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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 86

YUKON RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITES Nos. 34 AND 35

UPPER AND LOWER PORCUPINE CANYON DAM SITES

(MAPS AND PRELIMINARY REPORT)

BY

E. B. OWEN

OTTAWA

1964

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PORCUPINE CANYON SITES (UPPER AND LOWER)

Introduction

Upper and Lower Porcupine dam sites are alternate sites in the multiple stage power development proposed for McDougall Pass, some 285 miles to the east, in the Northwest Territories. The sites are located on Porcupine River in Yukon Territory about 7 and 10 miles respectively upstream from the Alaska-Yukon boundary. They are presently accessible from Dawson City, Yukon Territory, by proceeding downstream along Yukon River to Fort Yukon, Alaska and hence upstream along Porcupine River, a total distance of some 400 miles. The sites are about 250 air miles north of Dawson City. Except in stages of extremely low water, light aircraft can land on Porcupine River in many places near the sites.

The purpose of the dam is to divert Porcupine River water east to McDougall Pass. At the same time, the dam will prevent the westward escape of Peel River water diverted north through Eagle Plain by a large dam located on Peel River at Aberdeen Falls. This latter site is described in Topical Report No. 83.

The elevation of Porcupine River at the Upper site is about 750 feet whereas the water in Summit Lake at the west end of McDougall Pass over which the diverted water will flow is about 1,029 feet above sea level. Consequently the minimum height of a dam constructed at this site will be in the order of 280 feet. The difference in elevation in the level of the water in Porcupine River at the Upper and Lower sites is about 13 feet. Consequently the minimum height of a dam built at the Lower site will be a few feet higher than at the Upper site.

The reservoirs created at either site would be large. They would cover an area of several hundreds of square miles and extend as far east as Summit Lake. Old Crow Plain would be inundated as well as the valleys of several small streams tributary to Porcupine River.

Bell site, an alternate to the Porcupine Canyon sites, is situated on Porcupine River about 11 and a half miles downstream from the mouth of Bell River. The construction of a dam at Bell site would mean the water in the streams flowing into Porcupine River downstream from the site would be lost to the project. However, with the exception of Old Crow River, the volume of water entering this part of Porcupine River is not large and its loss would have little effect on the total amount of hydroelectric power produced by the project.

General Description

Porcupine River has its source in the Ogilvie Mountains. It flows first in a northerly direction across a wide, shallow depression described as Porcupine Plain[1] and then curves to the west to pass along the north edge of the Porcupine Plateau. It crosses the Alaska-Yukon Territory boundary close to the 67°30' parallel and finally joins Yukon River in Alaska about 130 miles southwest of the boundary.

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[1] Bostock, H.S. : Physiography of the Canadian Cordillera, with special reference to the area north of the fifty-fifth parallel; Geol. Surv. Can., Mem. 247, 1948, p. 75.

Throughout most of its length Porcupine River is north of the Arctic Circle. In general it is a slow moving, meandering stream that can be navigated without difficulty.

Bedrock is exposed along both sides of Porcupine River almost continuously for a distance of about 16 miles upstream from the Alaska-Yukon Territory boundary. In places it forms steep bluffs which rise to heights as great as 300 feet above the river. This rock-walled canyon is known as the Ramparts. It continues for many miles along Porcupine River downstream from the boundary.

Both Upper and Lower Porcupine Canyon dam sites are located in the Ramparts. The Upper site is about 6 miles downstream from the head of the Ramparts and the Lower about 3 miles further downstream. Bedrock which is exposed in that part of the Ramparts located in Yukon Territory consists almost entirely of sedimentary rocks which in places have been intruded by large, irregular dikes of fine- to medium-grained, grey to black diorite. None of this intrusive rock is visible at either of the Porcupine Canyon sites. The nearest is about 2 miles downstream from the Lower site.

At both sites Porcupine Canyon is flowing in a southwest direction between steep rock bluffs which vary in height from 250 to 300 feet. Bedrock is exposed on about 60 per cent of the bluffs; the remainder is covered with a thin veneer of talus and residual soil.

An undulating terrace covered with a thin deposit of badly weathered gravel occurs above the walls of the canyon along both sides of the river. In general this terrace has a reverse gradient of about 2 feet per mile in a direction opposite to the flow of Porcupine River. In places small streams flowing toward Porcupine River have cut narrow, steep-walled valleys into the terrace. Usually these valleys are located where the underlying bedrock consists of soft, easily eroded shale. They seldom extend back more than 2 miles from the river. Their gradients in the areas included by the accompanying geological maps are steep, ranging up to 1 in 4. These valleys are not interconnected and there is no place where reservoir water could flow through them to by-pass either dam.

At the Upper site a terrace, 400 to 500 feet in width, occurs in the right wall of the canyon about 250 feet above the river. This terrace extends to the toe of a small, steep bluff, some 50 feet in height, above which the more extensive terrace occurs. As in the case of the latter, the lower terrace is also covered with a thin deposit of highly weathered, coarse-grained gravel.

Another terrace probably formed by Porcupine River when it flowed at a higher elevation occurs along the left side of the river in the downstream part of the Upper site. This terrace varies in width from 100 to 300 feet and is covered with a thin deposit of relatively fresh silt, sand and gravel. The maximum elevation at which the material occurs is about 805 feet or about 50 feet above the present river.

The average width of the river at the Upper site is 650 feet and at the Lower site about 700 feet. The temperature of the water about 12 inches beneath the surface was 13.6 degrees centigrade (June 18, 1962).

Unconsolidated Deposits

Three types of unconsolidated deposits were identified at the two proposed dam sites. A fourth deposit consisting of Recent alluvium is also present. However, at the time of the investigation the river was at a high water stage and very little of this material was exposed.

1. Talus: Talus is the deposit of loose rock fragments lying on and along the bottoms of the walls of the canyon. It is the result of the mechanical disintegration of adjacent bedrock. In general it consists of small fragments of bedrock ranging from sand-size particles to sharp-edged, flat-sided cobbles up to 6 inches in diameter. In localities where the source rock is more massive the fragments range up to 24 inches. Mixed with the talus are small quantities of silty, sandy, residual soil produced by the decomposition of the more shaly bedrock and of rounded cobbles and boulders, chiefly grey sandstone, which have slumped from the gravel deposit covering the terrace above the bluff.

2. Alluvium: This material was probably deposited by Porcupine River when it flowed at a higher elevation. It occurs only on a sloping terrace located along the left side of the river in the downstream part of the Upper site. The material consists of silt, sand and gravel containing boulders up to 12 inches in diameter. Scattered bedrock outcrops on the terrace suggest it is a thin deposit directly overlying bedrock. The maximum elevation at which the material occurs is 805 feet or about 50 feet above the present river. The quantity of material available is small and it is doubtful if it has any use as a construction material.

3. Glacio-fluvial (gravel): This material consists of coarse-grained, sandy gravel containing minor quantities of silt. It is exposed along the tops of the bluffs at both sites as well as in many other places along the canyon. The greatest thickness observed was 6 feet. It is believed to directly overlie bedrock but because of the large quantity of slumped material present the contact was not observed. Test pits dug several hundred feet back from the canyon encountered the same material beneath 12 to 18 inches of moss and decayed organic material. It also occurs along the tops of the narrow valleys which have been cut by small streams tributary to Porcupine River.

The gravel-size rock fragments, which range up to boulders 12 inches in diameter, consist chiefly of fine-grained, grey to brown sandstone and quartzite. Many of the sandstone fragments are badly weathered and readily disintegrate when struck with a hammer. Weathering has also penetrated many of the harder, more resistant quartzite fragments to depths up to 1 inch.

Bedrock

General Description

Bedrock exposed at both sites consists of hard, fine-grained, grey to buff, calcareous dolomite with minor quantities of black, fissile shale. The dolomite varies from thin-bedded material to massive beds several feet in thickness. Thin interbeds of shale are frequently associated with the less massive dolomite beds but are absent in the thicker beds. Nodules and lenses of white or black chert are common throughout the dolomite. The lenses range up to 6 inches in thickness and 12 feet in length. The nodules are usually 2 to 3 inches in diameter.

The following geological section shows the relation of the various bedrock units exposed at the sites. The upper part of the section was measured in a small valley cut into the right wall of the canyon at the Upper site. The lower part was measured along the same canyon wall immediately downstream from the valley.

