CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
TOPICAL REPORT NO. 65

MACKENZIE RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITES NOS. 11-12

RAT CANYON SITES (Upper & Lower)

(MAPS AND PRELIMINARY REPORT)

BY
E. B. OWEN

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RAT CANYON DAM SITES (Upper and Lower)

General Description

Upper and Lower Rat Canyon dam sites are alternate sites in the multiple stage power development proposed for McDougall Pass in the Northwest Territories. The Upper site is about 8 miles east of Horn Lake site which is described in Topical Report No. 73, site No. 10. The Lower site is about one mile downstream from the Upper.

This report deals chiefly with the geology at the Upper site. The emphasis is placed on this site because of the possibility a dam could be constructed here to direct water through a power canal directly to a power house located near Delta site some 8 miles east. If this scheme is carried out three proposed dams, namely Barrier, Longstick and Delta, all located in the Pass downstream from Rat Canyon, will not be required.

Rat Canyon is considered to be the most favourable location for a dam throughout the entire length of McDougall Pass. Here Rat River has cut a narrow, steep-walled valley some 260 feet into bedrock. Overlying bedrock is an extensive deposit of coarse-grained, permeable gravel ranging up to 50 feet in thickness. This gravel, which is probably glacio-fluvial in origin, is exposed almost continuously along both sides of the Pass downstream from the canyon and also extends a considerable distance upstream along the rim of the reservoir. Further investigations will be needed to determine if the gravel will provide satisfactory abutment material and also if its presence will result in seepage of reservoir water.

The elevation of bedrock surface at Upper Canyon site is about 850 feet. The reservoir imponded by a dam constructed to this elevation would extend 11 miles west to the Bear Creek site as well as up the valleys of several small streams presently flowing into the Pass. The surface topography gives no indication of the presence of buried channels in the reservoir rim. Such channels are deeply eroded surfaces in bedrock which are frequently filled with highly pervious materials.

Rat Canyon is not straight but rather consists of a series of parallel reaches separated by sharp bends. These continuous stretches in the canyon are believed to be related to two prominent, steeply dipping joint ~~sites~~ sets in bedrock one of which is usually parallel to the canyon while the other intersects it approximately at right angles. The canyon trends east in the upstream part of the Upper site. It turns abruptly south for about 800 feet and then east again and continues in this direction as it passes out of the site area. At the Lower site where the same two joint sets are present the canyon trends east parallel to one set and intersects the other set at about right angles. The walls of Rat Canyon consist of steep, rocky bluffs partly covered with talus and cut by narrow, deeply incised valleys containing small, intermittent streams. Bedrock terraces such as occur on the right abutment at the Horn Lake site do not exist.

The bluffs along the left side of the canyon are usually steeper than along the right. This is the result of the high angle dip of the jointing which is invariably toward the left side.

The average width of the canyon at the Upper site is less than 300 feet. The bluffs on both sides rise to heights greater than 350 feet above the floor. Bedrock is exposed on about 30 per cent of the bluff along the right side and about 5 per cent of the left. Above both bluffs an undulating terrace dotted with numerous small, shallow lakes extends for many miles north and south of the canyon.

Unconsolidated Deposits

Five types of unconsolidated deposits were identified at both Upper and Lower Canyon sites. These are as follows:

1. Recent alluvium (silt, sand, gravel): This is material which has been deposited by Rat River. It consists of silt, sand and coarse gravel containing numerous large, subrounded to rounded boulders up to 36 inches in diameter. Many of the boulders consist of sandstone similar to that exposed at the site. The extent of the Recent alluvial material in Rat Canyon is limited to narrow deposits between the canyon walls and the river and the material directly beneath the river. The Recent alluvium is not considered an important source of construction material because of the small quantity available.

2. Alluvium (silt, clay, minor sand): This material was probably deposited by Rat River when it was flowing at a higher elevation. It's origin, however, is uncertain and consequently in the Upper site area it is referred to as being partly glacio-lacustrine. At the Upper site the material consists of horizontally stratified clay and silt with a few narrow interbeds of fine-grained sand. At the Lower site it is more coarse-grained with very little

clay present. At both sites the material occurs on gently sloping terraces situated south of the river in the downstream part of the site area. If sufficient quantity were available the material could possibly be used in the impervious core of an earth or rock-fill dam.

3. Talus: Talus is material resulting from the mechanical disintegration of adjacent bedrock. Talus derived from sandstone consists of rock fragments ranging from sand-size particles to boulders several feet in diameter. The size and shape of the fragments depends in general upon the thickness of the strata from which they have been derived and the spacing of the jointing which usually intersects the bedding at acute angles. The more massive beds yield large, irregular boulders whereas the thinner beds produce more platy fragments. Talus derived from shale usually consists of small, angular blocks of the more resistant rock mixed with a soft, black, clayey, residual soil.

Most of the talus in Rat Canyon has been derived from sandstone. It frequently contains small quantities of silt and gravel which have slumped from deposits of these materials exposed on the upper parts of the canyon walls.

At the Upper site shale occurs in the bluff along the left (north) side of the canyon in the downstream part of the site area. Here the talus consists almost entirely of small shale fragments mixed with clayey, residual soil. Landslides are common and as a result the bluff here has receded a considerable distance back from the river. A similar situation exists along the left side of the river a few hundred feet upstream from

the site area at the point where it was suggested in the field the upper end of the proposed power canal be located. At the Lower site the shale exposed in the right wall of the canyon has a relatively high sand content and as a result the material derived from the weathering of this rock consists chiefly of small, angular blocks with little residual soil such as occurs at the Upper site.

