of Quaternary deposits.

4.4 Recommended future investigations

If proximity to highway is the prime concern, isolated holes might be drilled to find the exact depth of ice-rich overburden in any areas labelled as unit 3 in Figures 2 and 3 near the highway alignment, specifically between MP997 and 1000. Areas of probable shallow cover near RPW-8 also deserve special attention for this reason. Some depth of Tertiary strata also should be drilled to determine its lithology and ice content.

Poorly indurated and consolidated sandstone definitely appears to be near the surface at RPW-8, RPW-9, and RPW-10. Exploratory drill holes such as those shown on Figure 4 at sites C to F should be attempted to determine the exact thickness of cover and nature of the Tertiary strata, i.e. its lithology and degree of induration. The results from one line of holes drilled perpendicular to the escarpment could be confidently extrapolated parallel to the escarpment.

If finer grained borrow is desired and is not found at shallow depths in any of the above locations, the shoulders at RPW-4 and RPW-5 might be drilled in a manner similar to that shown by locations A and B on Figure 4. Some volume of finer grained borrow may be available on these shoulders without removal of thick overburden.

4.5 Development

If borrow pits were developed along the rims of the spillways or on shoulders along their edges, some erosion of denuded Quaternary sediments or Tertiary strata is possible with siltation of the streams and lakes below. Most eroded material would be sand if the Quaternary sediments were thin and probably would be deposited on the alluvial fans and colluvial slopes along the edges of the spillways. Much of the finer grained deposits also would be trapped on the alluvial fans and colluvial slopes.

Minor amounts of sediment that might reach the small creeks would only temporarily increase the turbidity of these small streams. At RPW-9 some sediment might enter the lake immediately to the east. Only the lower end of the lake, however, would be temporarily affected, if it was at all. If the sediment reaching the lake were sand, it would soon settle and the turbidity would be increased for a very short time.

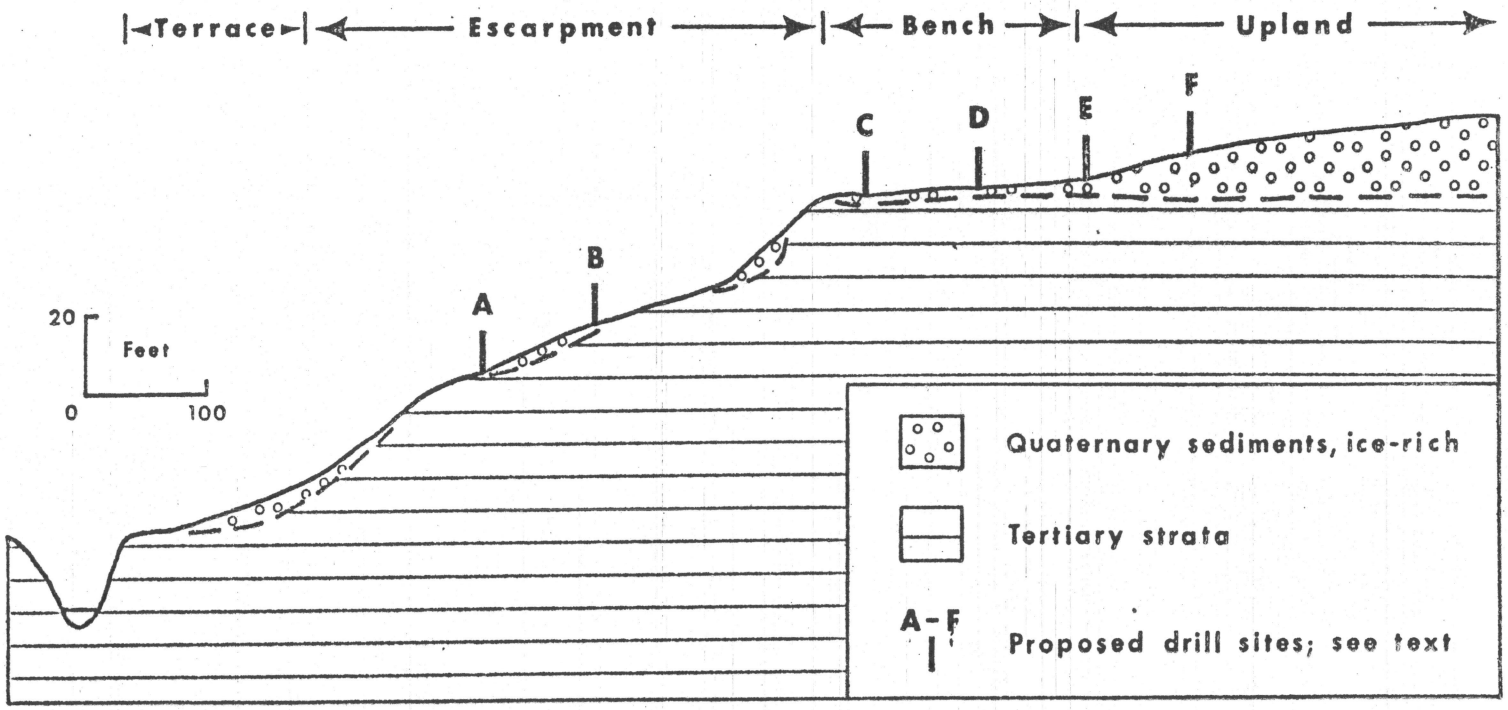


Figure 4 Schematic section across edge of spillway, showing areas that are likely to have a thin cover of ice-rich Quaternary sediments.

5. DOUGLAS CREEK AREA

5.1 General geomorphology and geology

On the flanks of the narrow canyon that has been incised by Douglas Creek, a relatively flat morainic plain is present which shows east-west trending curvilinear ridges (Fig. 5). In this area, thin till directly overlies late Cretaceous shale. Patches of lacustrine clays and silt, 2-8 feet thick, may overlie the till, and peat, 5 to 10 feet thick, fills most depressions. The total thickness of Quaternary sediments probably ranges from 5 to over 20 feet.

Small basins inset into the general level of the plain, especially on the southeast side of the creek, appear to have been formed by thermokarst expansion of a pond occupying the site. The pond subsequently has been drained.

5.2 Bedrock

Bedrock in this area is flat-lying shale of late Cretaceous age. The shale may contain a few bentonite beds. Regional structure indicates that the shale in the Douglas Creek area is younger than that in the DPW borrow pit between Inuvik and the airport. Thus identical lithologies are not to be expected.

Although fresh unweathered shale can be seen at the base of the canyon formed by Douglas Creek (Appendix 1, 32114-21), the upper contact is not exposed, and the exact nature of the near-surface shale and its ice content could not be examined.

5.3 Nature and thickness of cover

Quaternary sediments in this area appear to be relatively ice-rich as is indicated by ice slumps in surrounding adjacent areas. The thickness of the Quaternary sediments may be directly related to the amount excess ice within them as the thickness of Quaternary sediments over the Cretaceous shale in thermokarst basins (generally mapped as unit 2 on Figure 5) appears to be less than on the surrounding terrain, i.e. the ice has melted out of the sediments in the thermokarst basins during formation of the basins. Even though the sediments in the thermokarst basins have refrozen, excess ice has not developed within them to the same thickness as in sediments of the surrounding terrain.

In the area northwest of Douglas Creek, where the airphotos show a linear pattern, the cover of Quaternary sediments may be thin but a more exact estimate requires subsurface investigations.

5.4 Recommended future investigations

Drilling should be carried out in areas noted as unit 2 in Figure 5 in order to determine the exact thicknesses of Quaternary sediments as presented in Figure 6. Also drilling or trenching along the rim of Douglas Creek canyon should be carried out to determine the nature of the upper shale and its ice contents.

5.5 Development

Development of borrow pits mapped as unit 2 on Figure 5 would not seem to pose any problem. Any sediment that might escape into Douglas Creek would little affect the turbidity of the creek. Development of any area northwest of the creek would involve either crossing Douglas Creek canyon or going around its upper end. Crossing of the canyon may cause some engineering problems. Cuts would be necessary that may intersect icy sediments

or massive ice. This situation would require special engineering design to prevent periodic road blockage from mudflows associated with melting of icy sediments or massive ice.

Some ice-cored hills would have to be crossed between this source of borrow and the present preferred highway alignment. Thus, the access road would have to be designed according to standard procedures that would prevent any lowering of the base of the active layer.

LEGEND

1A Escarpments; negligible to thin cover (0-10 feet) of colluvium on weathered Cretaceous strata.

1B Escarpments; variable thickness (2-20 feet) of colluvium over weathered Cretaceous strata.

