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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
TOPICAL REPORT NO. 88

YUKON RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITE No. 36

BELL DAM SITE

(MAP AND PRELIMINARY REPORT)

BY
E. B. OWEN

OTTAWA
1964

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BELL DAM SITE

General Description

Bell dam site is situated on Porcupine River about 11 and a half miles downstream from the mouth of Bell River, at approximate latitude 67°25' and longitude 137°47'.

Upstream from the site Porcupine and Bell Rivers flow through a low, flat area, dotted with lakes and swamps, which has been called Bell Basin[1]. Both rivers have cut below the level of the plain and are now flowing between banks of sand, silt and clay, 20 to 30 feet high. The reservoir of the proposed dam will probably extend over a large part of Bell Basin.

At the site Porcupine River is flowing in a northerly direction through a canyon-like valley cut through flat-lying beds of Mesozoic sandstone. The sides of the valley in which the abutments of the dam will be located rise steeply from the high water line of the river to heights greater than 300 feet above the river. They are covered almost completely with talus. This material consists of angular fragments of sandstone, many of which are several feet in diameter.

Scattered outcrops of sandstone, partly covered with alluvium, occur along the right side of the river for a distance of about one-half mile upstream from the proposed centre line, the location of which is indicated on the accompanying geological map. Similar rock is exposed along the left side of the river downstream from the centre line. Immediately downstream from the site area dark, greyish-brown shale which underlies the sandstone is exposed along the left side of the river for a distance of several hundred feet.

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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.; Memoir 247, 1948, p. 76.

In places bedrock is highly weathered. This, along with the large quantity of talus present, suggests the site area was not glaciated during the last ice stage. However, the extent to which bedrock has been cut down to form the canyon-like valley at the site indicates large volumes of water have passed through the area. The lack of water-laid material implies the streams were fast-moving. It is believed the site area was a major escape route for west-flowing melt waters which originated in ice sheets located to the east and south in the Richardson and Ogilvy Mountains respectively. This water would have first moved slowly across Eagle Plain where most of its sediment load could have been deposited. Some of the water could also have originated from melting ice in the Mackenzie Mountains to the southeast.

Another discharge route for the water may have existed about 2 miles northeast of the site. This possible partly buried stream channel extends from a point on Bell River about 13 miles upstream from its mouth northwest along the valley of a small creek, across a narrow divide and west along the valley of another small creek which enters the right side of Porcupine River about 3 miles downstream from the site. This area should be examined to determine if leakage of reservoir water could occur through it. Water stored in the reservoir will thaw the surrounding ground and could eventually, if the material was sufficiently permeable, cause leakage. It is suggested a seismic investigation be conducted here to determine the elevations of bedrock surface and, if possible, the types of overburden present. At the same time elevations of ground surface should be obtained to investigate the possibility of surface drainage away from the reservoir.

Unconsolidated Deposits

Two types of unconsolidated deposits were identified at Bell dam site. They are as follows:

1. Recent alluvium: This material consists chiefly of sand and silt with minor quantities of fine-grained gravel. It occurs along both sides of the River as a thin flood-plain deposit extending from the edge of the River up to approximate elevation 918. Mixed with the Recent alluvium are large, angular rock fragments from the talus on the adjacent slope and smaller, platy fragments from the underlying bedrock. In most places on the flood plain the Recent alluvium is no more than a few inches thick. The quantity beneath Porcupine River is unknown and could only be determined by test borings. It is not believed there is sufficient quantity available at the site for it to be considered as a source of construction material.

2. Talus: Talus is the deposit of loose rock fragments lying on and along the bottoms of the steep sides of the valley at the site. It is the result of mechanical disentegration of adjacent bedrock. The sizes of the fragments range from sharp-edged, angular cobbles to large boulders several feet in diameter. They consist entirely of fine-grained, grey sandstone which constitutes most of the bedrock exposed at the site.

Both sides of the valley are covered almost entirely with talus. The size of the rock fragments on the slopes increases upwards suggesting they have originated up slope and while moving downward are disentegrating into smaller fragments. The left (west) side of the valley extends steeply upward to a bedrock terrace some 600 feet above the river. This is well beyond the limit included on the accompanying map. Bedrock exposed on the terrace is deeply weathered and broken into large, angular blocks separated by open fractures many of which are several inches in width.