4. Glacio-fluvial (sand, gravel): This material consists of extremely coarse-grained gravel containing minor quantities of sand-size particles many of which are fragments of black shale. A field estimate indicated about 70 per cent by weight of the material consists of boulders greater than 3 inches in diameter. The boulders are mainly sandstone with about 20 per cent consisting of hard, grey to white quartzite. The gravel which directly overlies bedrock is exposed in many places on both sides of McDougall Pass between the Upper site and the east end of the Pass. At the Upper site the thickness of the deposit varies from about 10 feet along the right side of the canyon to 50 feet on the left side near the downstream end of the site area. The material is not exposed on ground surface but everywhere is overlain by glacio-lacustrine silt. A sample of the gravel was taken from near the top of the bluff along the left side of the canyon immediately downstream from the Upper site. The grain size analyses curve included at the end of this report was prepared from that part of the sample which passed through a 3-inch screen (about 30 per cent by weight).

5. Glacio-lacustrine (silt): This material consists of an extensive deposit of yellowish-brown silt which covers the terraces above both walls

of the canyon. The thickness of the deposit varies from about 4 feet at the Upper site to 10 or more feet at the Lower. It continues to increase in thickness downstream from the canyon and at Barrier site, some 7 miles from the Lower site, is about 40 feet thick. The silt may provide material suitable for the impervious core of an earth or rock-fill dam.

Bedrock

General Description

Bedrock occuring at the sites consists of fairly massive to massive, fine-grained, grey sandstone and soft, black, laminated shale. Most of bedrock exposed consists of the more resistant sandstone whereas the less durable shale occurs in the concave portions of the canyon walls where it is almost invariably covered with a mixture of talus and residual soil along with small quantities of silt and gravel. The sandstone varies from a relatively soft, poorly cemented rock with a calcareous matrix similar to the sandstone downstream at Barrier, Longstick and Delta sites to a more competent, thick-bedded rock with a siliceous matrix comparable to the sandstone occurring at the sites further upstream. The weathered sandstone is usually buff coloured and frequently soft and friable due to leaching of the calcarous matrix.

The thickness of the sandstone exposed at the Upper site is about 300 feet and 100 feet at the Lower site. At both sites shale occurs above and below the sandstone. The thickness of the shale was estimated to be as great or greater than that of the sandstone.

Bedrock Structures

The strike of the strata at the Upper site is variable; intersecting the proposed centre line at angles between zero and 85 degrees. The low-angle dips are consistantly upstream or into the right abutment. At the Lower site the strata in general are north-trending and intersect the proposed centre line at angles between 40 and 50 degrees. The dip here is likewise upstream or into the right abutment.

The shale underlying the fine talus and black, clayey, residual soil on the left wall of the canyon in the downstream part of the Upper site is believed to be continuous with the shale on the same side at the entrance to the proposed power canal. The latter shale exposure occurs upstream from the site area. The shale dips beneath the left wall and the floor of the canyon and underlies the sandstone exposed in the right wall. The sandstone exposed in the left wall at the downstream end of the site underlies the shale. The thickness of the shale is believed to be about 300 feet. The overlying sandstone exposed in the right wall has a similar thickness.

The abrupt changes in direction which Rat Canyon undergoes are probably due to two prominent and consistant joint sets which closely parallel the canyon walls. At the Upper site one set strikes south to south 20 degrees east and dips steeply east. The trend of the second set is almost at right angles to the first. It strikes between north 80 degrees east and south 70 degrees east and dips steeply into the left abutment. Rosettes which present diagrammatically the direction and dip of bedding and jointing at both Upper and Lower sites are included on the following pages. Faulting was not

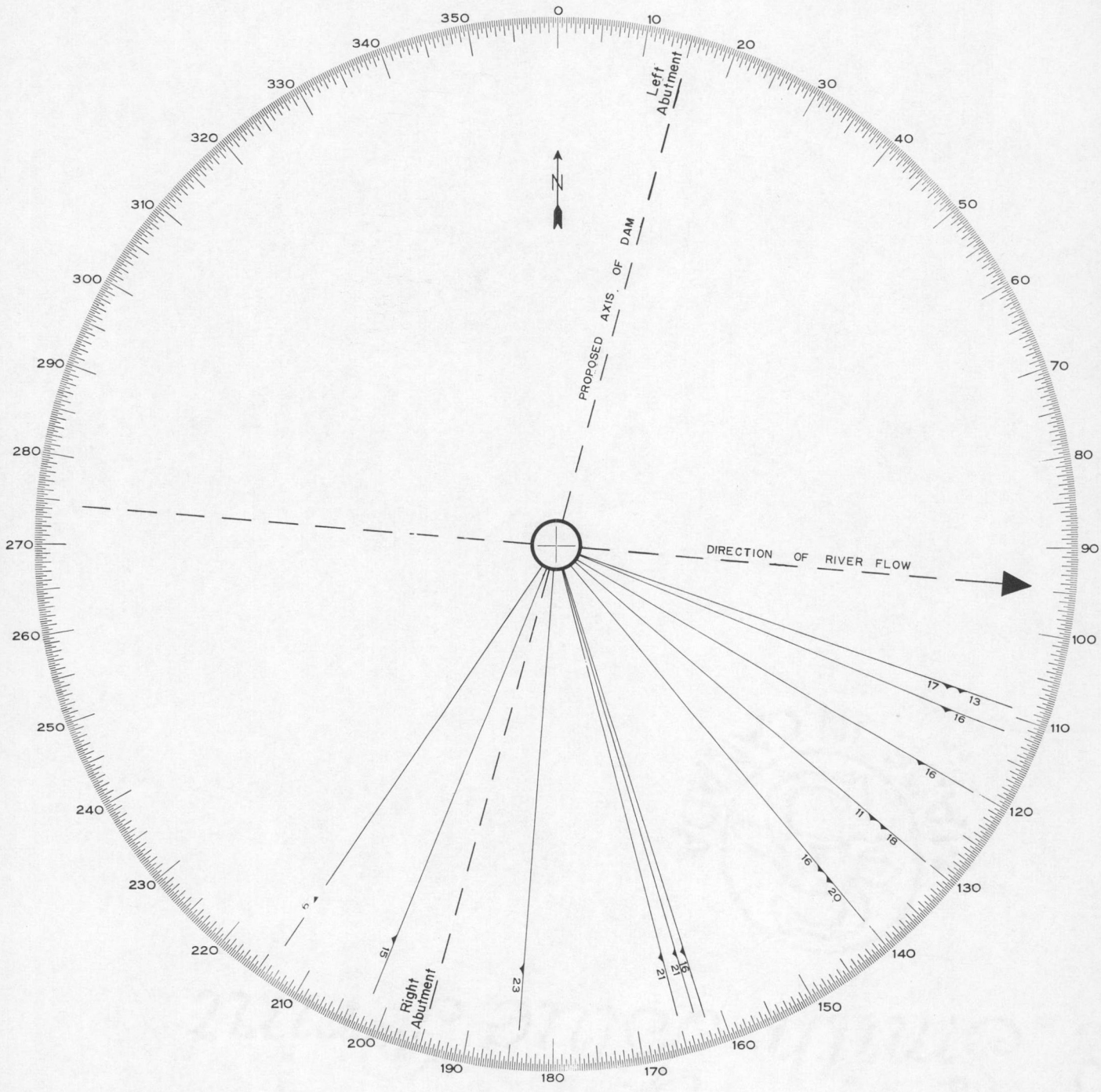
observed at either site. Minor folding occurs at the Upper site. This has resulted in local changes in the dip and strike of the strata as indicated on the accompanying rosette.