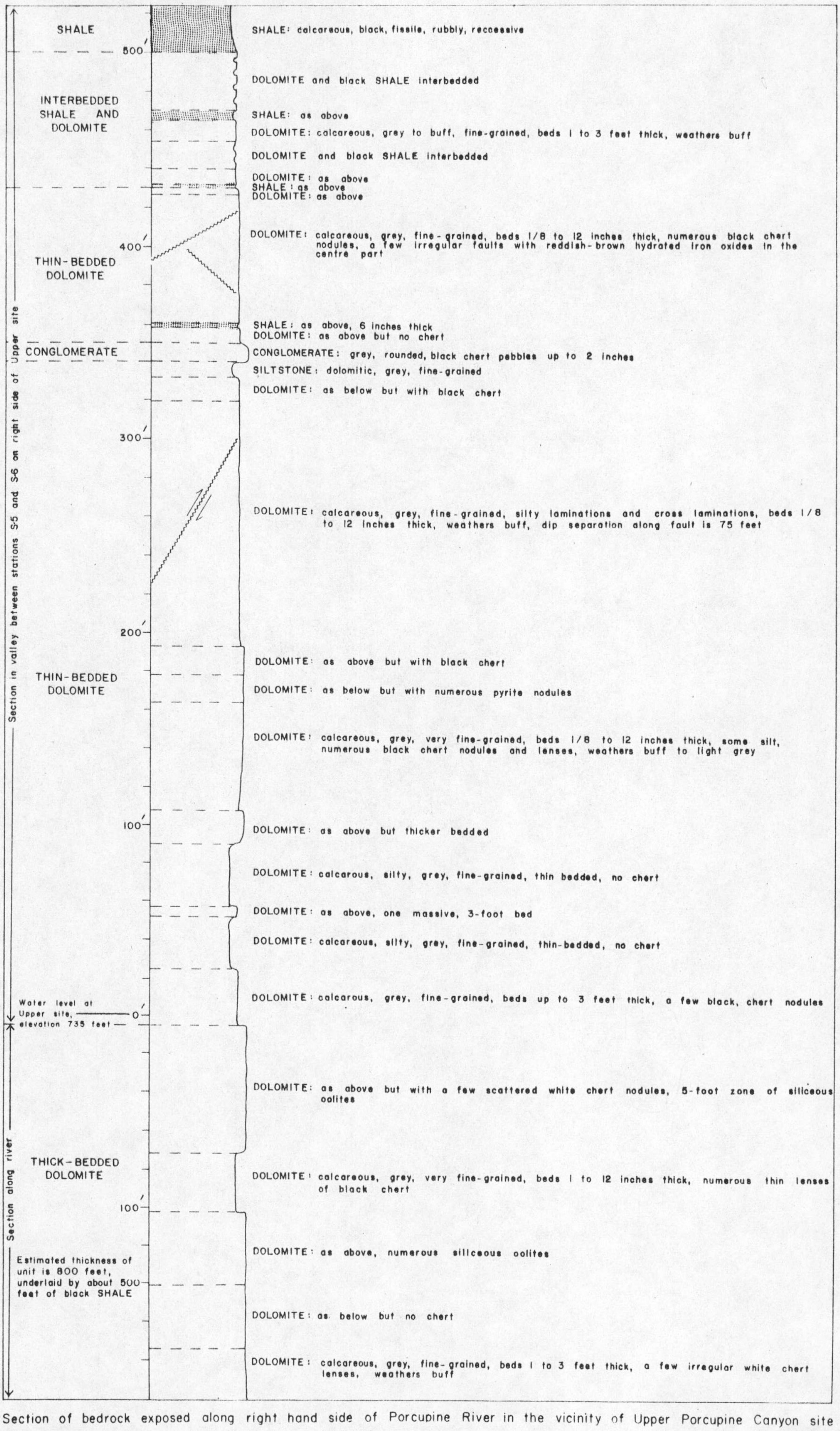
Several faults in the area may have had some effect upon the thicknesses of the various units. Consequently they may not be exactly as represented in the section.

The proposed centre lines at both sites have been located so that the abutments and foundations for the various structures will, for the most part, consist of the massive, thick-bedded dolomite which occurs in the bottom part of the section.

Bedrock Structures

Except for minor differences due to local undulations in the bedding the attitudes of the various bedrock structures at the two sites are much the same. Any difference in the effect of these structures on the abutments and foundations for the dams is due to the change in direction of the flow of Porcupine River from almost due west at the Upper site to southwest at the Lower. As a result the same structures intersect the river at different angles at the two sites.

In general the bedding strikes in a southwest direction and dips northeast at angles varying from 18 to 57 degrees. Consequently at the Upper site the bedding intersects the river at an average angle of about 60 degrees and dips downstream or into the right abutment. A small, north-plunging synclinal fold visible in the right wall of the



Section of bedrock exposed along right hand side of Porcupine River in the vicinity of Upper Porcupine Canyon site canyon in the centre part of the Upper site has resulted in a wide variance in the dip of the strata indicated on the accompanying bedding rosette. At the Lower site the bedding closely parallels the river and dips into the right abutment.

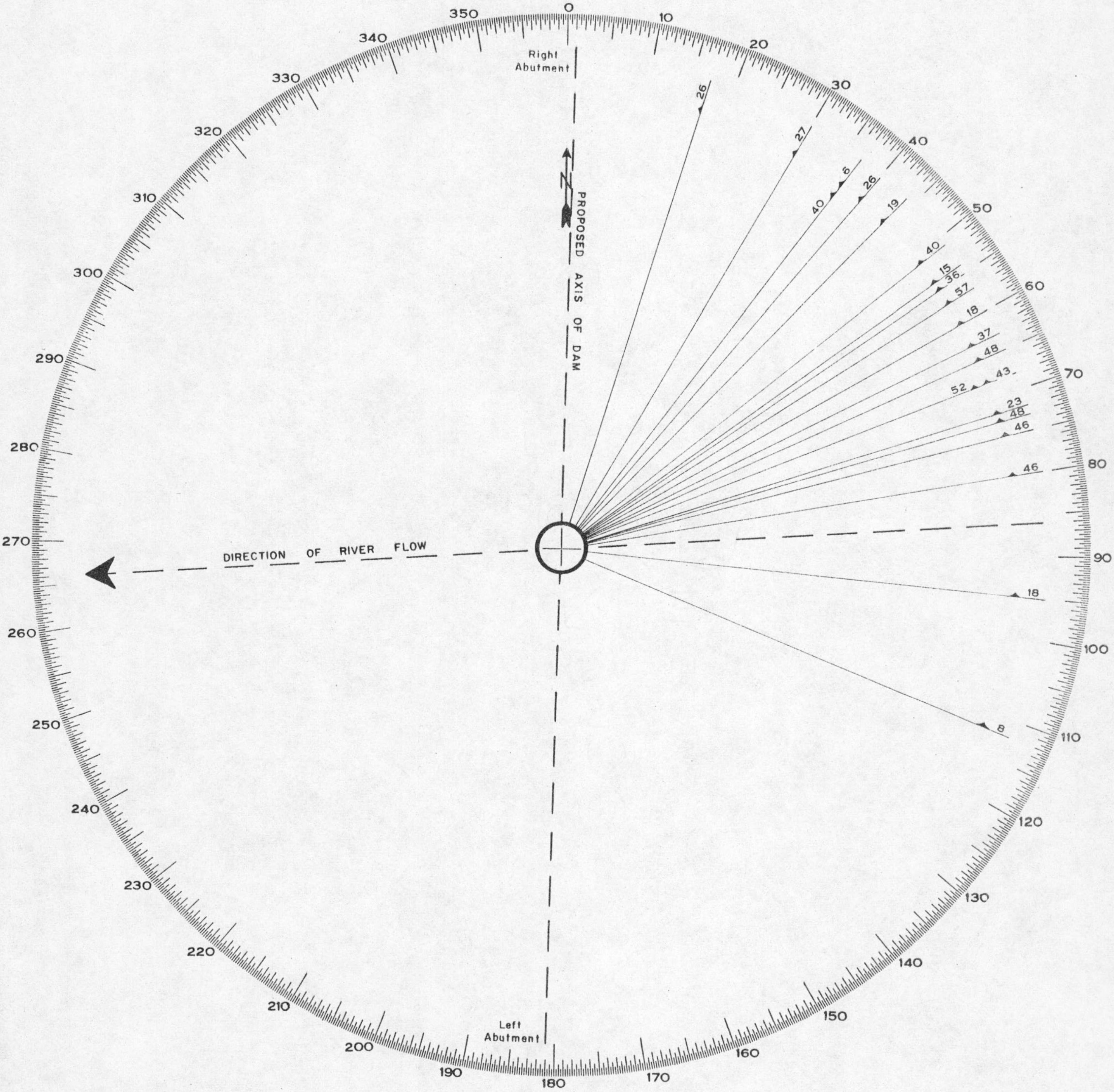
At both sites there is one prominent joint set as well as several minor sets with extremely irregular attitudes. At the Upper site the most prominent set intersects the river at angles between 40 and 60 degrees and dips steeply upstream. The dips of the other joint fractures at this site are also steep; the strikes, however, vary from almost parallel to the river to close to right angles. In general, the spacing of the jointing is close, ranging from 1 to 12 inches. However, it increases to 36 inches in the more massive dolomite beds. In areas of close jointing weathering has frequently penetrated bedrock for many feet. The weathered rock is soft, dark orange to buff in colour and disintegrates into small, angular fragments. At the Lower site the most prominent set intersects the river at angles between 10 and 30 degrees and dips steeply into the left abutment.

The most common type of faulting present at the two sites are bedding faults. These faults, the dip and strike of which are parallel to the strata, usually occur in a narrow interbed of shale situated between more competent beds of dolomite. The presence of slickensiding indicates some movement has taken place along these faults although the actual amount of displacement is unknown.