The right side of the valley rises steeply to a height of about 200 feet and then gradually levels out to a less steep gradient. In the upper part the fragments consist of weathered, angular blocks which are apparently creeping gradually downslope toward the steeper, talus-covered side of the

valley. It is believed this part could be described as a felsenmeer which is a fairly level or gently sloping area covered with moderate-size or large blocks or rock. It is apparently formed by upheaval and disentegration of large blocks of bedrock by frost action. At Bell site there is not distinct boundary between felsenmeer and talus. It is gradational and dependent to a large extent upon the slope of ground surface. The thickness of the felsenmeer is unknown but it is believed at least 25 feet of shattered rock would have to be removed before relatively solid rock would be encountered. The thickness of the talus varies throughout the area. It is probably about 25 feet thick along the toes of the slopes decreasing to 10 feet in the upper parts.

Bedrock

General Description

Elongated outcrops of bedrock occur in the flood plain along both sides of Porcupine River. It consists of fine-grained, grey to white, quartz sandstone in beds which vary in thickness from a few inches to more than 3 feet. It is similar to the sandstone occurring in the east end of McDougall Pass except it is harder, more siliceous and appears more durable. In places the bedrock surface has been highly weathered to a buff coloured, porous, friable rock. The sandstone is underlaid by a dark, greyish-brown shale which outcrops along the left side of the River immediately downstream from the site area. At the proposed centre line 250 to 300 feet of sandstone should overlie the shale.

Bedrock Structures

In general the dip of the strata at Bell site is shallow ranging from 3 to 8 degrees in a southeast direction. Local undulations, however, have resulted in equally shallow dips in the opposite direction. From the

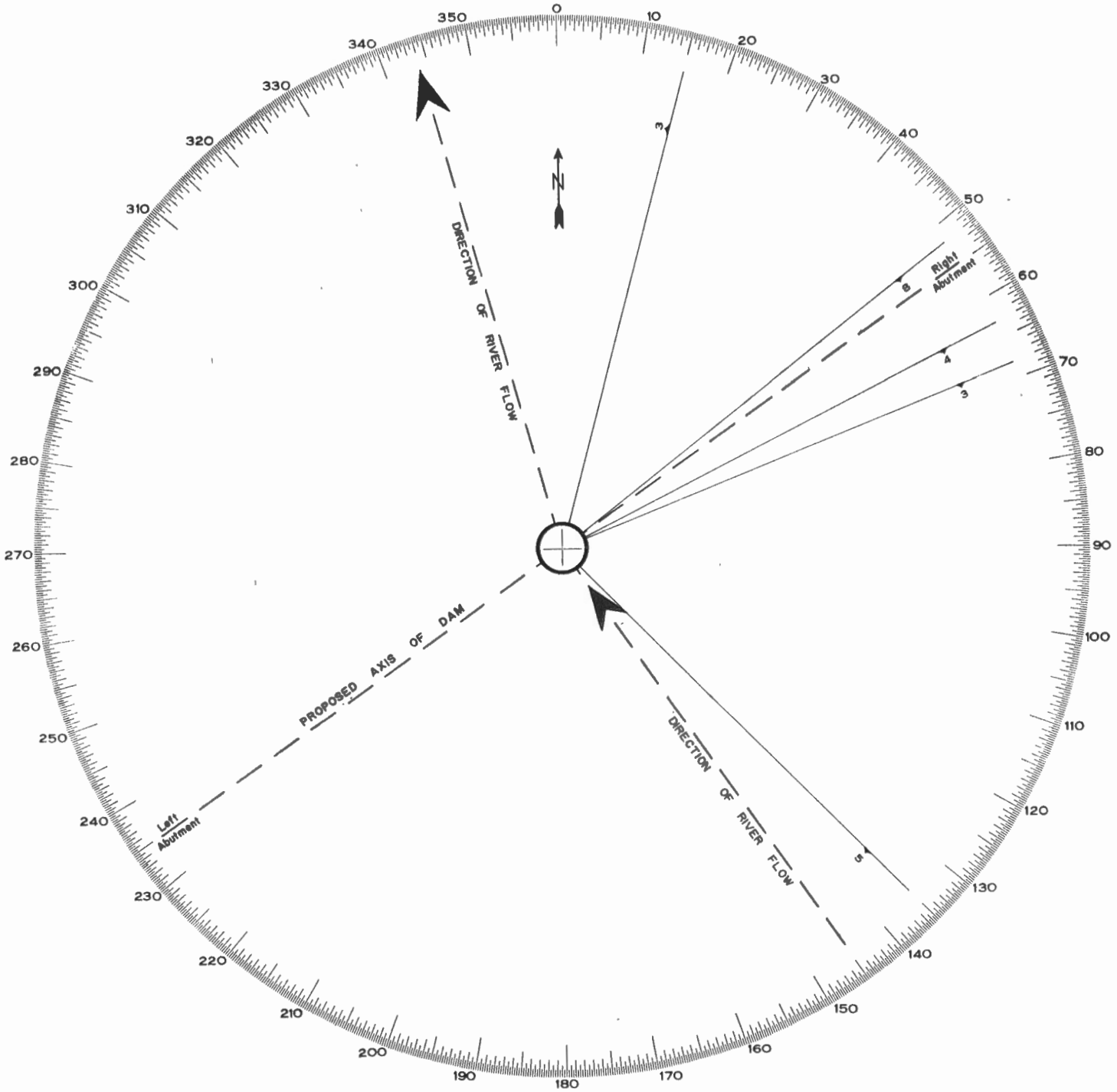
accompanying bedding rosette it can be seen the bedding closely parallels the proposed axis of the dam and dips upstream.