Quality of Bedrock

In the unweathered state the sandstone at the Upper site is believed to be competent and should provide satisfactory abutment and foundation material. The fresh rock could also be used as a source of coarse aggregate. A sample of the sandstone was forwarded to the Soils Laboratory of the Water Resources Branch for a determination of its physical properties. The information was not available at the time this report was written. It is intended to include the results of the tests in a subsequent report, probably that for Longstick and Delta sites, where similar rocks occur.

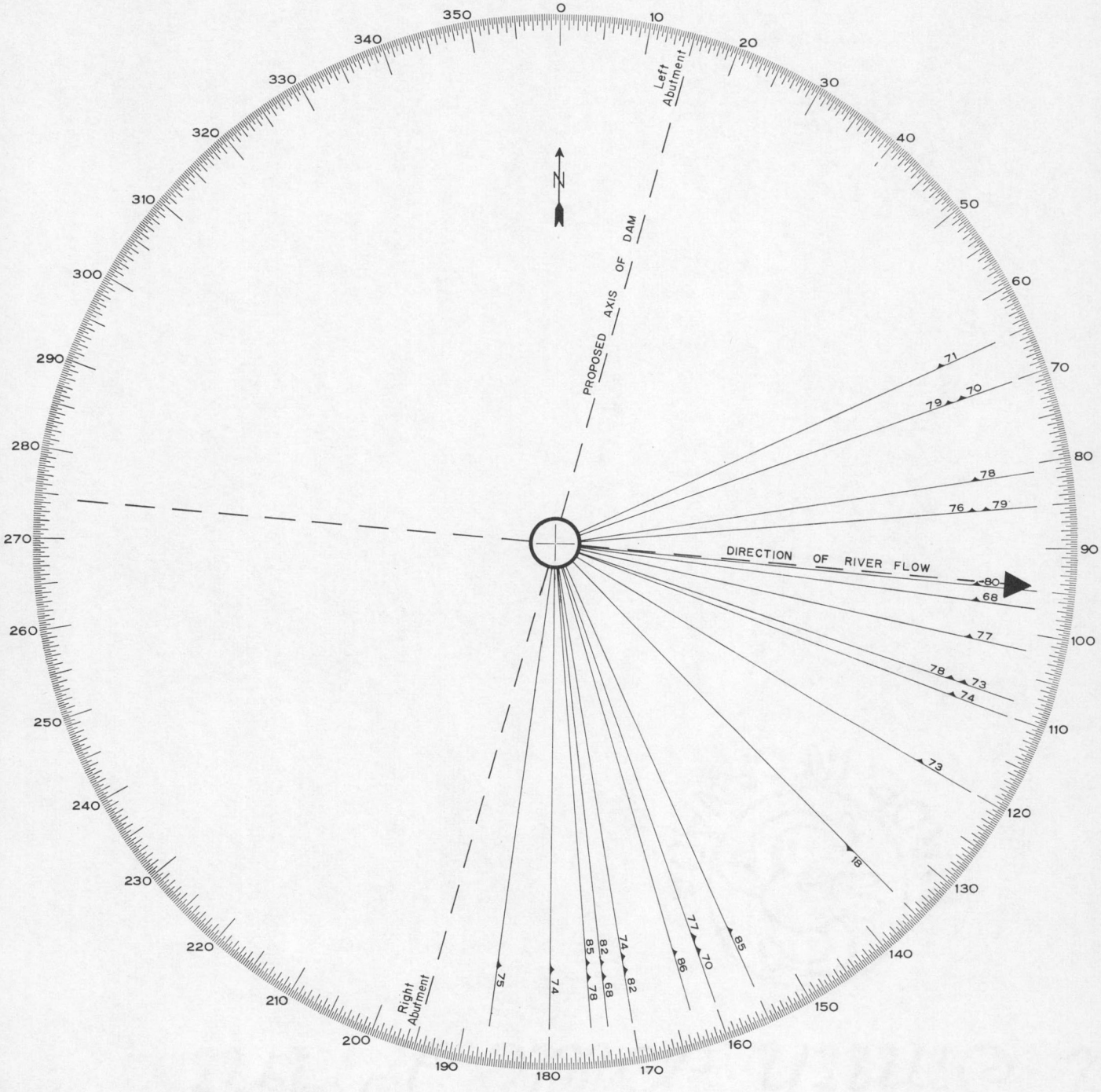
The weathered sandstone is a soft, friable, porous rock. The depth of weathering is unknown but is probably considerable because of the presence of numerous open fractures along the joint planes which greatly assist the penetration of weathering. It is believed a minimum of 25 feet of rock will have to be removed before fresh, solid rock against which concrete can be placed will be exposed.