Two thrust faults parallel to the bedding (and hence to the river) occur at the Lower site. As indicated on the accompanying fault rosette they dip in the same direction as the strata but at a steeper angle. Several large, steeply dipping faults which intersect the river at angles between 10 and 60 degrees occur at the Upper site. One of these faults, indicated on the bedrock section which accompanies this report, is a reverse or thrust fault which has a dip separation of about 75 feet. Many of the other faults are also believed to be thrust faults. It was not possible, however, to determine the amount of displacement along them. The zones of broken rock associated with these faults are as much as 100 feet in width. Some of the small, narrow, steep-walled valleys in the walls of the canyon, which are frequently filled with talus, resulted from the removal of this shattered rock. One such valley occurs below station S-15 in the Upper site. The gouge in these faults varies considerably in thickness but is nearly always present. It consists chiefly of sandy clay often containing small angular fragments of the adjacent wall rock. The gouge is believed to be relatively impermeable but the permeability of the adjoining shattered rock mass is probably high. Many of the rock fragments in the fault zones are covered with a brown coating of iron-bearing carbonates and oxides which may have been deposited by circulating groundwater.

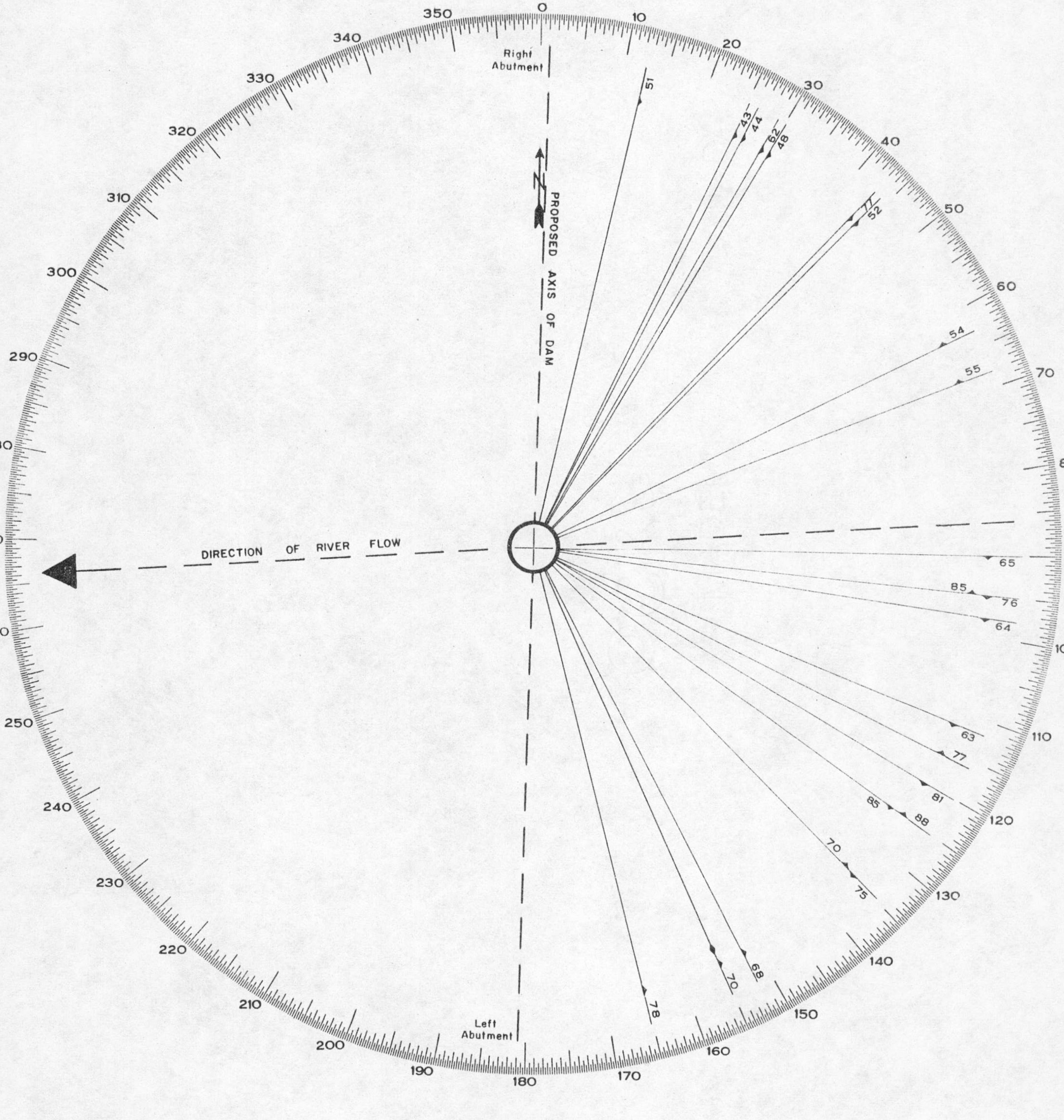
Quality of Bedrock

The most competent rock occurring at the sites consists of thick-bedded, calcareous dolomite which is exposed continuously in the bluff along the left side of the river and in some places along the right side. In some localities where close jointing occurs the surface rock is frequently highly weathered. Here as much as 25 feet of weathered material will have to be removed before fresh rock against which concrete or dike material can be placed will be exposed. It is believed the fresh rock is sufficiently competent to provide suitable foundation and abutment material for the dam structures.



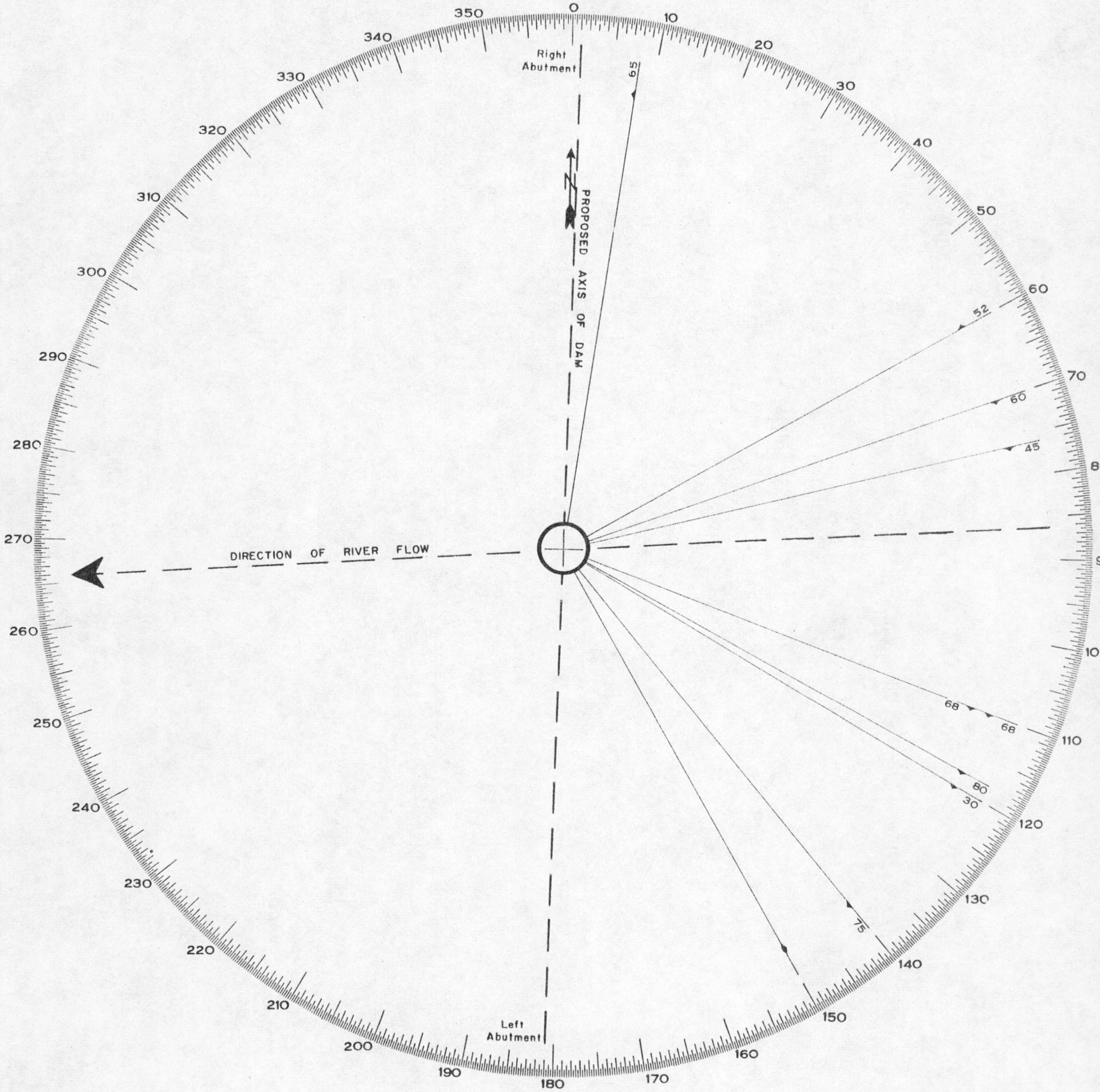
BEDDING ROSETTE

The above illustration presents diagrammatically the direction and dip of bedding in bedrock exposed at Porcupine Canyon site (Upper)