The strike of the jointing is extremely variable although the dips are relatively steep ranging from 59 degrees to vertical. One result of the great variation in the jointing is the many different shapes of rock fragments in the talus which in most instances have broken off along joint and bedding planes.

Faulting is uncommon at the site. One fault parallel to the bedding exists between stations G-3 and G-4. The shear zone contains about 2 inches of dark brown, clayey gouge but no shattered rock was associated with the fault. The fault was exposed for about 25 feet. It is probable other similar bedding faults occur in the sandstone. Their presence could only be determined by excavating so as to expose a fresh rock face or by careful test borings.

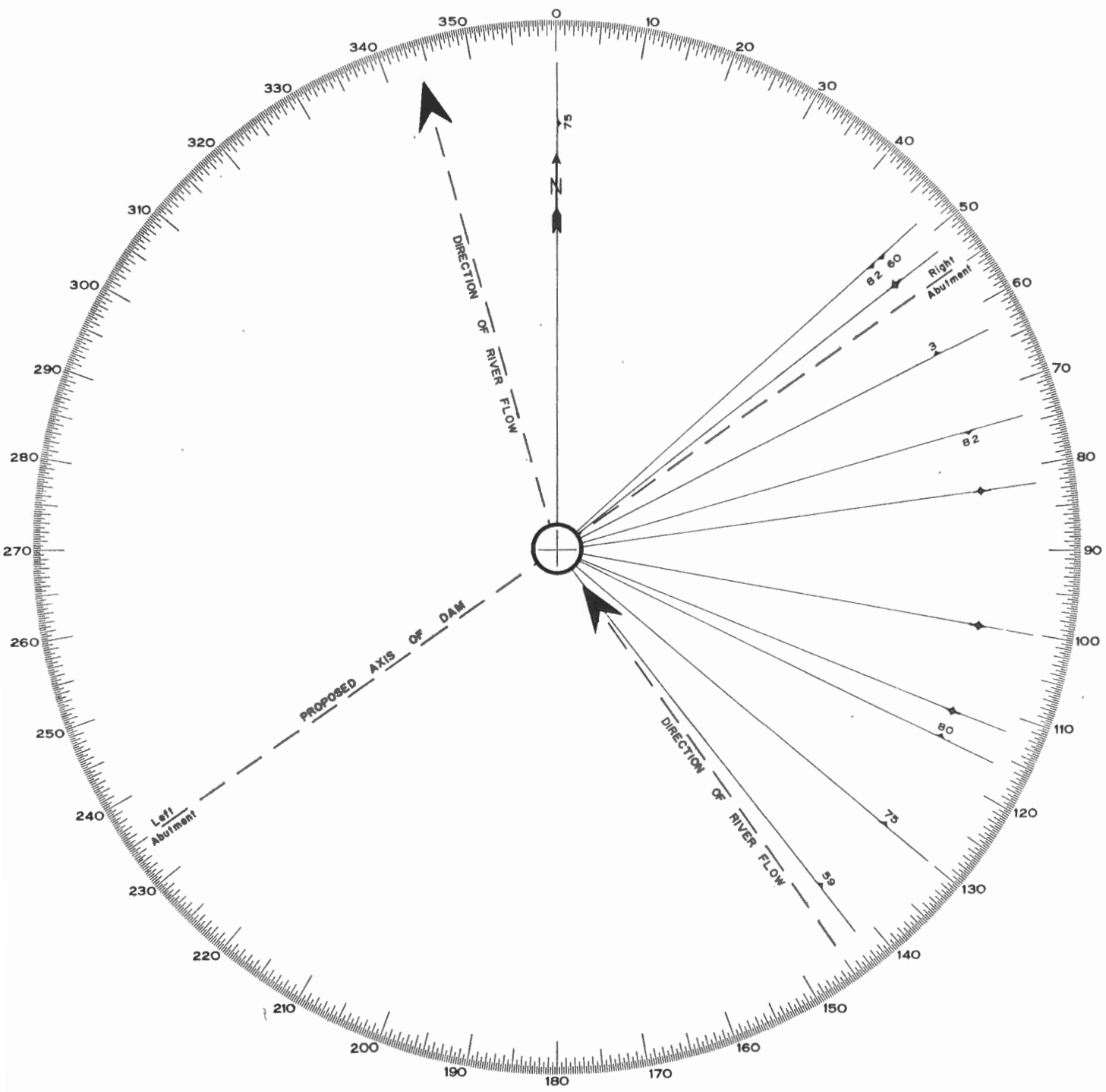
Quality of Bedrock

Bedrock at the site is a relatively dense, hard, insoluble rock and should provide satisfactory foundation and abutment material. The presence of clay gouge along horizontal bedding faults should be investigated. This material would have a low bearing capacity and could possibly squeeze out under imposed pressure. The permeability of the rock mass is low. However, the brittleness of the sandstone may result in the formation of a zone of broken rock (fault breccia) along any fault present which could actively transmit water. In places bedrock is deeply weathered and shattered by frost action. Consequently it is believed considerable material will have to be removed from bedrock surface before fresh rock against which concrete or dike material can be placed will be exposed. Test borings will be necessary to determine the actual quantity that will have to be removed.



BEDDING ROSETTE

The above illustration presents diagrammatically the direction and dip of bedding in bedrock exposed at Bell site



JOINT ROSETTE

The above illustration presents diagrammatically the direction and dip of jointing in bedrock exposed at Bell site

Engineering Considerations

Depth of Overburden

The thickness of the Recent alluvium on the narrow flood plain bordering both sides of Porcupine River at the site varies from a few inches to 4 or 5 feet. Test borings will be required to determine the thickness of the similar material which underlies the river. Considering the large amount of water which is believed to have passed through the site since the last glaciation it is possible the quantity of alluvium present here is considerable. The thickness of the talus which covers the abutment slopes varies from about 25 feet in some places along the toes of the slopes to 10 feet in the upper parts.

Proposed Centre Line

Geological conditions throughout the site are similar. Consequently from the viewpoint of geology the centre line could be located anywhere. The position of the centre line as indicated on the accompanying map was decided upon in the field as the most favourable because of the lesser amount of excavation and fill required to construct the dam.