The shale at the Upper site is a soft, easily weathered rock whose physical properties should be thoroughly investigated before its competency is evaluated. At the Lower site the shale contains minor amounts of sand with the result it is more competent and weathers less easily.



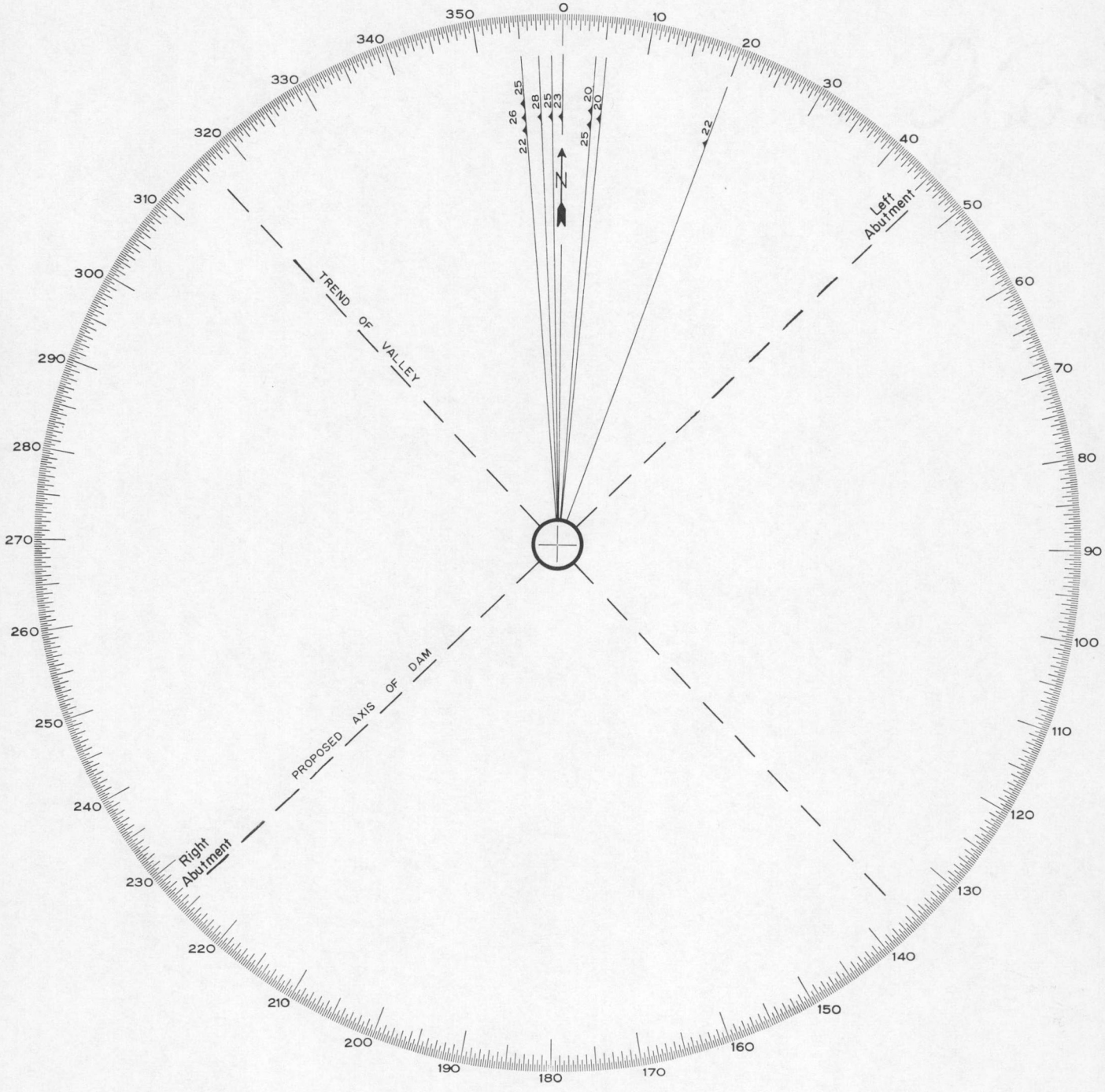
BEDDING ROSETTE

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



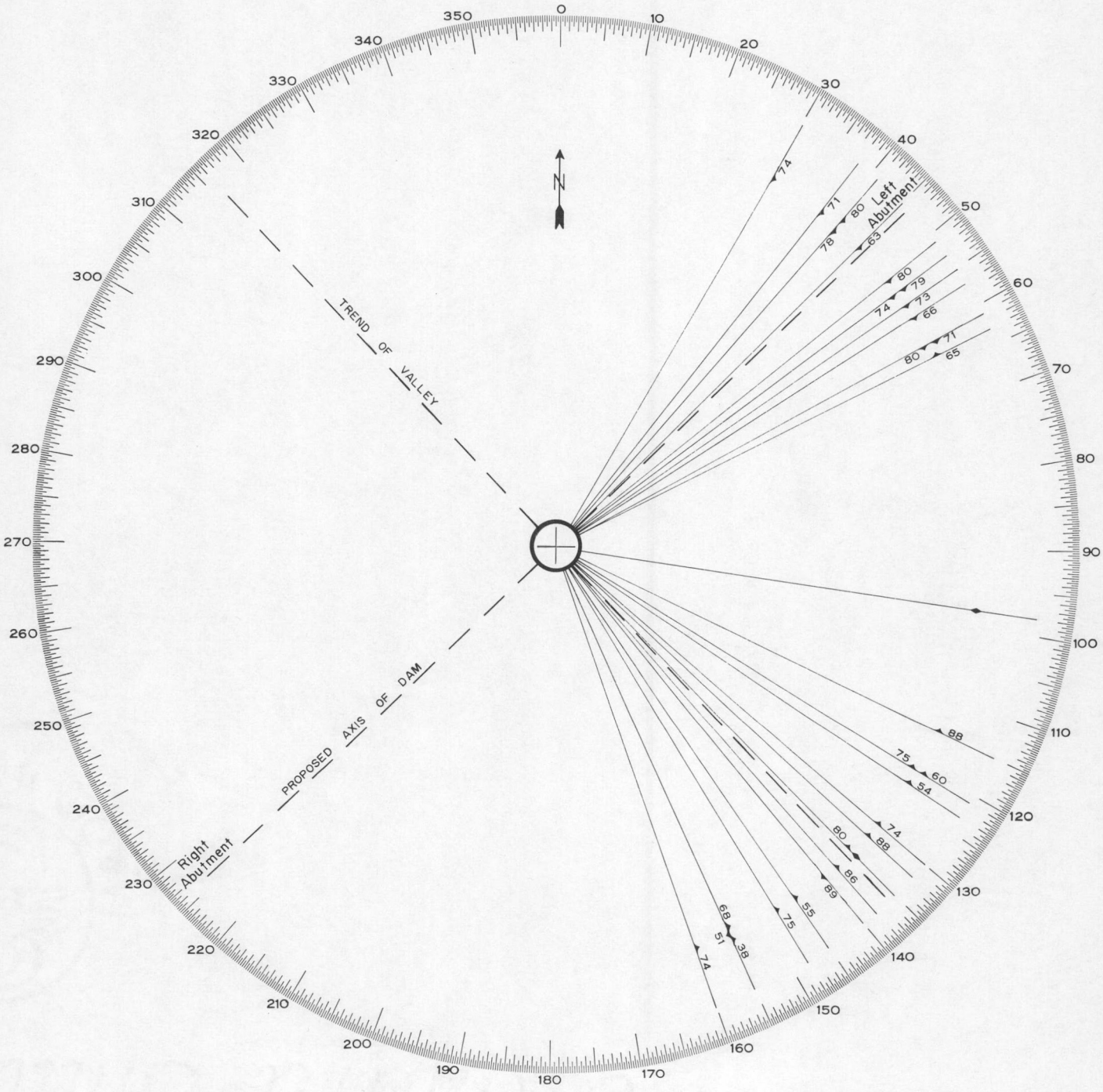
JOINT ROSETTE

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



BEDDING ROSETTE

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



JOINT ROSETTE

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

Engineering Considerations

Depth of Overburden

Overburden on the canyon walls at both sites consists chiefly of a thin deposit of talus which is nowhere believed to be greater than 10 feet in thickness. Mixed with the talus are quantities of gravel and silt which have slumped from deposits of these materials exposed along the tops of the bluffs. The average thickness of the black, clayey, residual soil which overlies the shale is about 3 feet. However, along the toes of the bluffs, accumulations of this material mixed with silt and gravel range up to 10 feet in thickness. The thickness of the silt and gravel deposits overlying bedrock at the sites is irregular. In places as much as 50 feet of these materials is visible in the upper part of the canyon walls. There is no information regarding the thickness of the overburden beneath the river. Test borings will be necessary here to determine the elevation of bedrock surface.

Proposed Centre Lines

Proposed locations for the centre lines for both dams are indicated on the accompanying geological maps. The centre line for the dam at the Upper site extends from near station X-7 on the left wall of the canyon at an approximate bearing of south 25 degrees west to the massive sandstone beds exposed in the right wall. Bedrock in the abutments is believed to be the most competent in the site area. Similarly at the Lower site the centre line was located to take advantage of the best possible bedrock conditions.

Abutments and Foundations

The sandstone exposed in the proposed abutments at the sites is situated between thick beds of shale which undoubtedly will be encountered during construction of the dam. At the Upper site the most obvious location for any diversion tunnel would be in the left abutment. Bedrock encountered in the tunnel would consist almost entirely of shale striking parallel to the tunnel and dipping 16 degrees southwest toward the river. The tunnel would have to be lined as the shale is an incompetent rock which disintegrates rapidly when exposed. The same shale beds extend upstream along the left side of the canyon to the upper end of the proposed power canal. Bedrock beneath the canyon floor at the Upper site is believed to be sandstone similar to that exposed in the abutments.