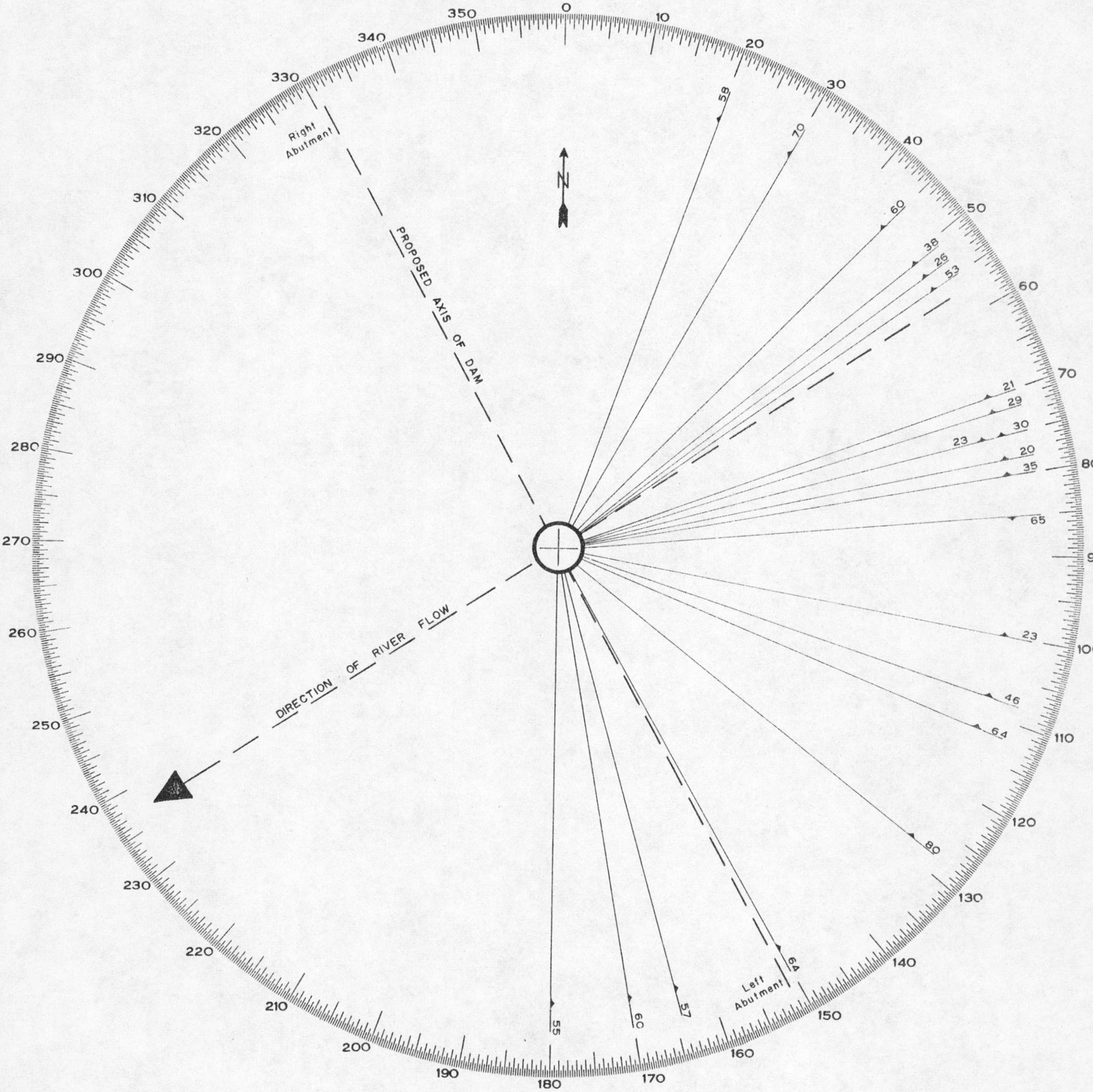
JOINT ROSETTE

The above illustration presents diagrammatically the direction and dip of jointing in bedrock exposed at Porcupine Canyon site (Upper)



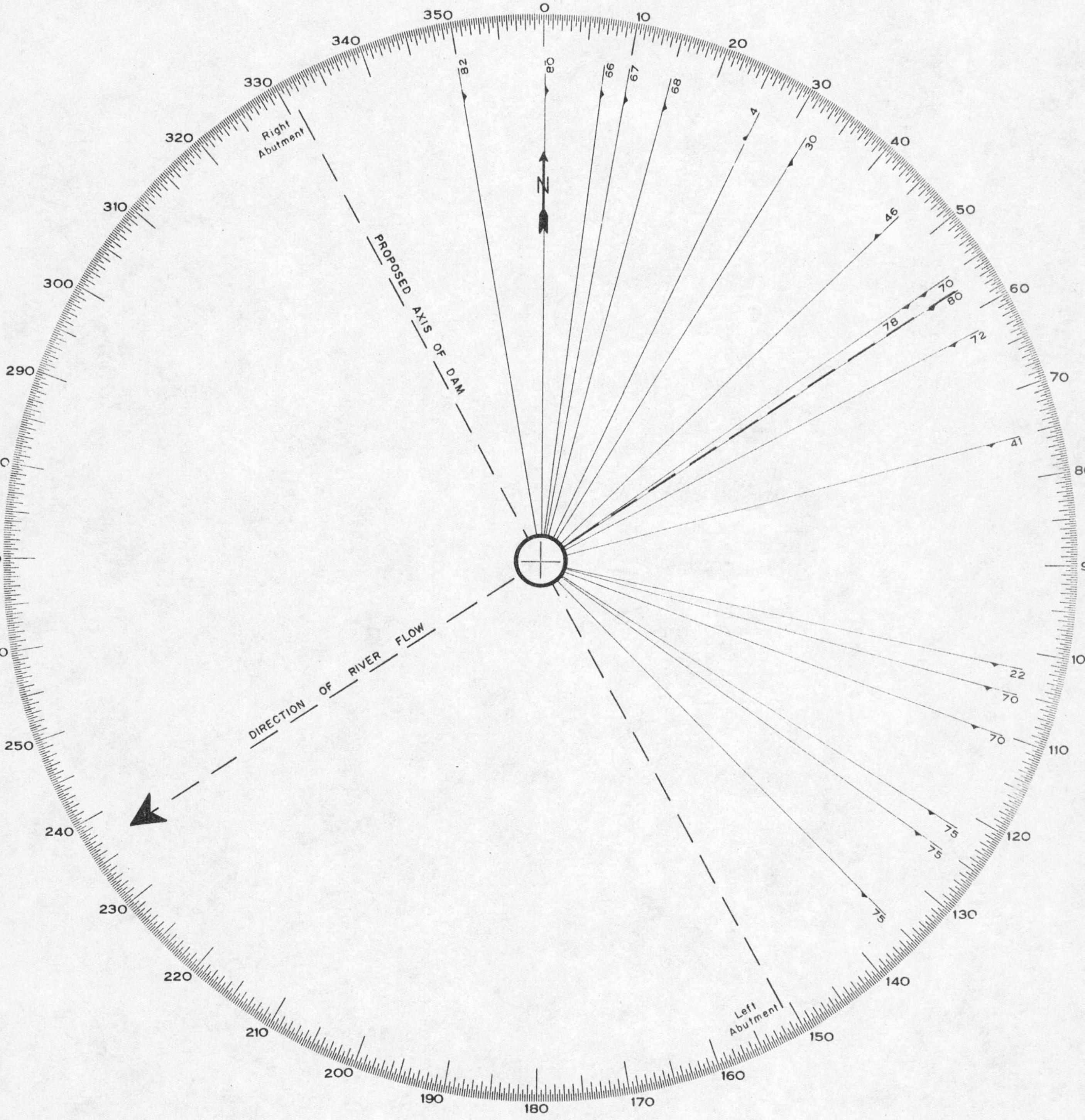
FAULT ROSETTE

The above illustration presents diagrammatically the direction and dip of faulting in bedrock exposed at Porcupine Canyon site (Upper)