Abutments and Foundations

Bedrock upon which the abutments and dam structures will be founded consists entirely of sandstone. It is believed competent and should provide satisfactory foundation material. Bedrock in the abutments is completely covered with talus and consequently not observed in place during the investigation. However, the quality of the rock where it was observed in the few scattered outcrops and in the talus was uniform throughout the site and it is doubtful if there are any significant changes in the concealed areas. The presence of structures such as faults with their associated permeable fault breccia or joints which may be represented by steeply dipping or vertical open fractures could only be determined by test borings or by stripping the loose rock from the slopes.

The sandstone is underlaid by a dark greyish-brown shale which, at the centre line, is believed to exist 250 to 300 feet beneath the surface of the river. It is doubtful if the shale will affect the competency of the foundation rocks. The upstream dip of the strata at the site is favourable for dam construction. Some leakage may occur along open joint fractures beneath the dam. The strike of these structures is unusually variable although the dips, in general, are steep or vertical. No prominent joint set was observed in the area. Grouting will undoubtedly be required to seal these structures.

Construction Materials

Aggregate

Deposits of sand and gravel suitable as aggregate were not observed in the site area. It is suggested, however, a systematic search for this type of material be conducted in the areas adjacent to the site. This area is considered to have been a drainage route for large volumes of west-flowing melt water and it is possible potential deposits of fine or coarse aggregate exist not far from the site.

The sandstone at the site may be crushed to produce satisfactory aggregate. Laboratory tests should be made on these rocks to determine their soundness, porosity and specific gravity in order to ascertain their suitability as a source of aggregate. The quantity of rock available is unlimited as far as the aggregate requirements of the project are concerned.

Impervious Materials

There is a shortage of materials suitable for the core of a rock-fill dam at Bell site. Two samples were taken of a brown, silty residual soil occurring in the face of a bluff on the left side of Porcupine River about one-half mile downstream from the site. The material contained numerous partly

disintegrated sandstone pebbles. Grain size analyses curves prepared by the Water Resources Branch for the samples are included at the end of this report. The results indicate this material could be used as impervious core material providing close control was exercised during placing. The quantity available is probably small. A program of test pitting would be necessary to determine the quantity available.