Less shale will probably be encountered at the Lower site than the Upper. Test borings will be required at both sites, however, to determine the extent of the two rock types and their relation to each other in the abutments.

Construction Materials

Aggregate

The coarse-grained, glacio-fluvial gravel which is exposed on both sides of the canyon where it immediately overlies bedrock is a potential source of natural aggregate. The material contains a high percentage (about 70 per cent by weight) of sandstone boulders which could be crushed to form part of the aggregate. However, it is suggested the

soundness and abrasion loss of the material be investigated as many of the boulders are badly weathered and the crushed material may be deleterious in coarse aggregate. The sand content in the gravel is low. Many of the sand-size particles consist of fragments of black shale. The grain size analyses curve included at the end of this report was prepared from a sample of gravel taken from near the top of the bluff along the left side of the canyon immediately downstream from the Upper site.

To utilize the gravel the overlying silt would have to be stripped. The average thickness of this deposit at the Upper site is about 4 feet. The thickness increases downstream so that at the Lower site it is about 10 feet thick and 40 feet at the east end of the Pass. The frost line in the silt is usually 2 to 3 feet beneath ground surface.

In the fresh, unweathered state the sandstone at both sites could be crushed to provide suitable coarse aggregate. The uniformity of the sand grains in the rock and the relatively poor bond suggests fine aggregate manufactured from the sandstone would probably be lacking in some sizes and blending sand will be required to obtain the proper grading.

Impervious Material

A potential source of material suitable for the impervious core of an earth- or rock-fill dam is the glacio-lacustrine silt which exists on the terraces above both walls of the canyon. The thickness of the deposit is variable. An extensive test pitting program should be conducted on the terraces to determine the quantity of material available. This would not be an easy task as the material is usually frozen close to ground surface.

The clayey, residual soil derived from the shale might provide suitable impervious material. The quantity of material available, however, is small.

Pervious Material

Material suitable for the pervious shells, filters or drains of an earth dam could be obtained from the gravel deposits described under the aggregate heading. The gravel would probably have to be screened, washed and reblended to produce the types of granular material required.