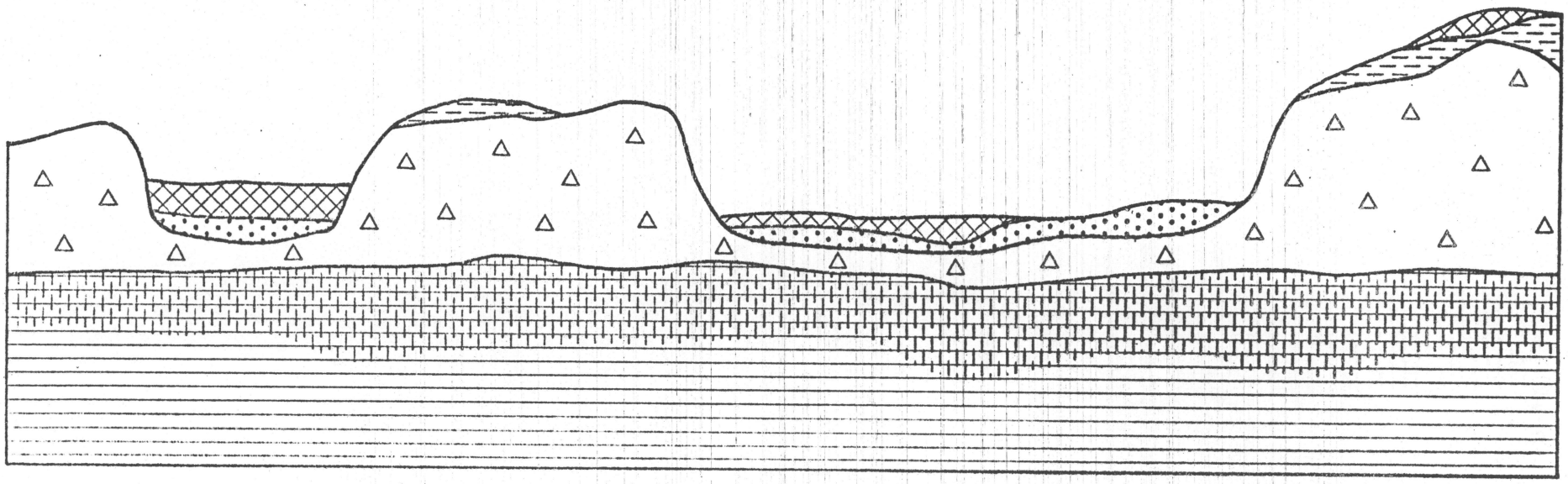
2 Veneered Cretaceous strata; cover of 0-10 feet of Quaternary sediments (till, colluvium, alluvium) on weathered Cretaceous strata.

3 Quaternary sediments; 10-20 feet of till, outwash, colluvium, alluvium, or peat over Cretaceous strata.

4 Quaternary sediments; 20 feet plus of till, outwash, colluvium, alluvium, or peat over Cretaceous strata.

0 Peat; 5-15 feet.

Figure 5 Airphoto of Douglas Creek area, showing expected thicknesses of Quaternary deposits.



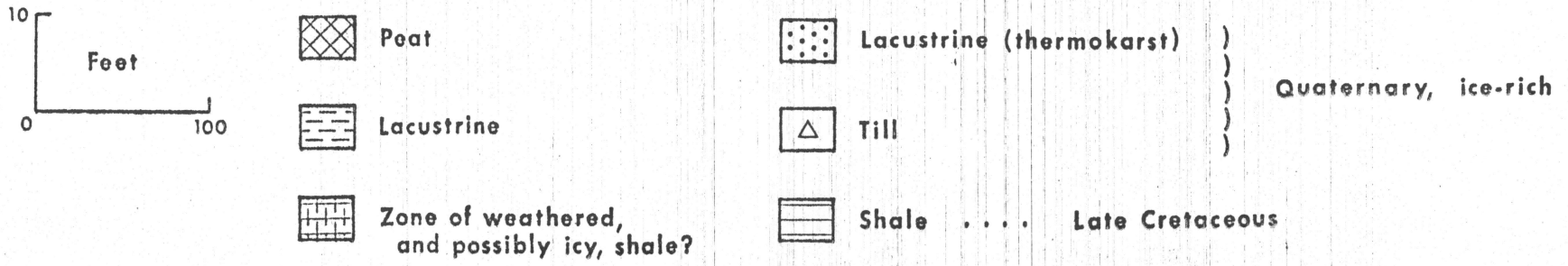


Figure 6 Schematic section of geology in Douglas Creek area.

6. NOELL LAKE AREA

6.1 General geomorphology and geology

Although the hummocky nature of the topography near Noell Lake is largely due to either the glacial origin of the surficial deposits or a combination of ground ice and thermokarst, some of the larger and higher hills have bedrock cores. Some hills are relatively bare of till; either they were areas of net scour during glaciation or else mass wastage has removed any glacial deposits that may have been left on their surfaces following glaciation.

As in the case of the Douglas Creek area, the shales making up the core of these hills are late Cretaceous in age, but are younger than those in the borrow pit at Inuvik.

6.2 Bedrock

Shale chips on the surface of the hills south of Noell Lake suggest that they are cored with shale that in part is relatively fissile. Siltstone and sandstone layers and bentonite beds are a possibility within the overall sequence.

Because of lack of exposure, some consideration must be given to the possibility that the upper part of the bedrock sequence may contain some icy beds.

6.3 Nature and thickness of cover

Although some hills appear to be free of glacial deposits, the shale is generally weathered at the surface, and colluvium is probably present on their flanks in areas mapped as unit 2 on Figure 7. In areas mapped as unit 3 on Figure 7, Quaternary sediments may be ice-rich and as much as 20 feet thick.

6.4 Recommended future investigations

Preferred sites of borrow within areas mapped as unit 2 on Figure 7 should be drilled to determine the exact nature and the ice content of the shallow bedrock. Drilling in areas mapped as unit 3 might be considered if haulage distance is of prime concern. Some areas of relatively shallow bedrock are probably present within unit 3.

6.5 Development

Development of this area should be relatively easy as slopes are available that should make pitting and pit drainage simple. The shale is probably not vulnerable to slumping or excessive erosion, and disturbance should be limited to the immediate pit area. A very slight risk exists of minor sedimentation of Noell Lake or the larger lake immediately south of it.

LEGEND

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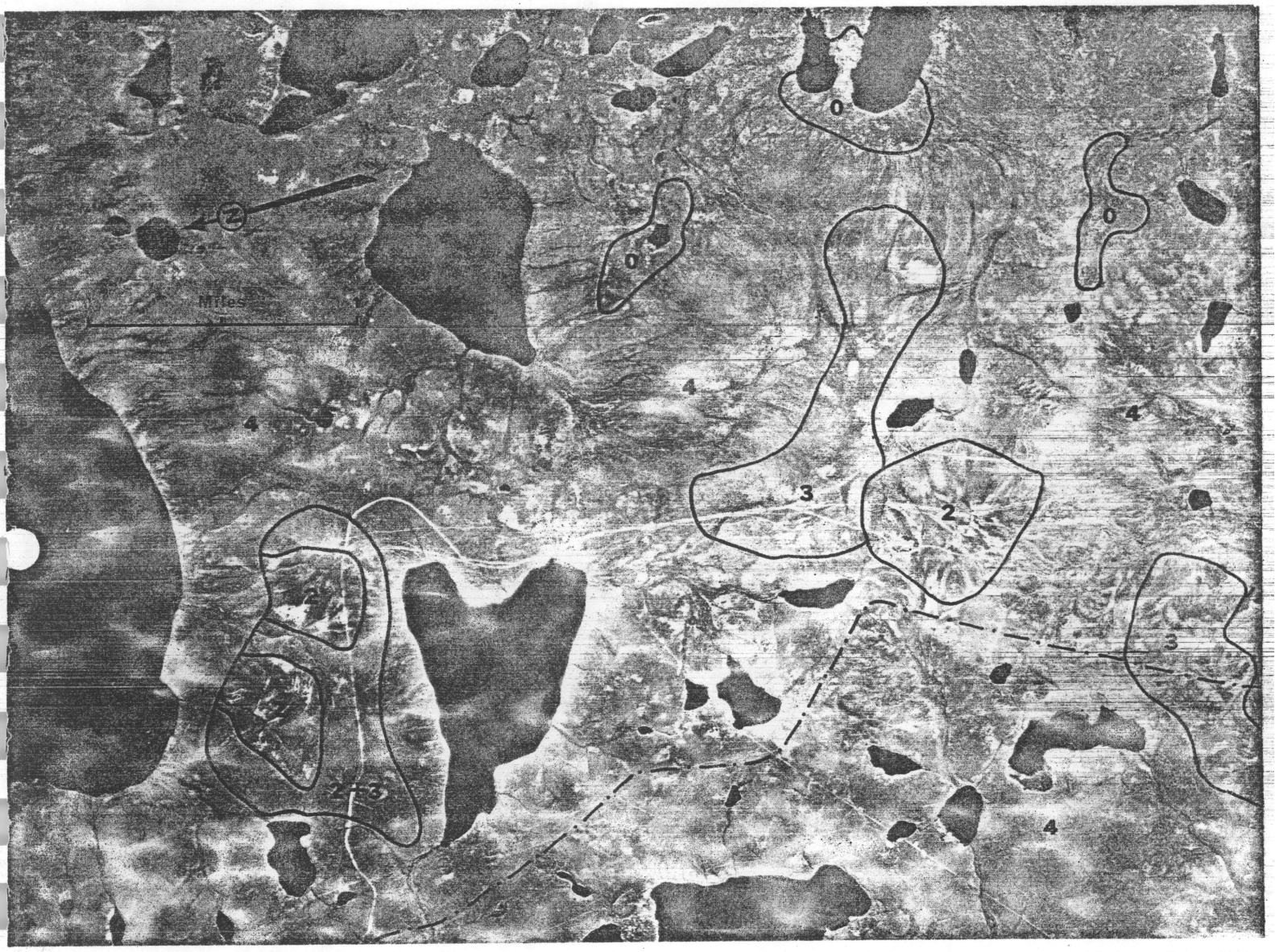

Figure 7 Airphoto of Noell Lake area, showing expected thicknesses of Quaternary deposits.