Another potential source of impervious material is the clay, silt and sand exposed in cut banks along the sides of Porcupine River for many miles upstream from the site area. Similar material exists downstream from the site. The cut banks usually range from 20 to 30 feet in height. The limited thickness of the deposit along with the fact it is frozen to ground surface, suggests it would be expensive to excavate and transport any large quantity to the site.

Pervious Materials

As in the case of natural aggregate materials suitable for the pervious shells, filters and drains of an earth or rock-fill dam do not occur in the site area. If it is decided to produce aggregate by crushing the sandstone occurring at the site pervious material could probably be produced at the same time.

Riprap and Rock Fill

Suitable riprap and rock fill can be obtained from the sandstone exposed at the site. Many of the rock fragments in the talus could be used as riprap especially the larger fragments on the upper parts of the slopes. The rock produced during excavation for the abutments and foundations could also be used but a quarry would have to be opened to obtain the large quantities required by the project. Possibly the best location for a quarry would be in the small valley immediately east of the right abutment. Bedrock here is sandstone similar to that at the site and is readily accessible. Bedrock

exposed along Porcupine River downstream from the site would not be suitable. Shale constitutes the rock in the first mile while further downstream it consists of shale, shaly sandstone and quartzite.

Groundwater

There is little information concerning groundwater conditions at Bell dam site. Numerous small streams flow out from beneath the talus along the toes of the slopes and empty into Porcupine River a few feet away. During the summer the daily volume of water fluctuates widely reaching its peak in the late afternoon. This is probably the result of daily thawing of frozen material beneath or in the talus.

Frozen Ground

During the investigation there was no direct evidence obtained to indicate frozen ground exists at Bell dam site. Test pits were not put down because of the types of overburden present. These along with the shot holes which are made during the seismic investigations are the only way frozen ground could be identified in this type of preliminary investigation. However, the daily fluctuation in the volume of water in several small streams flowing from the toes of the slopes suggests frozen ground is present.

Further Investigations - Conclusions

The result of the investigation indicates geological conditions at Bell site are favourable for construction of a dam. 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 site. The data presented in this report is only

sufficiently precise to permit office studies and obtain general cost estimates.

The sandstone occurring at the site is believed competent and should support the dam structures. However, more information is required concerning the depth of weathering and the extent to which the rock is fractured below surface. To prevent seepage it may be necessary to construct a concrete cut-off wall in bedrock beneath the dam and extend it up into the abutments. Grouting will certainly be required both in the abutment and foundation rock.

To make the best use of local construction materials the dam would probably be a rock-fill type. Suitable materials for an earth dam are not available whereas suitable rock can be quarried near the site. There is a lack of impervious material at the site although acceptable material may occur upstream along the sides of Porcupine River.

The thickness of overburden beneath the river is unknown. The geological history of the area suggests it may be considerable although the presence of outcrops of horizontally bedded rock along the sides of the river indicate otherwise. The possibility of leakage of reservoir water through a network of small valleys east of the right abutment should be investigated.

Chemical Analyses of Porcupine River Water

The results of a chemical analysis of Porcupine River water are included in the report on Upper and Lower Porcupine Canyon dam sites, described in Topical Report No. 86 (sites Nos. 34 and 35).

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 samples of potential impervious material were taken from the same

exposure. The results indicate this material could be used as impervious material providing close control was exercised during placing. The quantity available, however, is limited.