Riprap and Rock Fill

The non-calcareous sandstone or the calcareous type where it is not weathered should provide satisfactory riprap or rock fill. Rock fragments in the talus which have been derived from the more massive beds are frequently many feet in diameter. Much of the weathered sandstone is porous and consequently is believed to have a low durability. The results of laboratory tests to determine the physical properties of these rocks are included in a subsequent report describing one of the sites further east in McDougall Pass where similar rocks occur. The shale would not provide suitable riprap or rock fill.

Groundwater

There is little information regarding groundwater conditions in the areas about the proposed sites. Seepages were not observed in the canyon walls and there is no indication they have occurred in the past. In the unfrozen state the permeability of the glacio-fluvial gravel overlying

bedrock is probably high. However, in the exposures along the canyon walls there is no indication of the occurrence of groundwater in this material. The narrow, steep-walled valleys in the canyon walls were formed by intermittent streams originating on the terrace bordering the canyon.

Frozen Ground

Frozen ground exists at both site areas. Test pits put down on the terrace above the canyon and in the fine talus on the abutment slopes encountered the frost line at 24 to 36 inches (July 10, 1962). There is no information regarding the presence of frozen ground beneath the floor of the canyon. It is believed to exist, however, but at greater depths.

Comparison between Upper and Lower Rat Canyon Sites

It should be remembered this report is based upon a preliminary geological investigation designed to furnish the engineer with general geological information regarding the proposed dam site. The data compiled is only sufficiently precise to permit office studies and obtain general cost estimates. In the case of alternate sites, such as at Rat Canyon, it is sufficiently accurate to aid the engineer in determining the most economic and suitable site.

The results of the investigation indicate that, geologically, the two sites at Rat Canyon are similar. Consequently, some other criteria besides the geology will be needed to determine the most suitable site.

1. Topography

The topography at the two sites is similar. At each site Rat River is flowing through a relatively narrow, steep-walled canyon the walls of which are formed of bedrock covered to a great extent with a thin deposit of talus derived from the adjacent rock. Undulating terraces of similar elevation occur above each wall of the canyon.

2. Overburden

Overburden at the two sites is the same. It consists chiefly of Recent alluvium along the present course of Rat River and glacio-lacustrine silt overlying glacio-fluvial gravel in the upper parts of the canyon walls. The latter two deposits are potential sources of construction materials.

3. Bedrock

Bedrock exposed at the two sites is similar. It consists chiefly of a fairly massive to massive sandstone which in places has weathered to a soft, friable, porous rock. Soft, black, laminated shale occurs above and below the sandstone. The shale is extensively weathered and is seldom exposed at either site. It does, however, occur in all abutments and will be encountered during excavation at both sites.

4. Bedrock Structures

Jointing and bedding are the chief structures in bedrock at both sites. Faulting does not occur. Two prominent, steeply-dipping joint sets which intersect almost at right angles occur at the sites. The jointing exerts considerable influence on the degree of weathering of bedrock and

the manner in which bedrock breaks. At both sites the direction of the canyon is believed to be controlled to a large extent by the jointing. The bedding, in general, dips shallowly upstream or into the right abutments.

5. Depth of Overburden

The proposed abutments at both sites are covered with a mixture of fine and coarse talus and residual soil along with varying quantities of silt and gravel slumped from above. Except for local accumulations along the toes of the bluffs the thickness of this deposit seldom exceeds 10 feet. The thickness of the glacio-lacustrine silt and glacio-fluvial gravel overlying bedrock increases easterly along the Pass downstream from the Upper site. Consequently somewhat greater quantities of these materials are present at the Lower site than at the Upper. The thickness of the overburden beneath Rat River at the two sites should be about the same.

6. Construction Materials

The construction materials available in the vicinity of each site are the same. In fact the proximity of the sites to one another suggests the same sources of supply could be used for either site. There are unlimited quantities of silt and coarse-grained gravel available. However, the quality of these materials will have to be investigated to determine if they will be useful. It is suggested a rock-fill dam be considered for both sites.

Chemical Analyses of Rat River Water

During the 1962 field season samples of Rat River water were taken at Fish Creek dam site and at the point where Rat River leaves McDougall Pass and enters MacKenzie Delta. The samples were analysed for their mineral content by the Industrial Waters Section, Mines Branch, Department of Mines and Technical Surveys, Ottawa. The results of the analyses are included in the report on the Fish Creek site (Topical Report No. 71, site No. 8).

Grain Size Analysis Curve

The grain size analysis curve for potential aggregate included in this report was prepared in the Soils Laboratory of the Water Resources Branch in Vancouver. The sheet shows the following information:

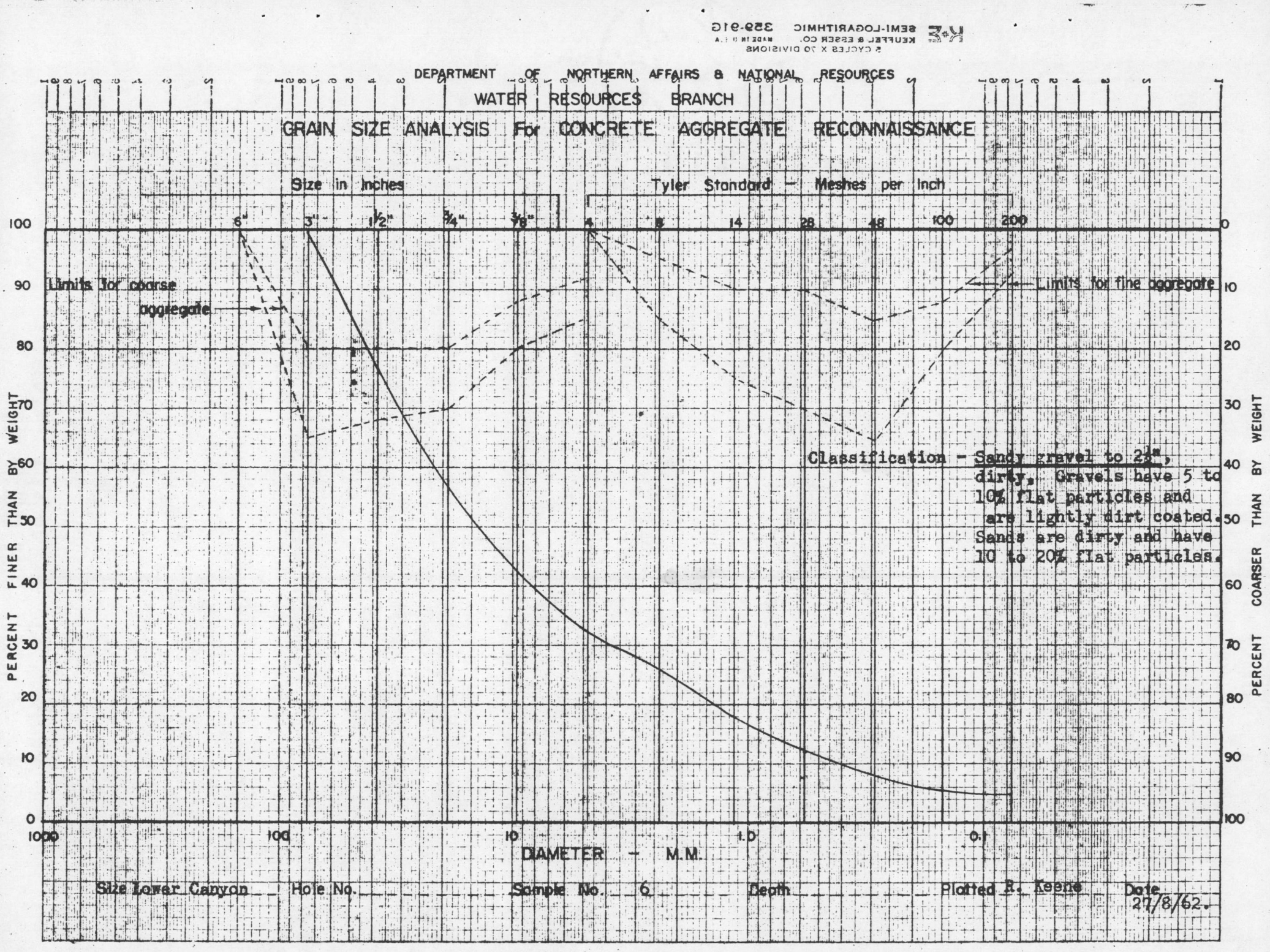
(a) Limits of coarse and fine aggregate based upon a 6-inch maximum size.

(b) A cumulative grain size curve for the sample.

(c) Curves showing the individual percentages of the coarse and fine fraction retained on each screen or sieve size. For these purposes the sample is divided at the No. 4 sieve into coarse and fine fractions.

Description of Potential Aggregate for the following Grain Size Analysis Curve

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
6	Left side of Rat Canyon; 200 feet downstream from Upper site area; 25 feet below top of bluff; 4 feet beneath ground surface.	Coarse-grained gravel; minor sand; stratified; considerable shale in sand-size particles; numerous rounded to subrounded boulders up to 24 inches; boulders are chiefly sandstone with 20 per cent quartzite and a few granites.	4+ feet of silt	50 feet	Unlimited	About 70 per cent by weight of the material consists of cobbles and boulders greater than 3 inches in diameter; easily accessible.


DEPARTMENT OF NORTHERN AFFAIRS & NATIONAL RESOURCES
WATER RESOURCES BRANCH
GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE
Size in Inches
Tyler Standard — Meshes per Inch
6"
3"
1½"
¾"
⅜"
4
8
14
28
48
100
200
Limits for coarse aggregate
Limits for fine aggregate
Classification - Sandy gravel to 2½", dirty. Gravels have 5 to 10% flat particles and are lightly dirt coated. Sands are dirty and have 10 to 20% flat particles.
PERCENT FINER THAN BY WEIGHT
PERCENT COARSER THAN BY WEIGHT
DIAMETER — M.M.
Size Lower Canyon
Hole No.
Sample No. 6
Depth
Plotted R. Keene
Date 27/8/62.

M-6

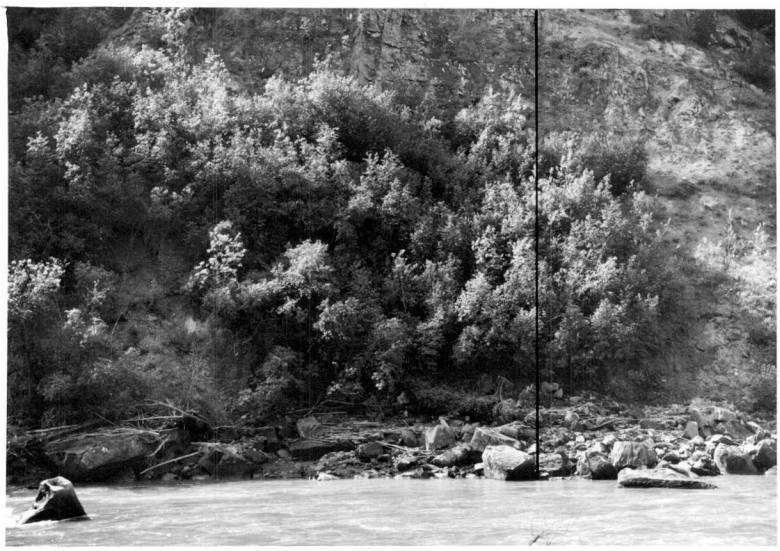


Plate 1

Lower part of right abutment, Upper Rat Canyon site, proposed centre line as indicated.

G.S.C. 18-5-62

Plate 2

Left abutment, Upper Rat Canyon site, proposed centre line as indicated.