7. INUVIK AREA

7.1 General geomorphology and geology

Immediately east of Inuvik and continuing to the north, a bedrock-controlled escarpment is present between uplands to the east, associated with the Caribou Hills, and the modern Mackenzie Delta and adjacent terraces to the west. Both the escarpment and the narrow canyons cut perpendicular to it are probably preglacial features; the canyons have been re-excavated since glaciation. The uplands are covered by variable thicknesses of till and isolated patches of glacial outwash. The till contains an abundance of ice, in many cases massive ice. Excavation of the narrow canyons would have exposed massive ice and icy sediments along their upper rims. Ice slumps (retrogressive-thaw flow slides) would have formed in the ice-rich sediments and the faces would have retreated some distance back from the rims of the canyon. Mudflow debris, formed in the process, would have been deposited in the canyon bottom and on the benches adjacent to the rim.

At present a large number of shallow failures confined to the active layer are present along the canyons (Appendix 1, 32114-22). These are due to the recent fire, which has caused the active layer to thicken and shallow ice-rich sediments to melt.

Shales in this area are late Cretaceous but probably are still younger than those in the borrow pit south of Inuvik. Although they are not exposed in the immediate area, they are probably flat lying.

7.2 Bedrock

Unweathered shale is not exposed in this area, but is probably similar to that exposed along Douglas Creek. The upper contact is nowhere exposed, but an upper weathered zone containing some ice is possible.

7.3 Nature and thickness of cover

Adjacent to some of the canyons and the escarpment east of Inuvik, benches are present where the Quaternary sediments are probably relatively thin, i.e. one to ten feet. The Quaternary sediments on these benches probably consist mainly of mudflow debris derived from weathered shale and clayey till. The ice content of the mudflow debris is probably variable, but is high enough, at least near the surface, to allow active layer detachment flows to develop.

The remainder of the area appears to be covered by relatively thick and ice-rich Quaternary deposits (unit 4 on Figure 8).

7.4 Recommended future investigations

To determine the thickness and ice contents of Quaternary sediments on the benches adjacent to canyons and escarpments in units 2 and 3 of Figure 8, drilling should be carried out at sites located similar to those shown on Figure 9.

Some drilling might be carried out on the slopes just north of MP972.5 as a narrow zone of shallow shale might exist near that point; it would reduce haulage distances for part of the highway.

7.5 Development

Borrow pits would best be located on benches adjacent to canyons or escarpments as the shallowest shale is probably present at these sites. Any erosion or slumping of sediment that might occur due to borrow pit development should not seriously alter the regime of the small creeks flowing in the adjacent canyons

as they are carrying sediment from the shallow failures that were activated by the tundra fire of 1968. Redeposition of eroded sediment probably occurs on the fans immediately below the escarpment to the west before it reaches the Mackenzie River, which is already very turbid in any case.

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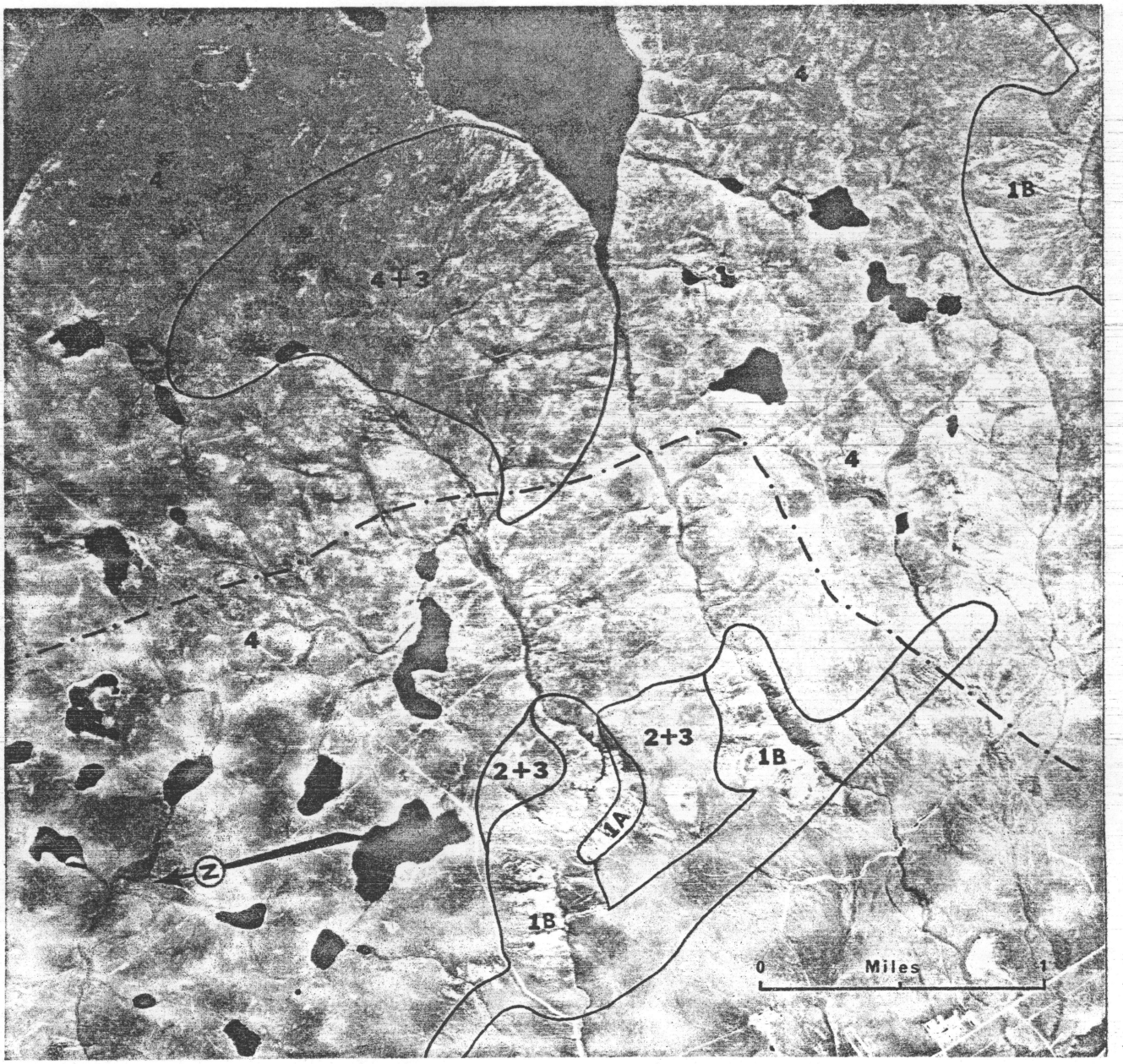


Figure 8 Airphoto of Inuvik area, showing expected thicknesses of Quaternary deposits.