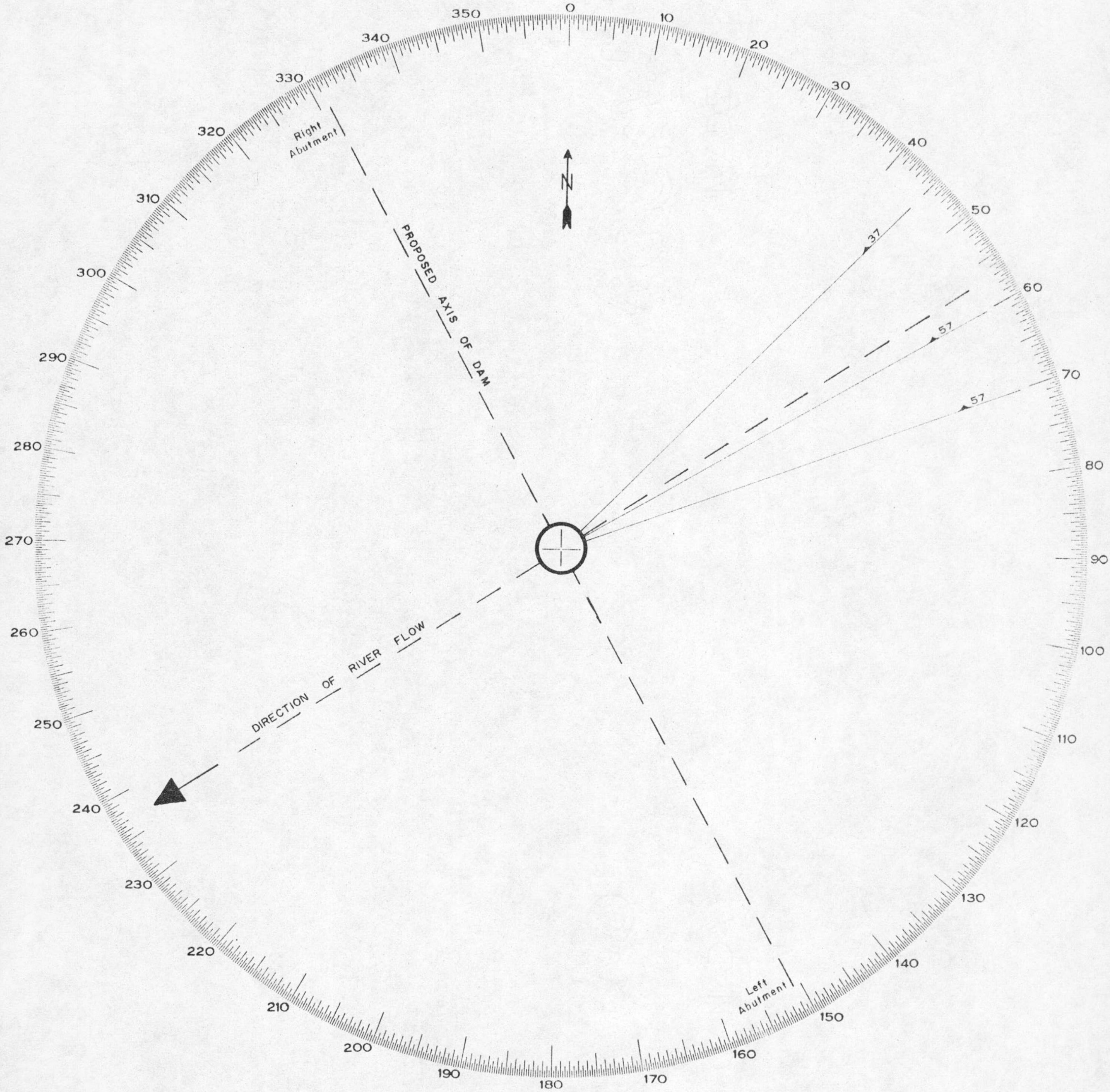
BEDDING ROSETTE

The above illustration presents diagrammatically the direction and dip of bedding in bedrock exposed at Porcupine Canyon site (Lower)



JOINT ROSETTE

The above illustration presents diagrammatically the direction and dip of jointing in bedrock exposed at Porcupine Canyon site (Lower)



FAULT ROSETTE

The above illustration presents diagrammatically the direction and dip of faulting in bedrock exposed at Porcupine Canyon site (Lower)

The thickness of the thick-bedded dolomite unit is about 800 feet. As indicated on the accompanying bedrock section it underlies a thin-bedded unit which contains narrow interbeds of shale along with minor amounts of siltstone and conglomerate. The rocks in the thin-bedded unit are not as competent as those in the underlying thick-bedded unit and should be avoided as much as possible. The presence of shale interbeds along which, in many instances, movement has taken place suggests the degree of stability of the rocks in the thin-bedded unit is low.

Engineering Considerations

Depth of Overburden

Bedrock is exposed almost continuously on the steep bluffs along the right side of the river at both sites. Overburden on the bluffs consists of a thin deposit of talus mixed with minor quantities of residual soil and sand and gravel which have slumped from the terraces above the bluffs. The bluffs along the left side of the river are covered with talus with bedrock exposed in only a few scattered outcrops. The thickness of the material is nowhere believed to exceed 10 feet.

Overburden on the terraces above the bluffs consists of weathered, coarse-grained, sandy gravel directly overlying bedrock. The thickness of this deposit is hard to determine as the contact between it and the underlying rock is usually concealed by slumped material. It is believed, however, to vary between 2 and 6 feet but, in places, may range up to 10 feet. The thickness of the overburden beneath Porcupine River at both sites probably does not exceed 50 feet. It is suggested this figure be used for preliminary design purposes.

Proposed Centre Lines

Proposed centre lines for both sites have been indicated on the accompanying geological drawings. In both instances the chief consideration has been the quality of bedrock in the abutments and foundations; the consequent crest lengths of the dams have been disregarded.

Abutments and Foundations

The centre lines proposed for both Upper and Lower Porcupine Canyon dam sites have been located to take advantage of what is considered to be the most competent bedrock occurring at the sites. This rock consists essentially of a thick-bedded, calcareous dolomite which, in general, dips at low angles downstream or into the right abutment.

Structural conditions in bedrock in the abutments may produce streamward movement during excavation. This is especially true at the Lower site where both the bedding and a prominent joint set closely parallel the river. It is possible these fractures may open up for a considerable distance back from the abutment. This could result in leakage around the ends of the dam and also reduce the resistance of the rock to horizontal forces.

The height of the proposed dam at Upper Canyon site would be about 325 feet above the water surface of Porcupine River. To achieve this height the ends of the dam will extend onto the gravel-covered terrace which exists above the canyon walls. Test borings will be necessary on both sides of the river to determine the thickness of the overburden and also the types of bedrock underlying the unconsolidated material. The character of bedrock here is especially important because it is believed overburden is thin and consequently will be excavated in order to locate the dam on bedrock. It is possible if the dam extends sufficiently far back from the left side of the river that at least part of the rock in this abutment will consist of the black shale which underlies the thick-bedded unit. Likewise bedrock in the right abutment may consist of the thin-bedded rocks which overlie the more massive material. A similar situation exists at the Lower site where the same sequence of rocks occur.

The thick-bedded dolomitic rocks underlie the river at both sites and consequently the dam structures located here will be founded on these competent rocks. The quantity and quality of the overburden beneath the river is not known although, it has been suggested for design purposes the thickness of the deposit be assumed as 50 feet. Test borings will be necessary to determine if there are boulders present in the material sufficiently large to prevent driving steel sheet piling to bedrock. There is no doubt the material is highly permeable and if coffer dams are constructed in the river the cut-off will have to extend to bedrock.

Diversion tunnels constructed at either site should be located in the right abutment. The left abutments are unfavourable for these structures because of the black shale which underlies the thick-bedded dolomite unit. This shale is visible near the heads of some of the small tributary valleys which have been cut into the left wall of the canyon and might possibly be encountered by a tunnel driven through the abutment.

The numerous fault zones occurring in both site areas should be investigated. Many contain a large amount of highly permeable fault breccia or broken rock, which, if present in the abutments or foundations of the dam, could result in leakage of reservoir water. Grouting will be necessary to consolidate this rock and seal all the openings. Usually there exists in the fault zone one or more prominent shear surfaces along which a soft, impermeable, clayey gouge containing small angular fragments of bedrock has formed. The gouge may act as a barrier and prevent the passage of grout throughout the entire mass of broken rock.

In places, especially where close jointing occurs, the surface rock is highly weathered. Here bedrock has been partially decomposed into a soft, brown, porous material which has disintegrated into small, angular fragments separated by open fractures usually formed along joint and bedding planes. Test borings will be necessary to determine the depth that weathering has penetrated bedrock. In some localities it is estimated as much as 25 feet of surface rock will have to be removed before fresh rock is exposed.

The permeability of the rock mass is low, seepage will be confined mainly to the broken rock in the fault zones and to a lesser extent along the joint and bedding planes. The rock is not soluble and it is doubtful if caverns or underground solution channels exist in them. Grouting will certainly be required in both abutment areas and in the foundation rock beneath the dam.

Construction Materials

Aggregate

Deposits of sand or gravel that could be used as aggregate were not observed in either site area. The sandy gravel which occurs on the terraces above the bluffs along both sides of the river is too highly weathered to be suitable and the deposits of Recent alluvial gravels present are too small to be considered for a project as large as the one proposed.

