CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
TOPICAL REPORT NO. 103

MACKENZIE RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITE NO. 1

UPPER CANYON DAM SITE
(Frances River)

(MAP AND PRELIMINARY REPORT)

BY
E. B. OWEN

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Upper Canyon Dam Site (Frances River)

General Description

Upper Canyon dam site is located on Frances River, Yukon Territory about one mile upstream from the bridge over the Frances on the road to Canada Tungsten Mines. This road joins the road between the communities of Watson Lake Wye and Ross River at mile 67.5 from Watson Lake. The bridge is about 4 miles east of the junction of the two roads. False Canyon dam site described in Topical Report No. 40 is situated about 21 miles downstream. These sites along with Lower Canyon dam site located about 12 miles upstream from the junction of Frances and Liard Rivers were examined as part of an investigation by the Water Resources Branch of the Department of Northern Affairs and National Resources of the power potential of Frances River. Lower Canyon dam site is described in Topical Report No. 41.

The height of the dam at Upper Canyon site will depend, among other things, upon the amount of storage necessary for continuous operation of the plant. Frances Lake would doubtless be included in the reservoir area. The elevation of the lake is 2,393 (± 6) feet[1] whereas the elevation of Frances River in the upstream part of Upper Canyon is about 2,346. Consequently the minimum height of the dam would be about 62 feet above the water level of the river at the site. Like most lakes in mountainous areas Frances Lake is long and narrow and is confined between fairly steep slopes. For the most part its shores slope upward to a narrow terrace situated about 90 feet above the lake. A second, more prominent terrace exists about 300 feet above the lake. Both terraces as well as the intervening slopes are covered with varying

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[1] H.N. Spence: personal communication.

thicknesses of sand and gravel overlying till or bedrock. Considerable bank storage around the perimeter of the lake will be obtained from these permeable materials.

Geology of the Site Area

Frances River is in the Mackenzie River drainage basin. It flows from Frances Lake situated about 25 miles upstream from Upper Canyon dam site in a general southerly direction to its junction with Liard River 15 miles northwest of Watson Lake. The Liard joins the Mackenzie at Fort Simpson, N.W.T. Frances River is about 90 miles long and has an average gradient of 3.3 feet per mile. Its water is remarkably clear, probably due to the settling effect of Frances Lake along with the absence of silt deposits along its course and the fact that much of its water originates on the rocky slopes of Logan and Pelly Mountains which border the lake and the upper part of the river.

Frances Lake occupies a broad north-northwest trending valley which separates the Logan Mountains on the east from the Pelly Mountains on the west[1]. The valley forms a connecting link between Pelly Plateau to the north and Hyland Plateau and Liard Plain on the south. It is believed the last ice to occupy that part of the valley at Upper Canyon dam site originated in Logan Mountains and moved in a southerly direction. Frances Lake is held back by moranic accumulations on the valley floor and a fairly dense silty, sandy till overlies bedrock in the abutments at the site. This till is exposed along the sides of the valley for several miles upstream and downstream from the site. It is probably of a different origin to the till on Liard Plain which is exposed at Lower Canyon dam site and in cuts along the Alaska Highway and the

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[1] Bostock, H.S.: Physiographic subdivisions of the Canadian Cordillera north of the fifty-fifth parallel; map 922A, Geol. Surv. Can., 1947.

road between Watson Lake and Frances River. The latter till contains numerous fragments of porous, volcanic rocks which are absent in the till at Upper Canyon dam site. It is believed to have originated in the Cassiar Mountains and to have moved in a general southeast direction across the plain.

Excavations for the south approach to the bridge* over Frances River exposed a soft blue-grey, clayey till-like material directly overlying soft, shaly bedrock and overlaid by silty, sandy till. The contact between the two unconsolidated materials was distinct. There was not sufficient evidence to indicate the materials were products of different advances of the ice. The soft, blue-grey material may have resulted from wearing away (ablation) of the underlying shale by the ice at the same time that the coarser-grained material was being deposited. Consequently the blue-grey material may not be an extensive deposit but will only occur in areas underlaid by shale.

Bedrock exposures are not common along Frances River. The areas where most of the exposures occur are described in the reports on the three dam sites proposed for the river. The rock consists chiefly of metamorphosed sediments; schist, quartzite and argillite, interbedded with limestone, chert and minor conglomerate. Most of the limestone occurs at Lower Canyon dam site. The only published description of bedrock is by Dawson[1] who in 1887 ascended Dease, Liard and Frances Rivers to Frances Lake. Bedrock is also exposed in the valleys cut down by tributary streams such as Finlayson River which flows into Frances Lake.