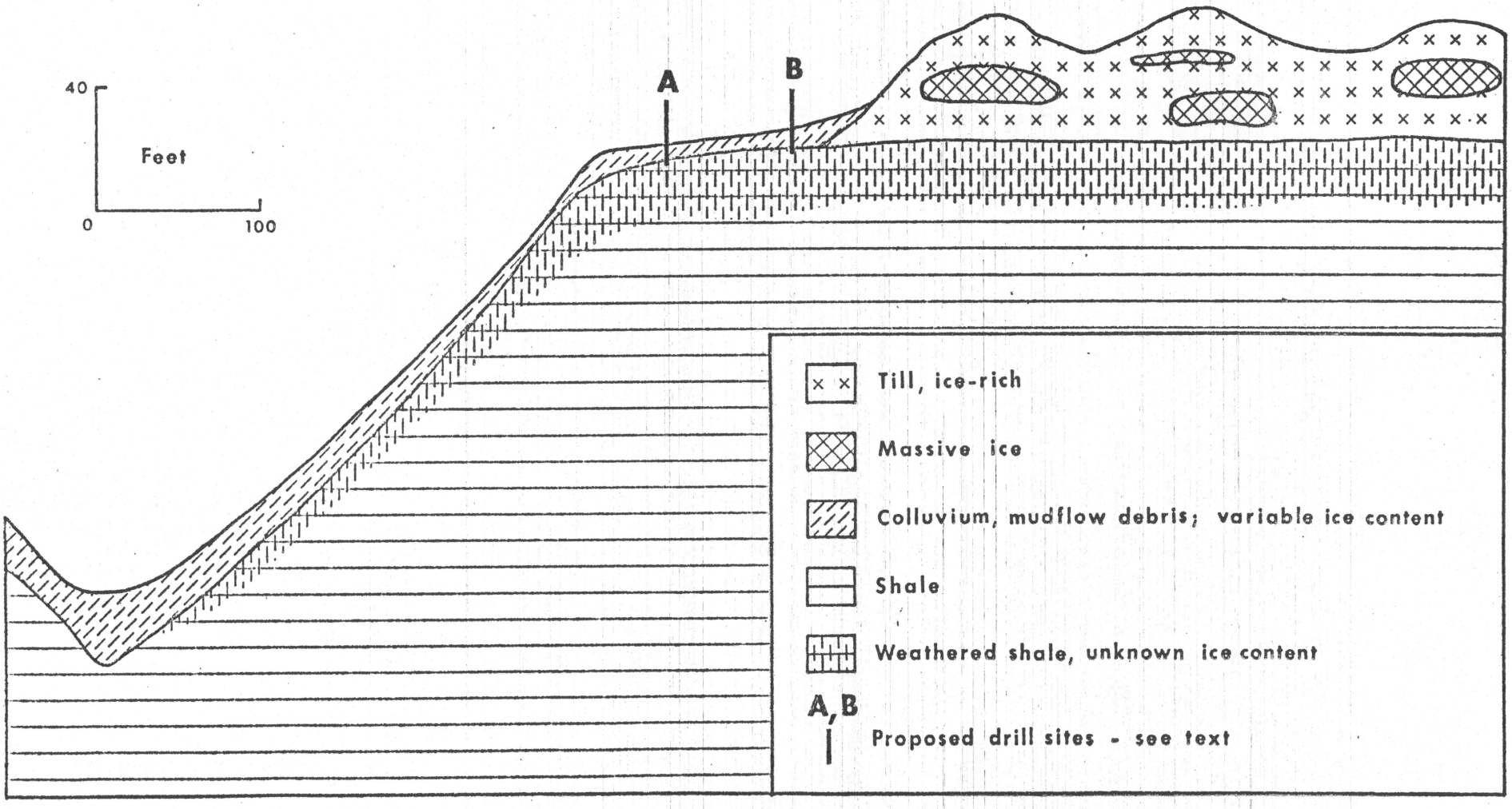


Figure 9 Schematic cross-section across canyon rim east of Inuvik.

8. SUMMARY

1. Near-surface Tertiary strata is present near the highway alignment between MP995 and 1005. The Tertiary strata appears to be mainly poorly consolidated to unconsolidated sandstone and may contain some ice.

2. Near-surface Cretaceous shale occurs adjacent to Douglas Creek, in the hills south of Noell Lake, and on benches adjacent to the canyons northeast of Inuvik. The exact depth to ice-free shales is not known at any of these localities, but is probably shallow.

3. Drilling programs outlined should indicate areas of shallow bedrock that would serve as adequate highway borrow.

4. Effects on the physical environment of borrow pit operations in any of the areas outlined should be minimal.

9. FUTURE INVESTIGATIONS

A slightly modified program, from that undertaken in this survey is recommended for future programs trying to delineate near-surface bedrock in permafrost areas. The following procedure might be best followed: (1) examination of published geological reports (bedrock and surficial) and preliminary airphoto analysis to locate potential areas of shallow bedrock; (2) field checking to collaborate results of airphoto analysis and to independently locate potential areas of shallow bedrock; (3) hammer-seismic or resistivity surveys of favourable areas; and (4) final location of shallow bedrock either by drilling or trenching. Locations of previously obtained geological and geophysical results should be carefully plotted to relate them to results of the drilling and trenching.

The type of geophysical operation carried out in item (3) depends upon the nature of the overburden and the bedrock type. For example, hammer-seismic can give relatively accurate depth determinations of contacts between icy sand and sand. Resistivity generally can detect the base of icy materials, but the depth determinations are not too accurate; drilling adds some control. Geophysical surveys should only be carried out where some geological input is applied in its planning, application, and interpretation.

10. RELEVANT LITERATURE

No published studies are available that describe in detail the bedrock or the subsurface configuration of the bedrock in the area of concern. Maps and papers that describe the surficial geology and that make passing reference to the general bedrock geology of the region are available and are listed below:

Dyke, L.D.
1975: Structural investigations in Campbell Uplift, District of Mackenzie; in Report of Activities, Part A, Geol. Surv. Can., Paper 75-1A, p. 525-532.

Fyles, J.G., Heginbottom, J.A., and Rampton, V.N.
1972: Quaternary geology and geomorphology, Mackenzie Delta to Hudson Bay; XXIV Internat. Geol. Congr., Guidebook A-30.

Mackay, J.R.
1963: The Mackenzie Delta area, N.W.T.; Can. Dept. Mines and Tech. Surv., Geograph. Br., Mem. 8.

Mountjoy, E.W.
1966: Upper Cretaceous and Tertiary stratigraphy, northern Yukon Territory and northwestern District of Mackenzie; Geol. Surv. Can., Paper 66-16.

Norris, D.K.
1974: Structural geometry and geological history of the Canadian Cordillera; in Proc. 1973 Nat. Conv., p. 18-45, Can. Soc. Exploration Geol., Calgary.

Rampton, V.N.
1972: Surficial deposits of portions of Mackenzie Delta, Stanton, Cape Dalhousie, and Malloch Hill map-sheets; Geol. Surv. Can., Open File 96.

Rampton, V.N.
1974: Surficial geology and landforms, Aklavik ($E\frac{1}{2}$); Geol. Surv. Can., Open File 119.

Rampton, V.N.
1974: Terrain evaluation with respect to pipeline construction, Mackenzie Transportation Corridor, Northern Part, Lat. 68°N to Coast; D.I.N.A., Environmental-Social Committee, Northern Pipelines, Report No. 73-47.

Yorath, C.J.
1973: Geology of Beaufort-Mackenzie Basin and eastern part of the Northern Interior Plains; in Arctic Geol., Am. Assoc. of Petr. Geol., Mem. 19, p. 41-47.