The presence of chert in much of the dolomite prevents the use of this rock as a source of artificial aggregate. The chert which is a deleterious constituent of concrete aggregates occurs in the dolomite as egg-shaped nodules up to 3 inches in diameter and as irregular lenses, 6 inches in width and up to 12 feet in length. The average chert content in the rock is about 3 per cent, although in some beds it probably reaches 10 per cent. The weathered, buff-coloured dolomite should also be avoided as a source of aggregate. This material which is porous can produce a poor bond in concrete and induce spalling or "pop-outs" on the surface of the concrete.

It is suggested a massive, white to grey, quartzitic sandstone exposed along both sides of Porcupine River about 2 miles downstream from the Lower site might be crushed to provide suitable fine and coarse aggregate. The quantity available is unlimited. The rock is visible for about one-half mile along the river and forms bluffs up to 200 feet in height.

Impervious Materials

There is a shortage of materials suitable for the impervious core of an earth-or rock-fill dam in the areas about the two sites. Deposits of clay, silt or till were not observed. A sample (No. 1) was taken from a deposit resembling a silty residual soil which is exposed for about 100 feet in a low bluff along the right side of Porcupine River about 6 miles upstream from the Upper site. The deposit is about 6 feet in thickness and directly overlies bedrock. It is overlaid by about 15 feet of weathered, coarse-grained, sandy gravel similar to the material covering the terrace above the walls of the canyon at the sites. The quantity of material visible in the bluff is small. It is possible, however, other larger deposits of similar material exist in the area.

A low bluff, up to 60 feet in height, in which stratified silt, sand and gravel overlying about 20 feet of yellowish, silty clay* is exposed, occurs along the right side of Porcupine River about 1¾ miles upstream from the Upper site. The bluff continues upstream for many miles and is reported to extend up Old Crow River. The silty clay is believed to be potential impervious material. A sample (No. 2) was taken and forwarded to the soils laboratory of the Water Resources Branch in Vancouver for grain size analysis. The resultant curve along with the classification and a few index properties of the material are included at the end of this report.

Pervious Material

Natural material suitable for the pervious shells, filters and drains of an earth dam are not present in the site areas. It is doubtful if suitable material could be obtained by processing the coarse-grained, weathered gravel on the adjacent terraces although this material should not be overlooked in the investigation for suitable material. If it is decided to produce aggregate by crushing the quartzitic sandstone exposed downstream from the Lower site suitable pervious material could probably be produced at the same time.

* A personal communication from O.L. Hughes indicates the thickness of the yellowish, silty clay is 55 feet. It is overlaid by stratified silt, sand and fine-grained gravel which in turn is overlaid by silt and silty clay. The thickness of the latter materials varies from 65 to 150 feet. The upper 30 feet which consists chiefly of silt and silty clay warrants further investigation as a potential source of impervious material.

Riprap and Rock Fill

The massive dolomite beds exposed for many miles along both sides of the river in the canyon should provide suitable rock fill or riprap. In the talus, the fragments derived from these rocks frequently consist of large, angular blocks several feet in diameter. It is believed similar size fragments could be produced when the rock is blasted. Smaller size material would be obtained from the overlying thin-bedded unit. Here the dolomite beds seldom exceed 12 inches in thickness and are separated by thin interbeds of shale.

Several irregular dikes of medium-grained, dark grey to black diorite are exposed in the walls of the canyon between the Lower site and the boundary. The nearest, which is about 2 miles downstream, intrudes the quartzitic sandstone suggested as a potential source of artificial aggregate. This dike is about 80 feet wide at the river but continues up the bluff in an irregular and lenticular manner. There are 4 other similar dikes between this place and the boundary. Two of these are emplaced in quartzite, one in argillaceous shale and the other cuts both dolomite and shale and is truncated against quartzite by a later fault.

The diorite is massive, sound and has a relatively high specific gravity (2.85). It should provide excellent riprap. The quantity exposed in any one place is not large but a larger volume may be found by test borings.

The dike nearest the Lower site intrudes the quartzitic sandstone suggested as a possible source of aggregate. Consequently both types of rock could be taken out of the same quarry and stock-piled separately.

Groundwater

There is little information concerning groundwater conditions in the areas about the proposed sites. Seepages were not observed in any part of the bluffs. Many of the fragments of broken rock in the fault zones were covered with a thin, brown coating of iron-bearing carbonates and oxides which may have been deposited by circulating groundwater. At the time of the investigation (June 15, 1962) the terraces above the bluffs were wet and many small streams were flowing from these areas along the narrow tributary valleys leading to Porcupine River.

Frozen Ground

During the investigation the frost line was encountered about 8 inches beneath ground surface on the terraces above the walls of the canyon. It usually occurs in the moss but sometimes in the underlying gravel if the moss cover is thin. It exists as close as 10 feet from the edge of the bluff but there is no information regarding how close it exists to surface on the bluff face. The presence of frozen ground beneath Porcupine River was not determined. This information could only be obtained by test borings.

Comparison between Upper and Lower Porcupine Canyon sites

The result of the investigation indicates bedrock conditions at the two sites are similar. The thick-bedded, calcareous dolomite which is the most competent rock in the site areas has been suggested as the most suitable rock for the abutments and foundations for the various dam structures. If either dam is extended onto the terraces above the canyon walls it is possible the left end will be underlaid by black shale and the right by the thin-bedded unit which overlies the more massive dolomitic rocks. Any diversion tunnel constructed at either site should be located in the right abutment so as to avoid the black shale. Grouting will be necessary at both sites to seal the numerous joints and the fault breccia or broken rock in the fault zones. The rock suggested as a source of aggregate and riprap is downstream from the Lower site and hence is closer to this site than the Upper. On the other hand sources of impervious material will probably occur upstream from the sites.

Further Investigations - Conclusions

The result of the investigation indicates that, geologically, the sites are similar and consequently the choice of which site to use will depend upon some other criteria. However, it should be remembered the investigation was preliminary in character and the purpose of this report is to furnish the engineer with general geological information regarding the proposed sites. The data compiled is only sufficiently precise to permit office studies and obtain general cost estimates.
The proximity of the sites to one another suggests the same sources of construction materials could be used. The silty clay which is exposed upstream along Porcupine River should be investigated to determine if it can be used as impervious material. The quantity of material available is unlimited and the range in variation throughout the deposit is probably small. Samples of the quartzitic sandstone exposed downstream from the Lower site should be taken to determine if this rock can be crushed to

produce satisfactory aggregate. It is doubtful if the sand size particles produced by crushing this rock will be sufficiently well graded for fine aggregate. In general, the quartz grains in the rock are uniform in size and in places the matrix is soft and calcareous. Consequently the rock will tend to break down into the original sand particles. Blending sand from some other source may be required to obtain the proper grading. The diorite exposed downstream from the Lower site should produce suitable riprap. The specific gravity of this rock, which is of utmost importance, is about 2.85. Test borings will be necessary, however, to determine if there is sufficient quantity of rock available. Test borings will also be required along the proposed centre lines to determine the quality and permeability of bedrock in the abutments and foundations. The thickness and permeability of the overburden beneath the river should be determined as well as the presence of large boulders which would prevent driving piling to bedrock.

Chemical Analysis of Porcupine River Water

On June 18, 1962 a sample of Porcupine River water was taken and sent to the Industrial Waters Section, Mines Branch, Department of Mines and Technical Surveys, Ottawa for chemical analyses. The results are included on the following page.

Chemical Analysis of Porcupine River Water
(parts per million)

Location	Date	River Discharge	pH	SiO_2	Ca	Mg	Na	K	Fe	CO_3	HCO_3	SO_4	Cl	F	NO_3	Turbidity	Hardness as $Ca\ CO_3$
11 miles upstream from International Boundary	June 18, 1962	Medium	7.3	2.2	17.0	3.8	1.1	0.5	1.57	0.0	57.0	10.7	1.3	0.10	0.1	17	58.0

The analysis of Porcupine River water indicates these waters are similar to those in Peel River as well as in other streams in Northern Canada. The analysis of Peel River water is contained in Topical Report No. 83 which describes Aberdeen Falls dam site. The small quantity of dissolved salts in Porcupine River water is doubtless due to the frozen condition of much of the ground within its drainage basin. This would result in relatively small quantities of groundwater entering the stream. Groundwater normally contains a higher proportion of dissolved constituents than surface water. Bicarbonate salts of calcium and magnesium constitute the chief mineralization of Porcupine River water. There are no salts present in sufficient quantity to be harmful to the concrete or other parts of the dam structures which would be exposed to the water. The value of the turbidity of Porcupine River water is somewhat higher than that for the Peel. This may be due to the time of the year the samples were taken. Porcupine River was sampled in June when the river was at a relatively high stage whereas the sample of Peel River water was taken in August at which time the river was dropping. The slightly higher mineral content of the water from Peel River may also be due to the time of year the sample was taken. In August the frozen ground along the river was gradually melting and the resultant increase in groundwater entering the river would cause an increase in the quantity of dissolved salts.

Grain Size Analyses Curves

The grain size analyses curves included in this report were prepared in the Soils Laboratory of the Water Resources Branch in Vancouver. Two different materials were sampled, both as potential impervious material. It is doubtful if there is sufficient material available in the deposit from which sample No. 1 was taken to satisfy the requirements of either project. It was sampled primarily because it was the closest deposit to the sites from which impervious material might be obtained. The results of the tests indicate the silty clay in sample No. 2 could be used in the core of an earth or rock-fill dam.