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

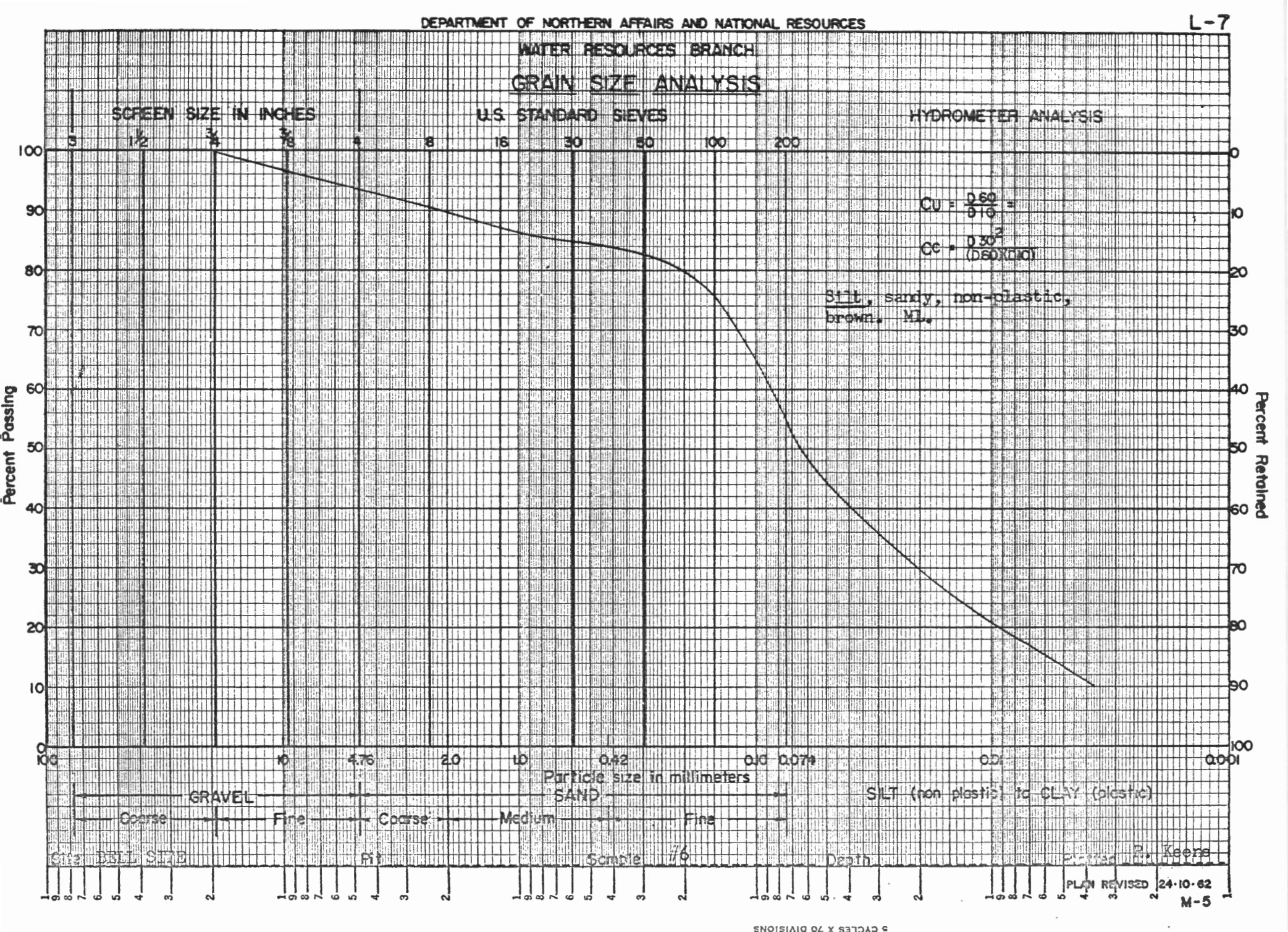
Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
6	Left side of Porcupine River; 1/2 mile downstream from site; in bluff face 50 feet above river and 2 feet below ground surface	Dark brown, silty, till-like, residual soil containing numerous platy sandstone pebbles; no foreign pebbles	None	10+ feet	Bluff face is 120 feet high and 300+ feet long	Limited quantity available
7	50 feet above sample No. 6	Dark brown, silty, till-like, residual soil containing numerous platy sandstone pebbles; no foreign pebbles	None	10+ feet	Bluff face is 120 feet high and 300+ feet long	Limited quantity available