G.S.C. 20-8-62

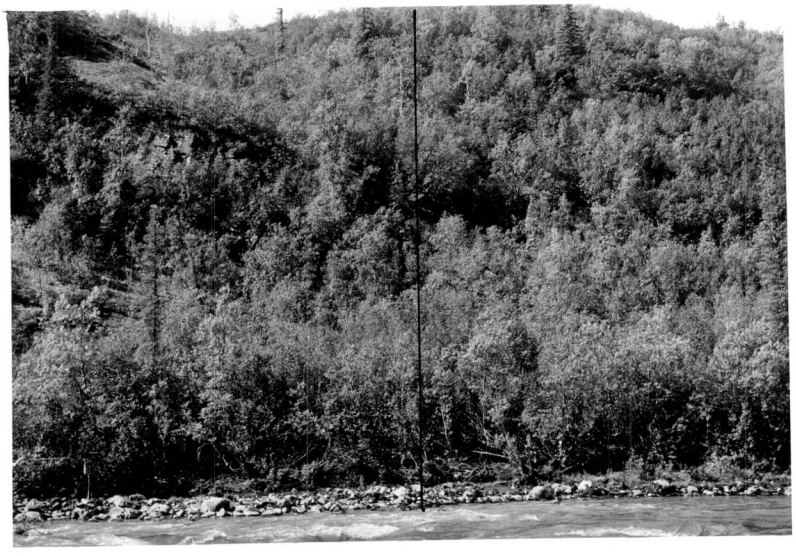


Plate 3

Right abutment, Lower Rat Canyon site, proposed centre line as indicated.

G.S.C. 25A-7-62

Plate 4

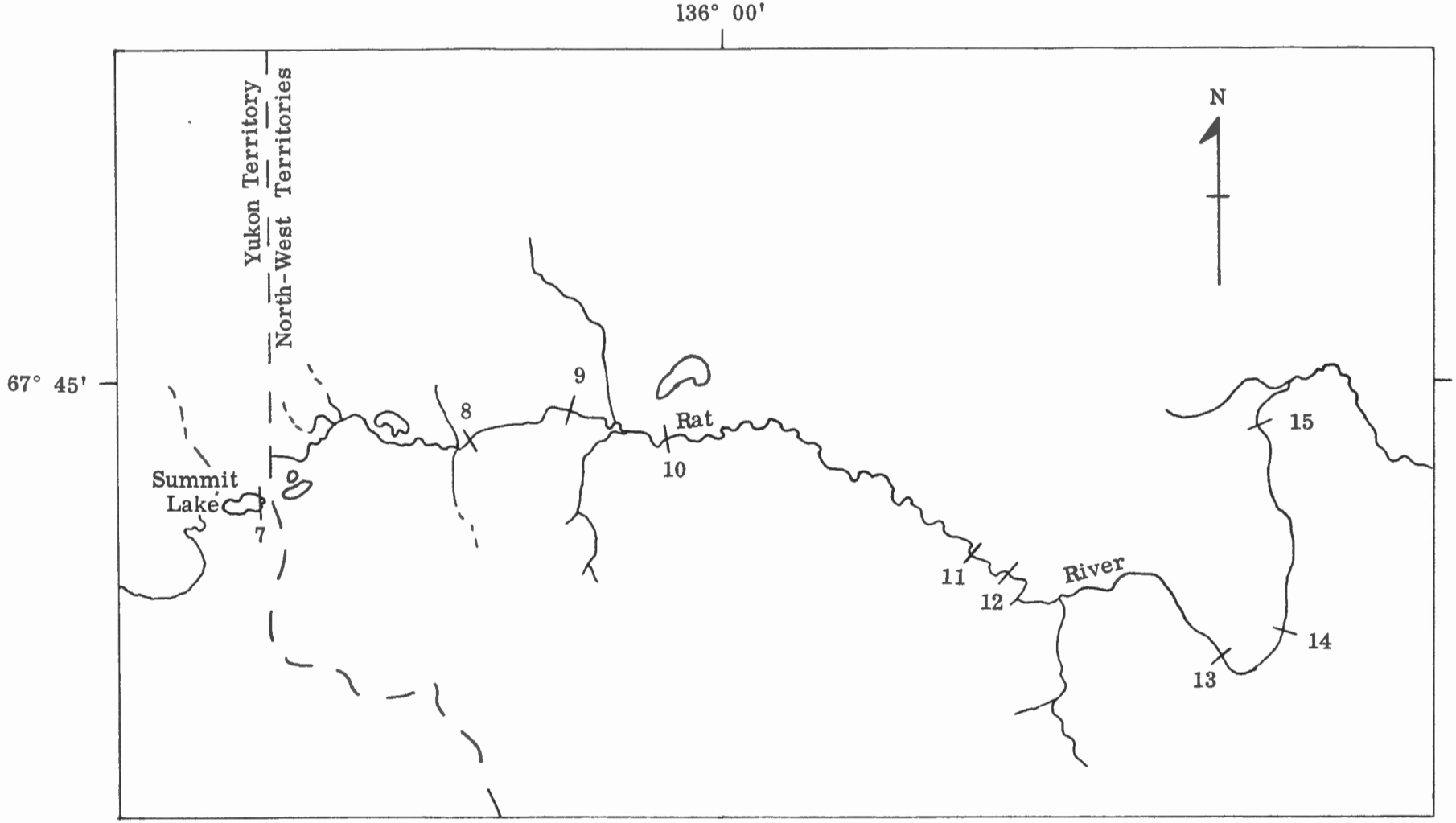
Left abutment, Lower Rat Canyon site, proposed centre line as indicated.

G.S.C. 28-4-62

Plate 5

Lower Rat Canyon site, looking upstream from downstream end of site.

G.S.C. 29-8-62



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

Site No.	Name	Site No.	Name	Site No.	Name
7 -	Summit Lake	10 -	Horn Lake	13 -	Barrier
8 -	Fish Creek	11 -	Rat Canyon (Upper)	14 -	Longstick
9 -	Bear Creek	12 -	Rat Canyon (Lower)	15 -	Delta