Description of Potential Impervious Material for the following Grain Size Analyses Curves

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
1	Bluff on right side of Porcupine River about 6 miles upstream from Upper Canyon site; 20 feet below top of bluff, 3 feet beneath ground surface	Grey, sandy silt containing a few angular weathered bedrock fragments up to $\frac{1}{2}$ inch in diameter; resembles in part residual soil	15 feet of weathered, sandy gravel	6 feet	Length - 300 feet Width - unknown	Overlies broken, weathered surface of bedrock; quantity probably small
2	Bluff on right side of Porcupine River about 11 miles upstream from Upper Canyon site; 40 feet below top of bluff, 3 feet beneath ground surface	Yellowish, stratified, silty clay with minor sand	30 feet of stratified silt, sand and gravel; chiefly sand	20 feet	Unlimited; extends upstream for many miles	Material exposed along the bottom part of a 50-foot bluff; accessible from the sites either by the river or by a road which could be constructed on the terrace along the river

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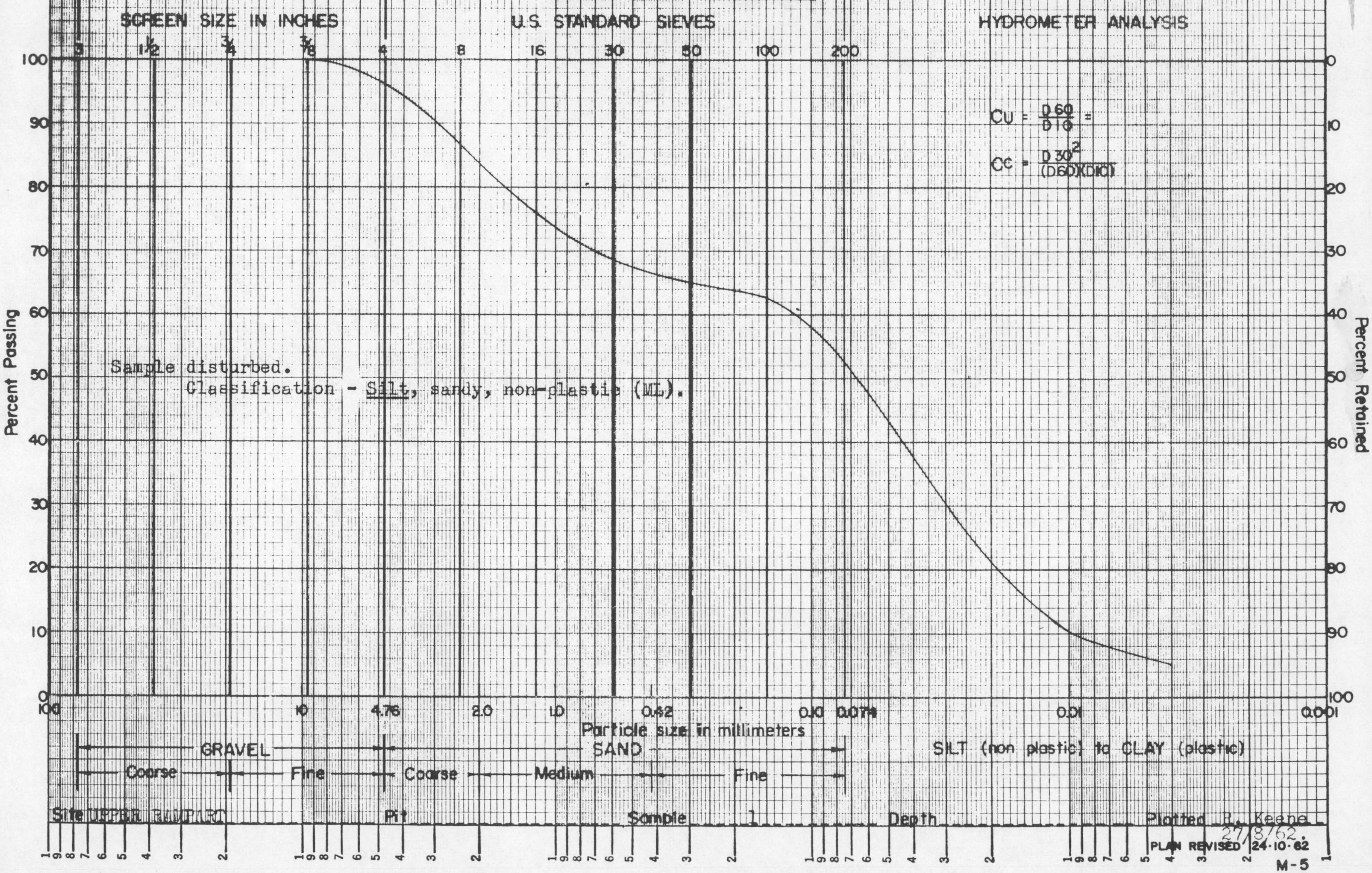
WATER RESOURCES BRANCH

GRAIN SIZE ANALYSIS



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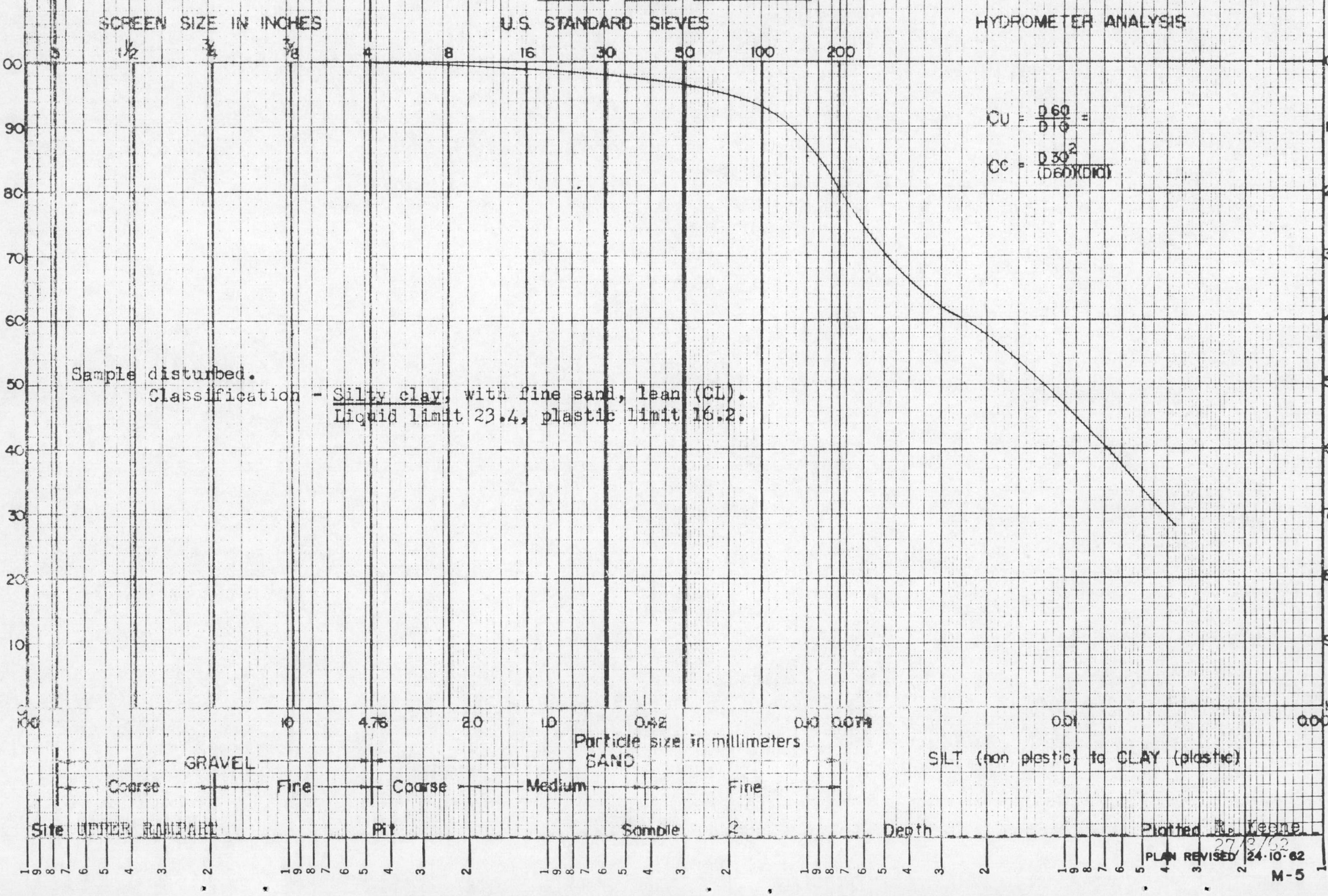
GRAIN SIZE ANALYSIS