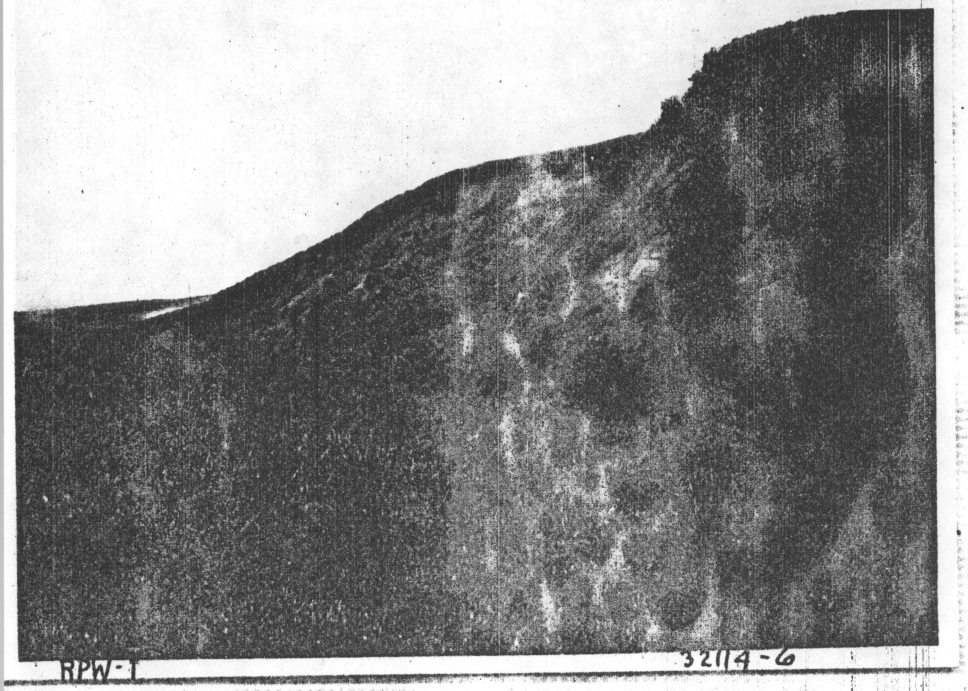
APPENDIX 1

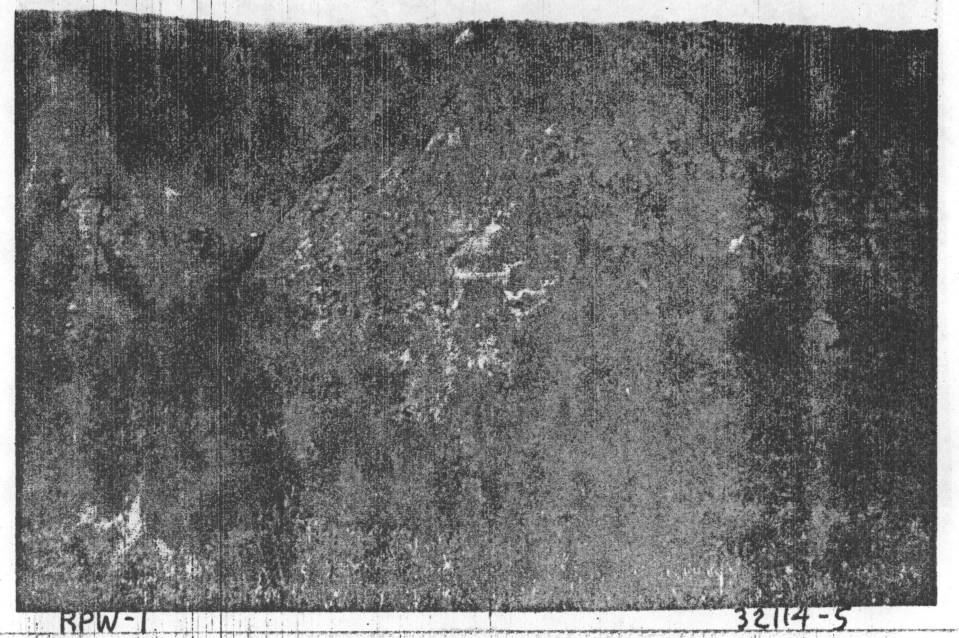
COLOURED PHOTOGRAPHS OF SITES

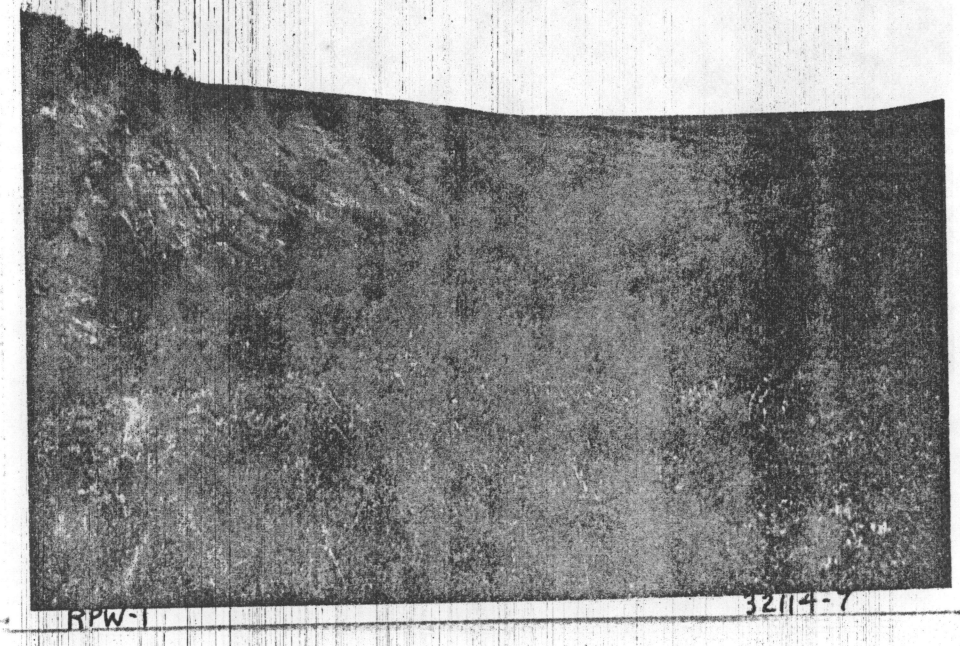
32114-6 Eastern end of outcrop of indurated Tertiary sandstone at RPW-1.

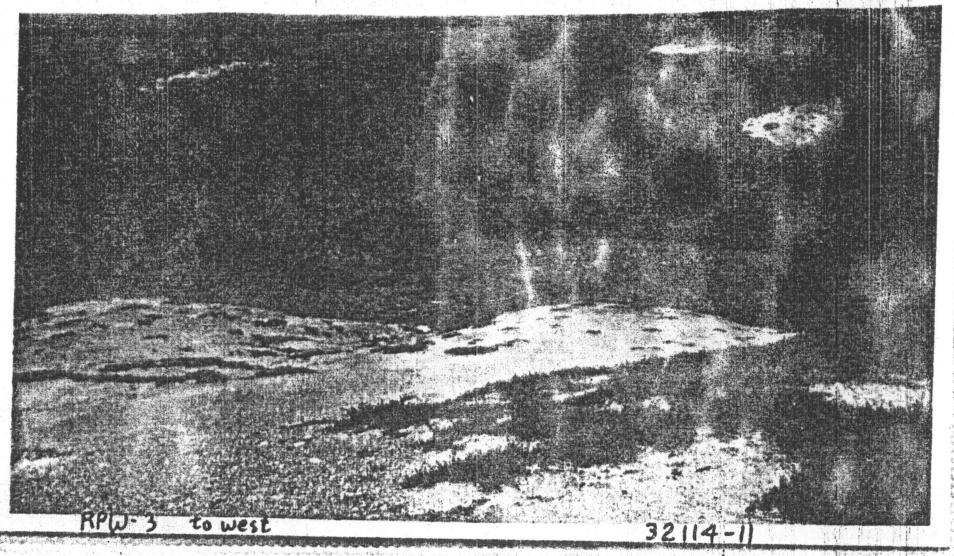
32114-5 Indurated Tertiary sandstone at RPW-1. About 2 feet of till-like material overlies the sandstone.

32114-7 Valley above at RPW-1 where indurated Tertiary sandstone outcrops.


RPW-1
32114-6

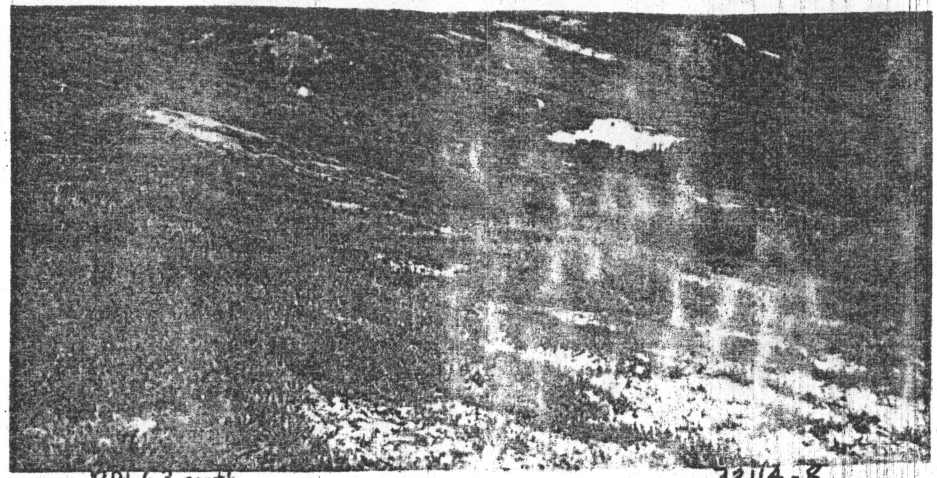

RPW-1
32114-5


RPW-1
32114-7

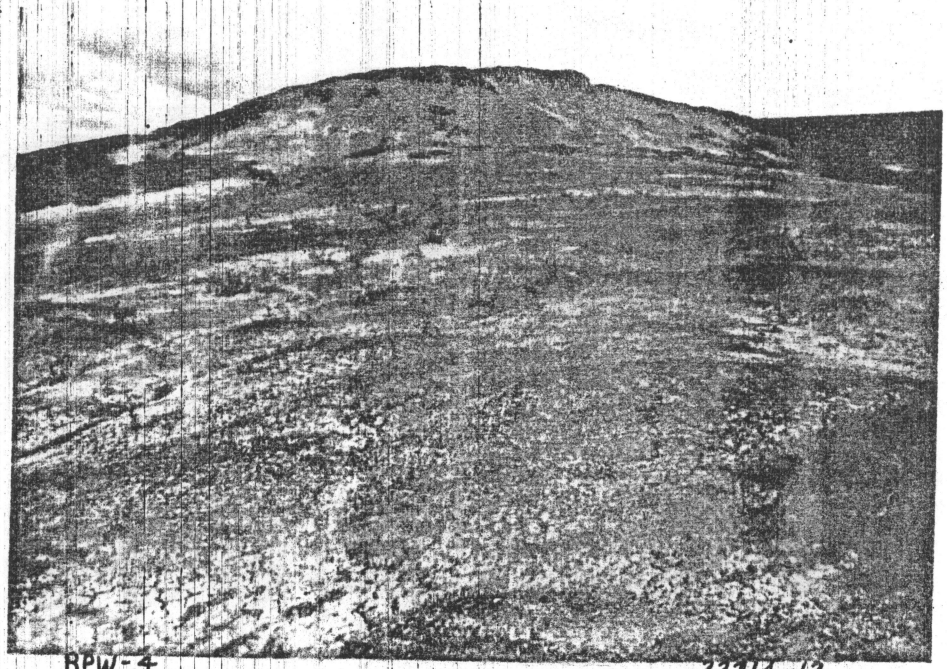


RPW-3 to west 32114-11

RPW-3 north 32114-9



RPW-3 south 32114-8



RPW-4 32114-12

32114-11 West escarpment along spillway opposite RPW-3. White areas are mainly sand.