Alluvium and till are the main unconsolidated materials exposed along Frances River. The alluvium covers the valley floor while the till occurs on the steep slopes which form the sides of the valley. On the upper parts of the slopes irregular deposits of glacio-fluvial sand and gravel frequently overlie

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[1] Dawson, G.M.: Report on an exploration in the Yukon District, N.W.T. and adjacent northern portion of British Columbia, 1887; Geol. Surv. Can., 1898.

* 32 miles north of Watson Lake.

the till. These can be seen in several cuts along the Canada Tungsten Mines road between Frances River and the Watson Lake - Ross River road. The extensive deposits of fine-grained sand exposed along the Watson Lake - Ross River road about a mile north of the bridge over Frances River are also believed to be glacio-fluvial in origin.

Engineering Geology of the Dam Site

Upper Canyon dam site area is located in the centre part of a mile long canyon on Frances River. Geological conditions throughout the canyon are similar. Consequently from the viewpoint of geology the dam could be located anywhere along the canyon. The centre part was chosen because here the walls are highest and thus lesser amounts of excavation and fill would be necessary in construction of the dam.

At the site the river which is flowing in an easterly direction is confined between two steep, rocky bluffs which rise abruptly from the edge of the river. The abutments of the dam will be located in the bluffs. The height of the bluff along the left (north) side of the river is greater than 130 feet. Except for a small alluvium-covered terrace in its upstream part the slope is continuous upward from the water to a gently undulating plain which extends north beyond the top of the bluff. Bedrock is exposed almost continuously along the lower part of the left abutment and extends upward to a maximum elevation of 2,435 or 90 feet above the river. The upper part of the abutment consists of silty, sandy till which directly overlies bedrock and extends onto the plain above the slope. A representative sample of this material was sent to the soils laboratory of the Water Resources Branch in Vancouver. The resulting grain size analysis curve is included at the end of this report along with a description of the material in the sample.

Several bedrock outcrops separated by areas of talus occur along the lower part of the right wall of the canyon. The slope up from the river

is steep to a height of about 60 feet and then flattens to a gently sloping bedrock terrace which extends beyond the limit of the area mapped. The terrace is partly covered by talus and partly by alluvium overlying till. It has the same elevation as the alluvium-covered terrace on the upstream end of the left wall of the canyon and was probably formed at the same time.

Schist, which varies from a silvery-grey to a black, graphitic rock, constitutes about 75 per cent of bedrock exposed at the dam site. Interbedded with the schist are massive beds of black chert up to 10 feet in thickness and smaller quantities of fine-grained, dark grey to black limestone and fine-grained, grey quartzite. The limestone which is a competent rock is exposed for about 300 feet along the right edge of the river and also in several small, rocky islands in the river. The dip is northerly beneath the river and consequently little is exposed along the left side.

The competency of bedrock at the dam site is questionable and more information is needed before it can be decided if it will provide satisfactory foundation and abutment material. The least competent rock is the black, graphitic schist which occurs as scattered lenses up to 24 inches in width and 50 feet in length. Much of the grey-silvery schist which is the most common rock at the site is a hard, competent rock. The limestone, chert and quartzite present are also competent but are frequently interbedded with soft schist which has the effect of lowering the competency of the rock mass. Test borings will be necessary to determine the extent of the soft zones.