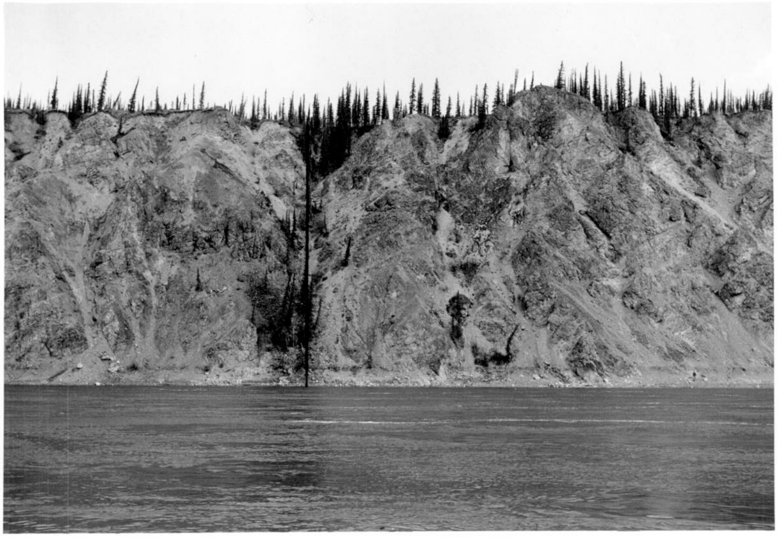


Plate 1

Right abutment of Upper site indicating proposed location of centre line; bed-rock is thick-bedded, calcareous dolomite; strata intersect river at 30 degrees and dip at about 60 degrees into the abutment; height of bluff is about 260 feet.
G.S.C. 2-4-62

Plate 2

Left abutment of Upper site indicating proposed location of centre line; bedrock is thick-bedded, calcareous dolomite as in right abutment; strata dip toward river; height of bluff is about 260 feet.

G.S.C. 5-6-62

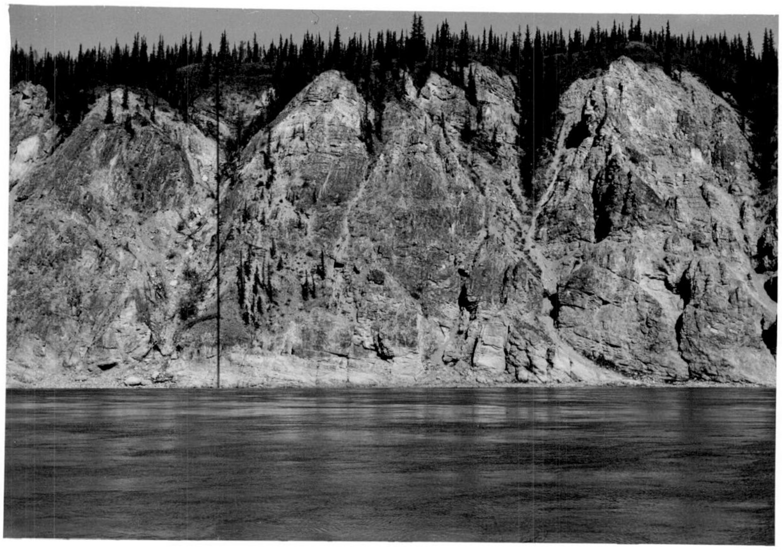


Plate 3

Right abutment of Lower site indicating proposed location of centre line; bed-rock is thick-bedded, calcareous dolomite; strata intersect river at 45 degrees and dip into abutment at 23 degrees; height of bluff is about 270 feet.

G.S.C. 6-5-62

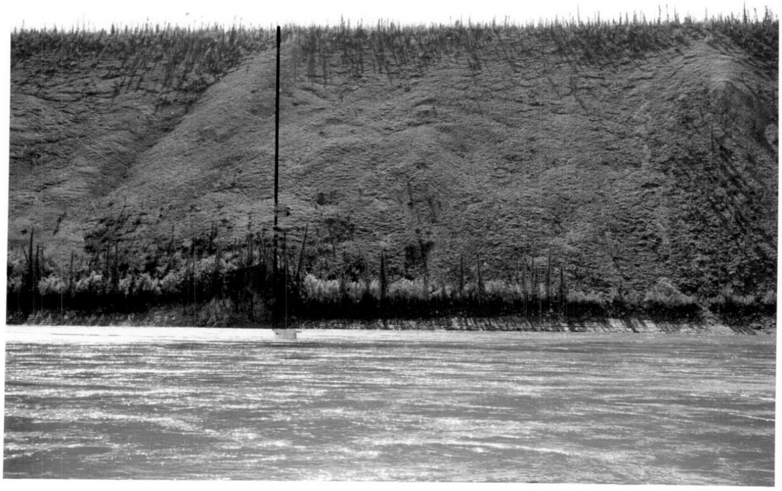
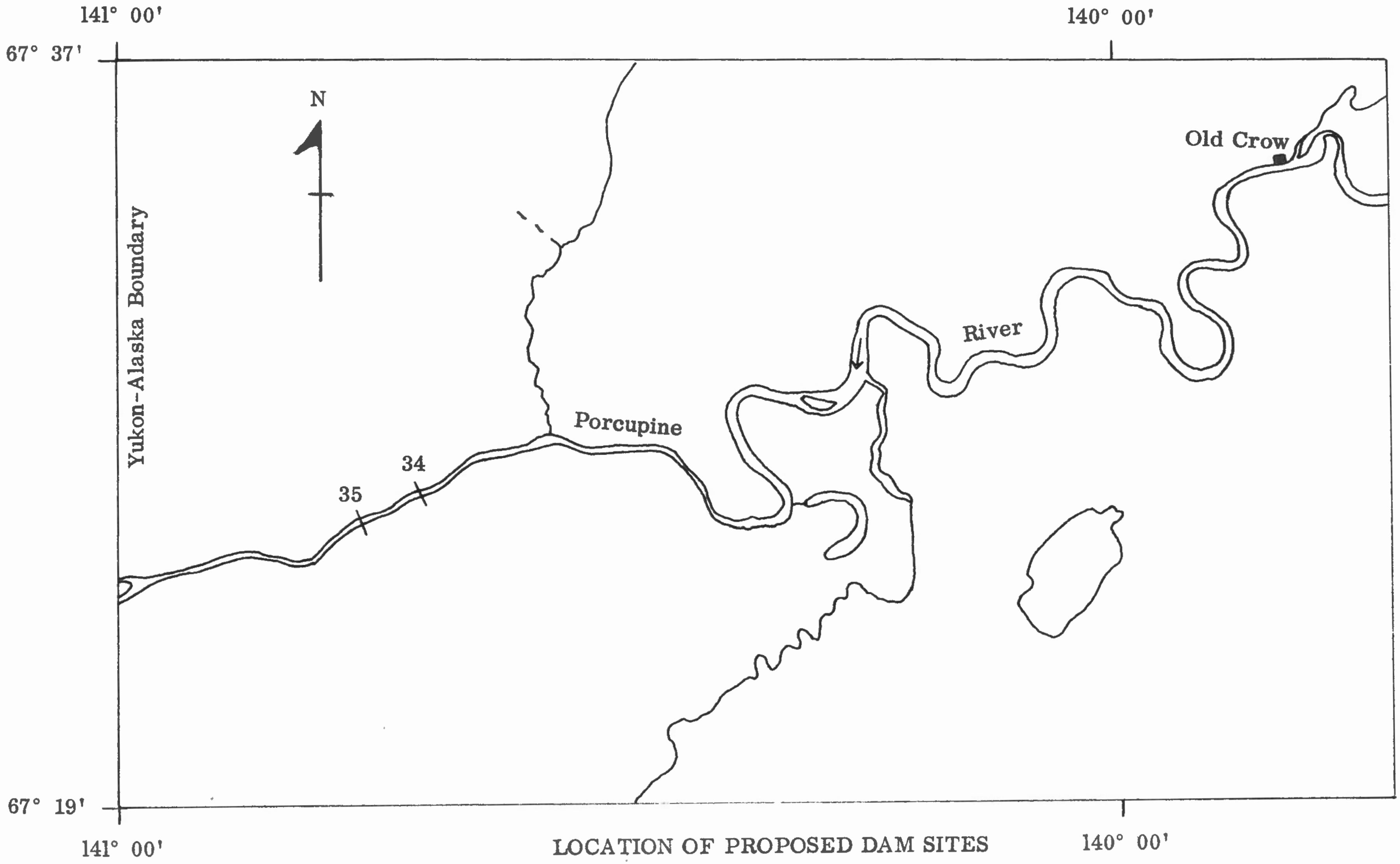


Plate 4

Left abutment of Lower site indicating proposed location of centre line; material on slope consists of a thin cover of talus overlying thick-bedded calcareous dolomite; height from river to level plateau above slope is about 350 feet.

G.S.C. 7-6-62



LOCATION OF PROPOSED DAM SITES
YUKON RIVER DRAINAGE BASIN
Scale: 1 inch to 4 miles (approx.)

Site No.	Name
34 -	Porcupine Canyon (Upper)
35 -	Porcupine Canyon (Lower)