32114-8 View south of RPW-3. Poorly consolidated and weathered Tertiary strata are exposed in "white areas". Cap of ice-rich Quaternary sediments is probably thin along upper edge of escarpment.

32114-9 View north of RPW-3 towards RPW-4. Bench above exposure appears to be relatively free of ice-rich Quaternary sediments. In background, break in slope, as traced by dashed line, indicates back of bench having thin cap of Quaternary sediments over Tertiary strata.

32114-12 Upper section at RPW-4. Unconsolidated Tertiary sand is present in steep part of exposure, whereas interbedded Tertiary sand and silt underlie bench in foreground. Orange-coloured band across bench is iron-rich siltstone chips.

32114-13 Exposure at RPW-7. Very weakly indurated Tertiary sandstones are present at the top of the exposure.

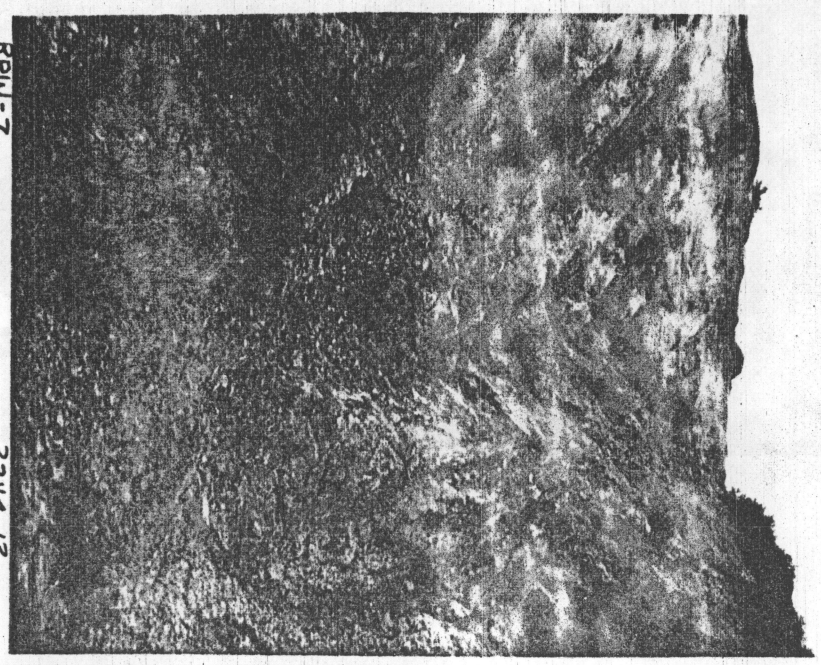
32114-14 Bench adjacent to spillway south of RPW-8. Benches may be free of ice-rich Quaternary cap near their outer edges.

32114-10 View across spillway to RPW-7. Present creek has entrenched itself into alluvium, colluvium, and Tertiary sediments in base of spillway. Cover over Tertiary sediments near rim of escarpment may be relatively thin.

32114-15 Bench adjacent to spillway to southwest of RPW-8. Benches may be free of ice-rich Quaternary cap near their outer edges.

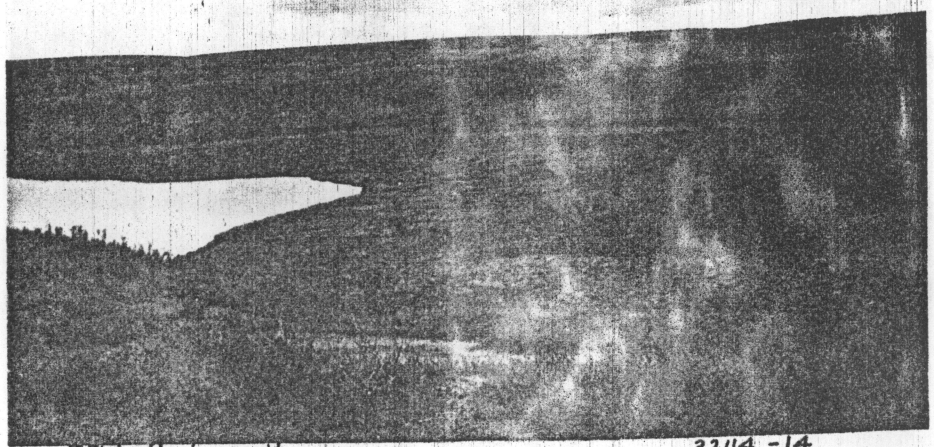
RPW-7

32114-13



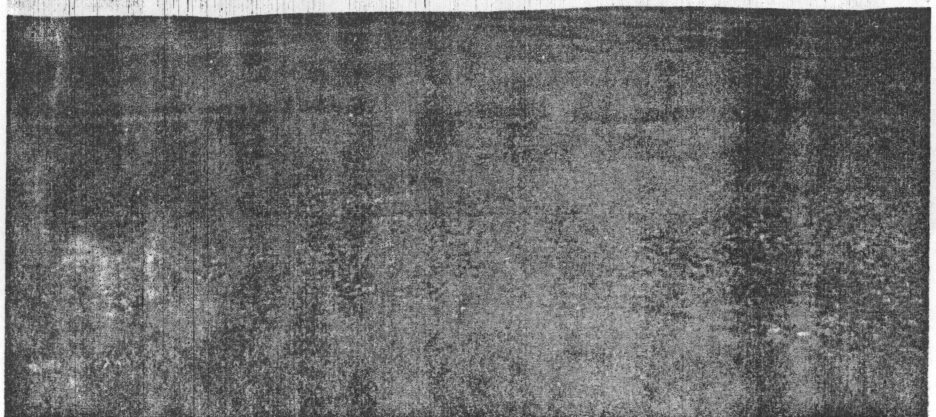
RPW-3 to west (RPW-7)