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

L-7

WATER RESOURCES BRANCH

GRAIN SIZE ANALYSIS

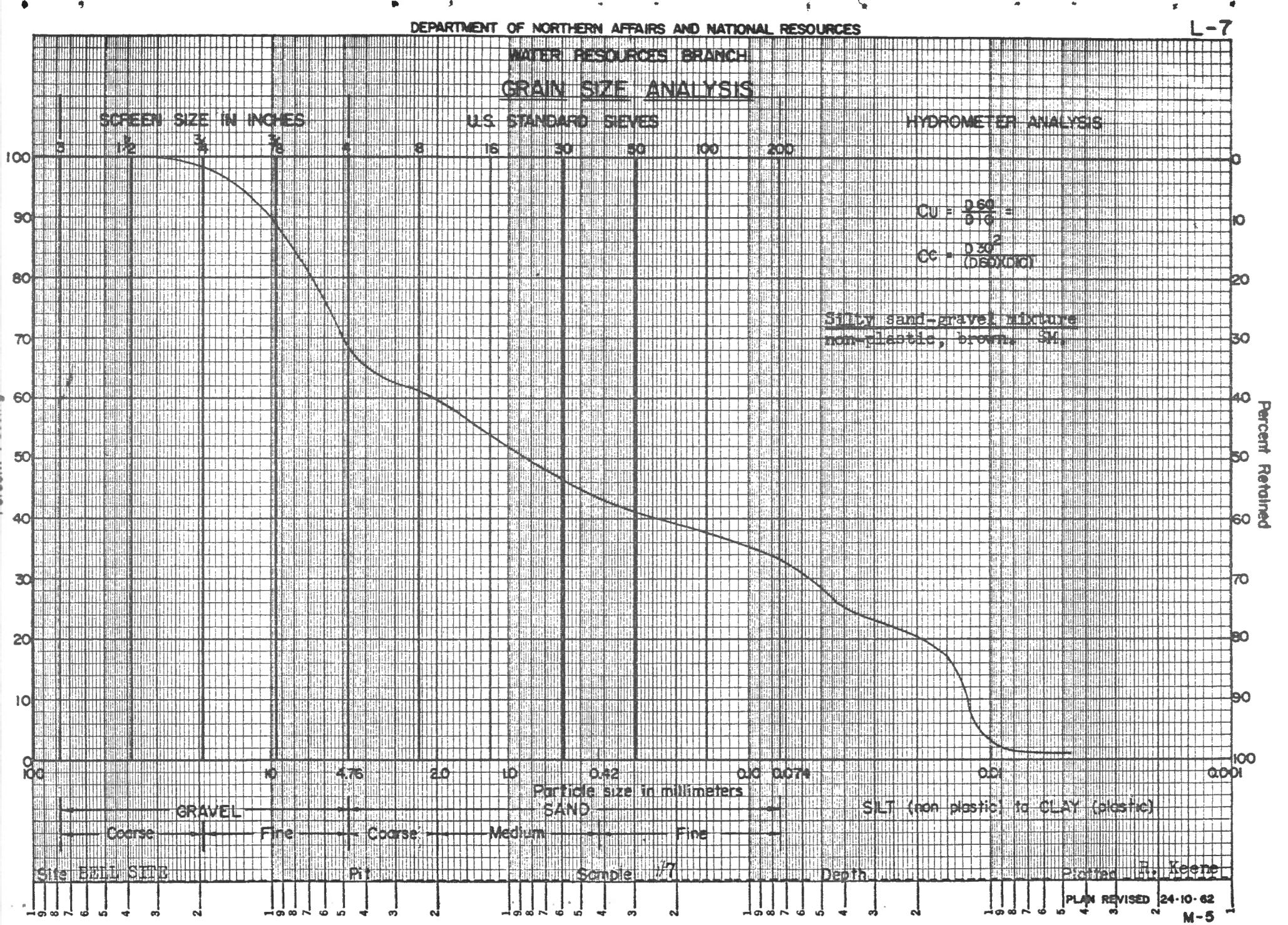


DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

L-7

WATER RESOURCES BRANCH

GRAIN SIZE ANALYSIS



Site Bell SITE Pit Sample #7 Depth Plotted R. Keene

PLAN REVISED 24-10-62

M-5

SEMI-LOGARITHMIC 359-91G
KEUFFEL & ESSER CO. MADE IN U.S.A.
5 CYCLES X 70 DIVISIONS

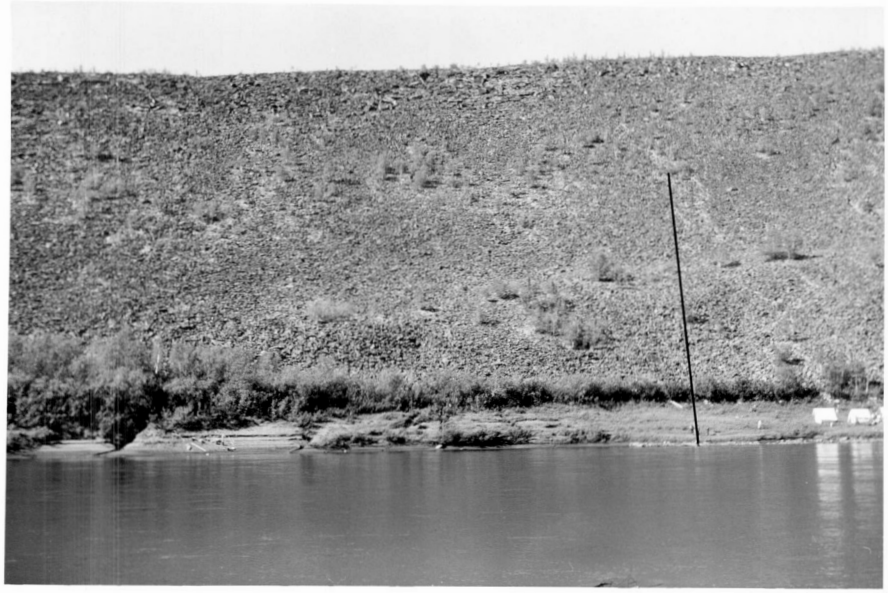


Plate 1

Talus-covered left abutment, Bell dam site, showing the approximate location of the proposed centre line; height from river to level plateau above slope is about 550 feet.