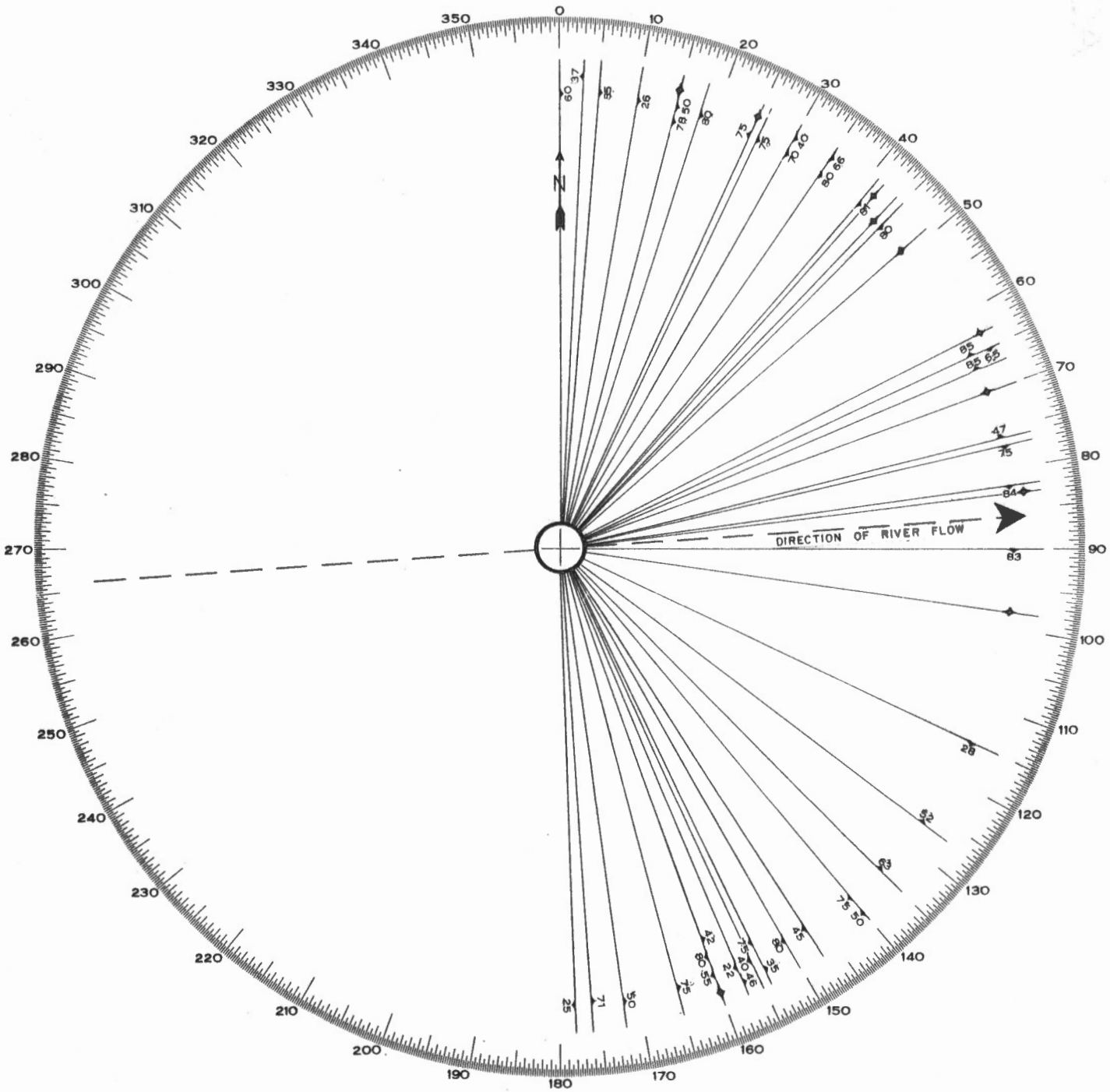
On surface bedrock is badly broken and weathered especially in the more schistose parts. The weathered material consists of clayey residual soil containing small, angular rock fragments. It grades downward into more solid rock. The broken condition of the surface rock is due to numerous closely spaced joint fractures along with a large number of faults which are common throughout the dam site area. Some faults are small with a displacement measured in inches, others are large with considerable quantities of gouge

and broken rock associated with them. Many are bedding faults which frequently occur along the contacts of the schist and chert beds. The permeability of the gouge which is almost always clayey is low. Its presence could influence the movement of groundwater through the rock. The general strike of the bedding is east (parallel to the river) and the dips are usually low and in a northerly direction. However, the presence of numerous local folds has resulted in many deviations from the general bedding attitudes. These are indicated on the bedding rosette which accompanies this report.

Three different types of unconsolidated materials were identified at the dam site.