32114-10



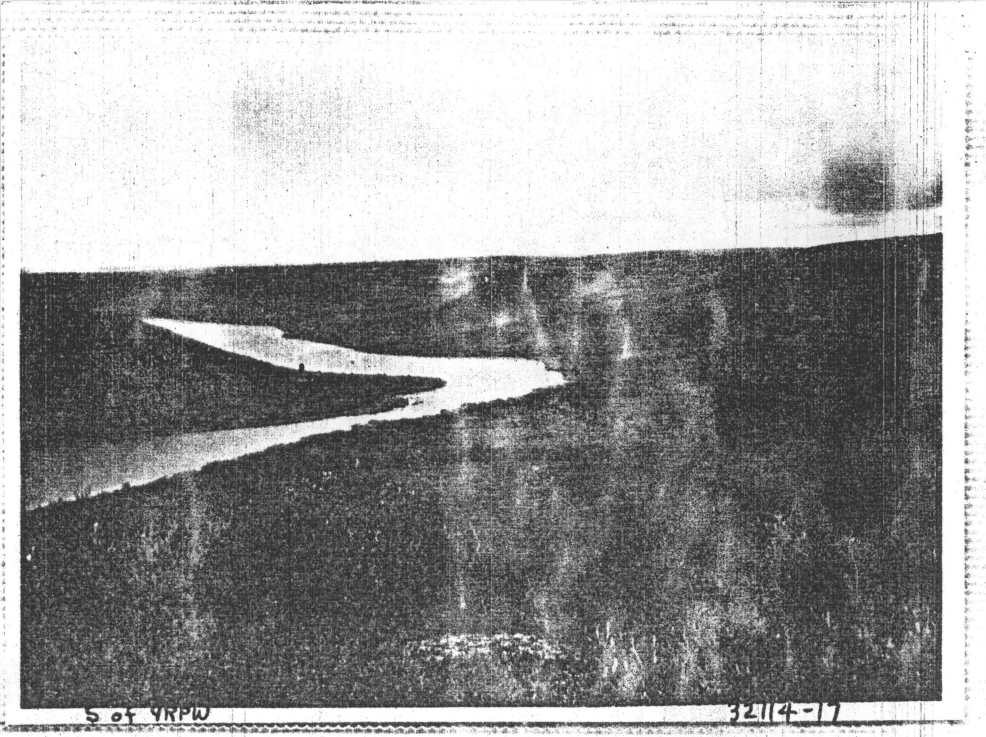
RPW-8 to south

32114-14

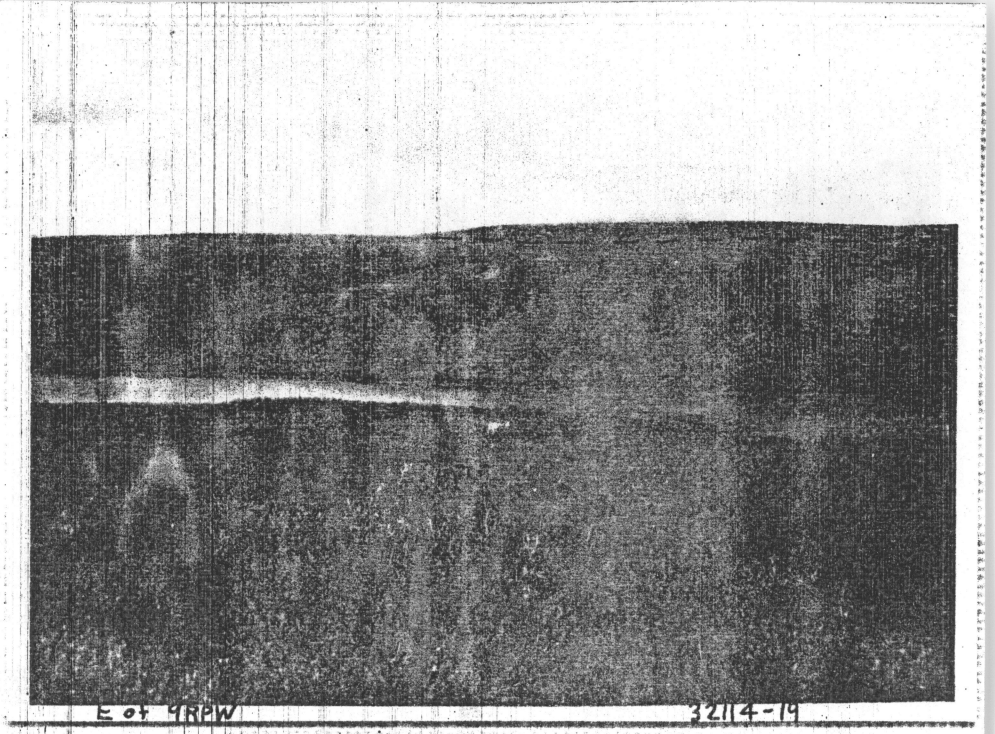


RPW-12 to southwest

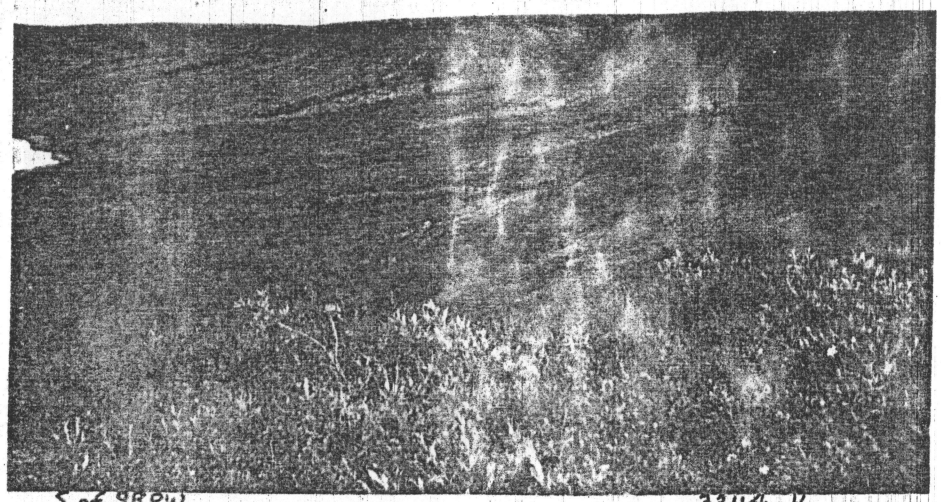
32114-15



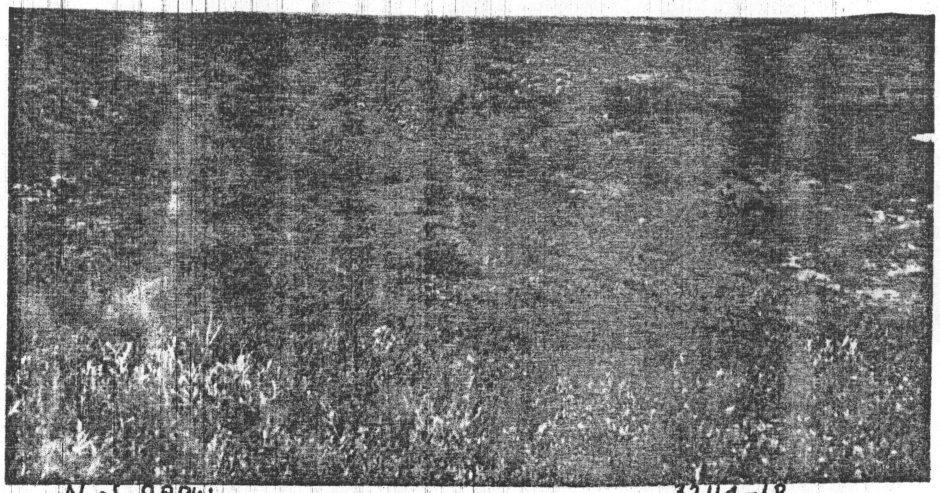
S of 9RPW 32114-17



E of 9RPW 32114-19



S of 9RPW 32114-16



N of 9RPW 32114-18

32114-17 Spillway south of RPW-9. Colluvium and alluvial fans can be seen along edges of lake. Spur in centre is free of cover of ice-rich Quaternary sediments.

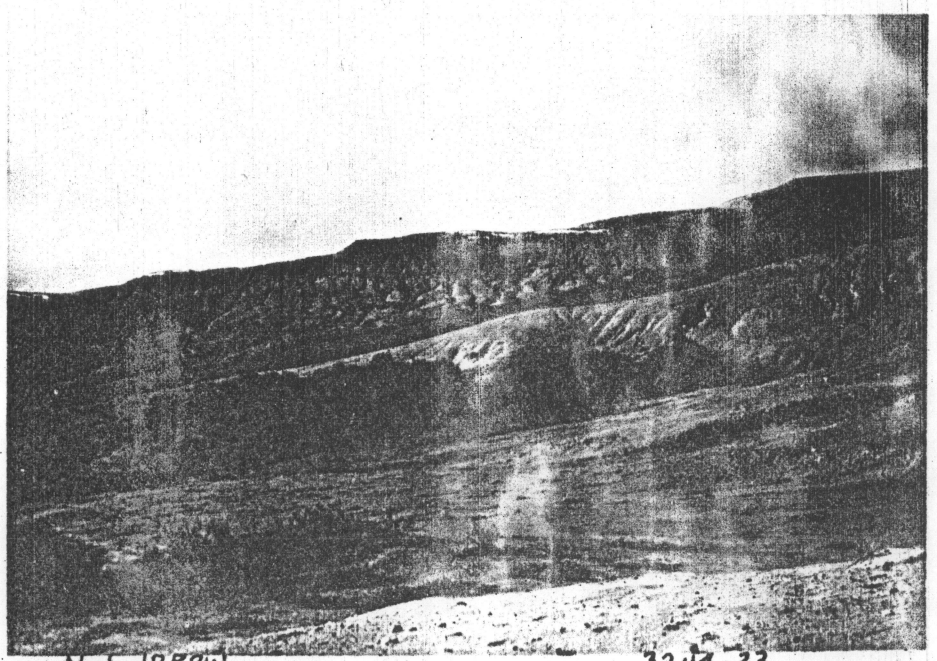
32114-16 Escarpment south of RPW-9 with morainal cover over Tertiary sediments on upper surface.

32114-19 East escarpment along spillway opposite RPW-9. Weathered Tertiary strata are exposed along escarpment. Helicopter is on an alluvial fan. Dashed line traces back edge of bench having thin cover of Quaternary sediments over Tertiary strata.