G.S.C. 5-6-63

Plate 2

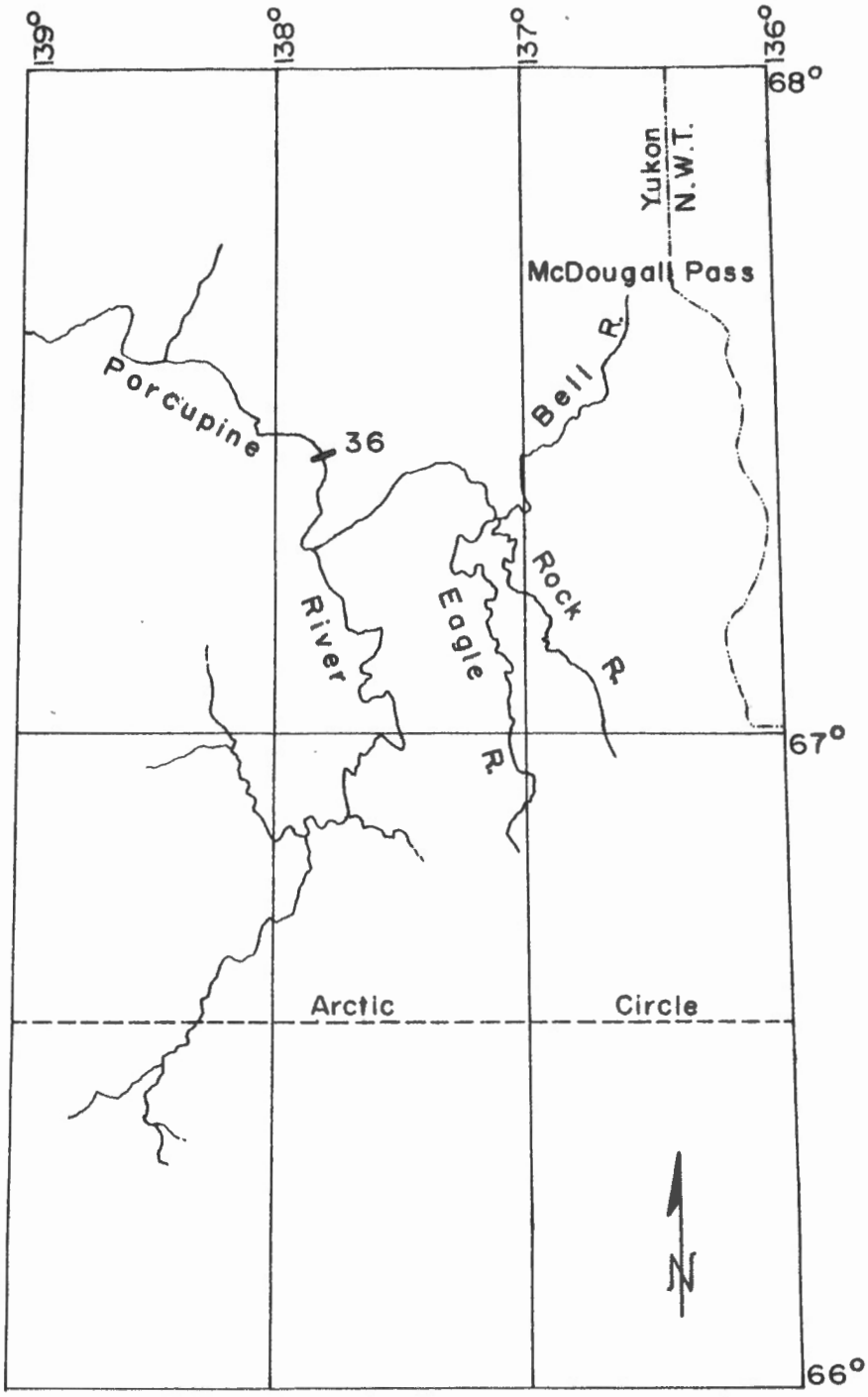
Talus-covered right abutment, Bell dam site, showing the approximate location of the proposed centre line.

G.S.C. 4-3-63

Plate 3

Bell dam site looking downstream showing the approximate location of the dam.

G.S.C. 7-3-63



LOCATION OF PROPOSED DAM SITE
YUKON RIVER DRAINAGE BASIN

Scale : 1 inch = 20 miles

Site No.	Name
36	Bell