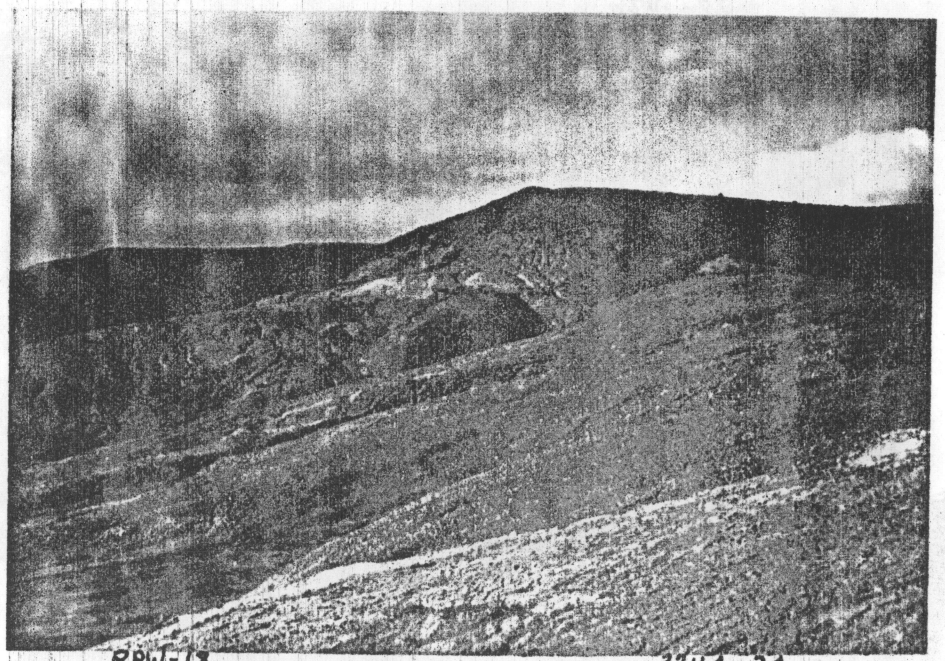
32114-18 Top edge of escarpment north of RPW-9 with small bench at lower level.

32114-23 Tertiary beds along the East Channel of Mackenzie River north of RPW-18.

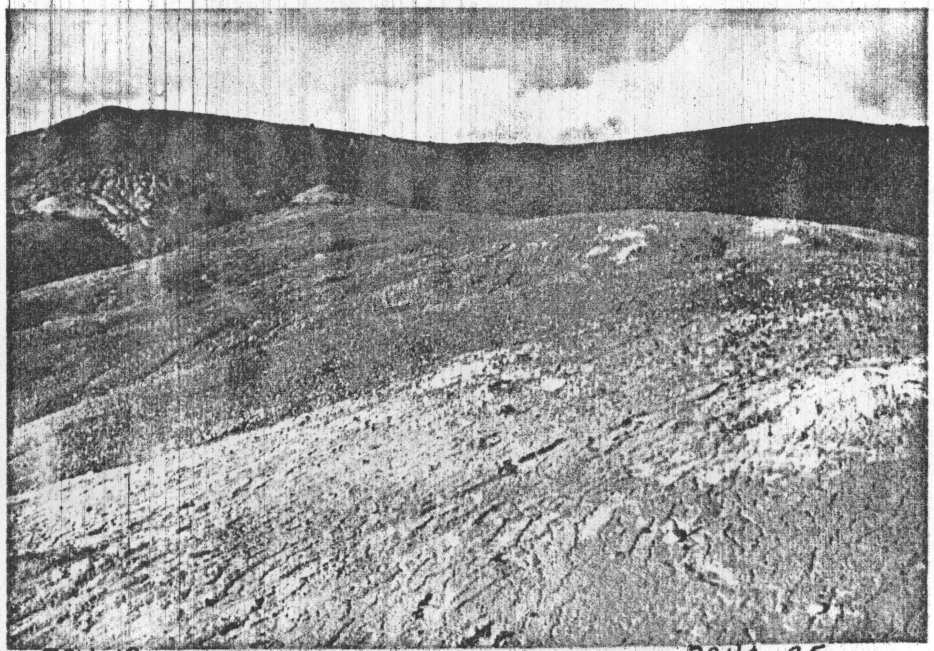
32114-24 and 32114-25 Tertiary sediments at RPW-18. Most of sequence is weathered sand, although clay, volcanic ash, and conglomerate beds are present.



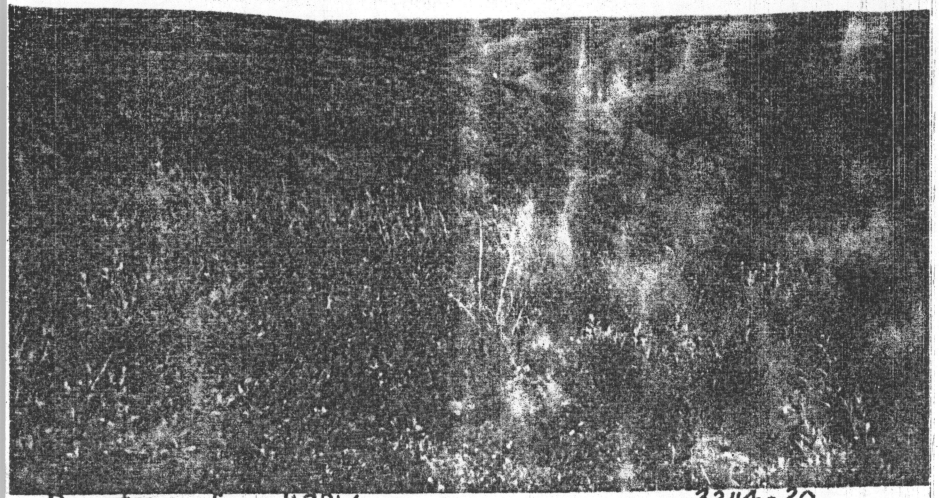
Not 18RPW 32114-23



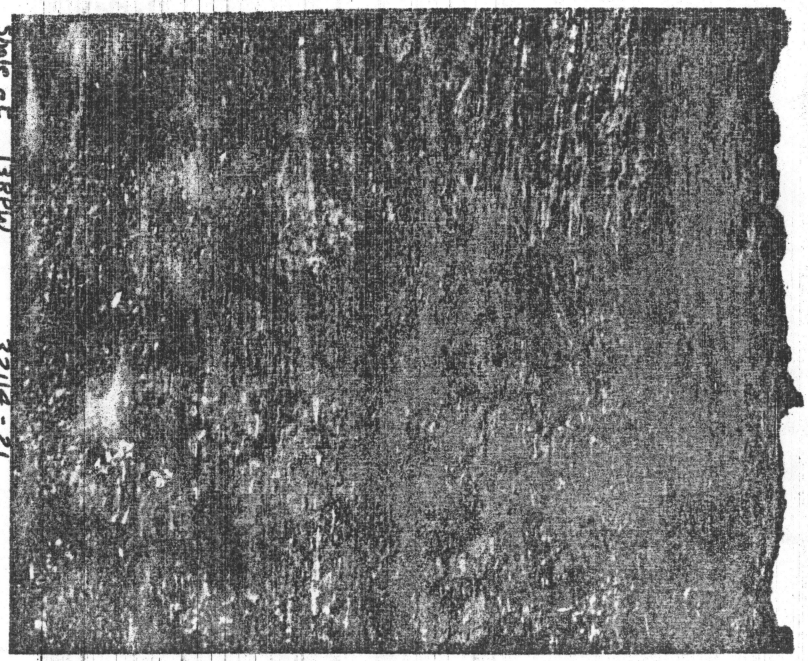
RPW-18 32114-24



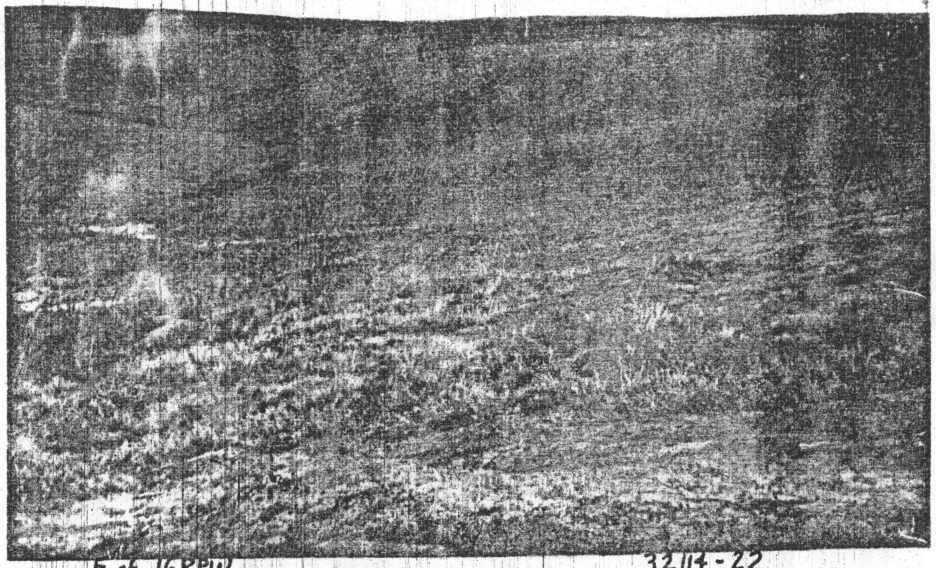
RPW-18 32114-25



Downstream from 11RPW 32114-20



Shale at 13RPW 32114-21



E of 16RPW 32117-22

32114-20 Narrow canyon cut in upper Cretaceous sediments, downstream from RPW-11.

32114-21 One hundred foot cliff at RPW-13 exposing 40 feet of upper Cretaceous siltstones and shales at base of cliff.

32114-22 Terrain to east of RPW-16. In foreground valley slopes are covered by active-layer slide material, which is mainly weathered shale.