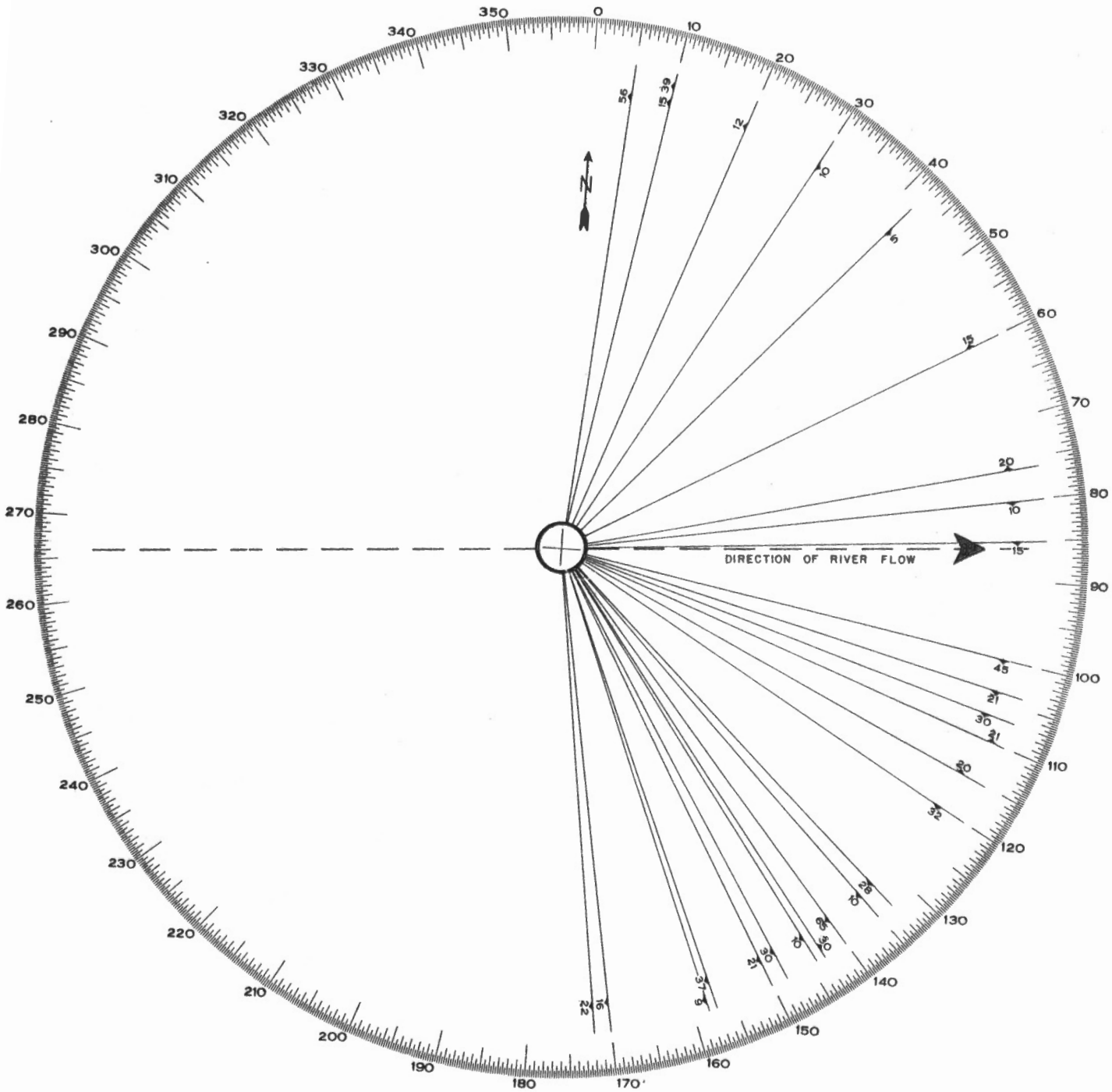
Alluvium consisting of fine-grained, uniform sand occurs on the bedrock terraces some 60 feet above the present river. This material is believed to have been deposited by Frances River when the river was flowing at a higher elevation before it settled into its present channel. The thickness of the alluvium ranges from 2 to 3 feet. It usually overlies bedrock although till was observed beneath it in some test pits put down on the terrace south of the river. The alluvium may have some use as a construction material. The quantity available in the site area is small but larger volumes may exist on similar terraces along both sides of the river upstream from the site.

The talus derived from bedrock at the dam site consists of relatively small rock fragments mixed in places with minor quantities of residual soil. The size of the fragments varies from clay-size particles to boulders 12 inches in diameter. The fragments derived from the schist are usually platy whereas those from the more massive chert, limestone and quartzite are blocky in character. It is doubtful if the talus has any use as a construction material. The unfavorable size and shape of the fragments indicates bedrock will not provide suitable riprap or rock fill. Accumulations of large, rounded quartz monzonite and granodiorite boulders are scattered along the toes of the talus slopes. Many are more than 3 feet in diameter. It is believed these boulders



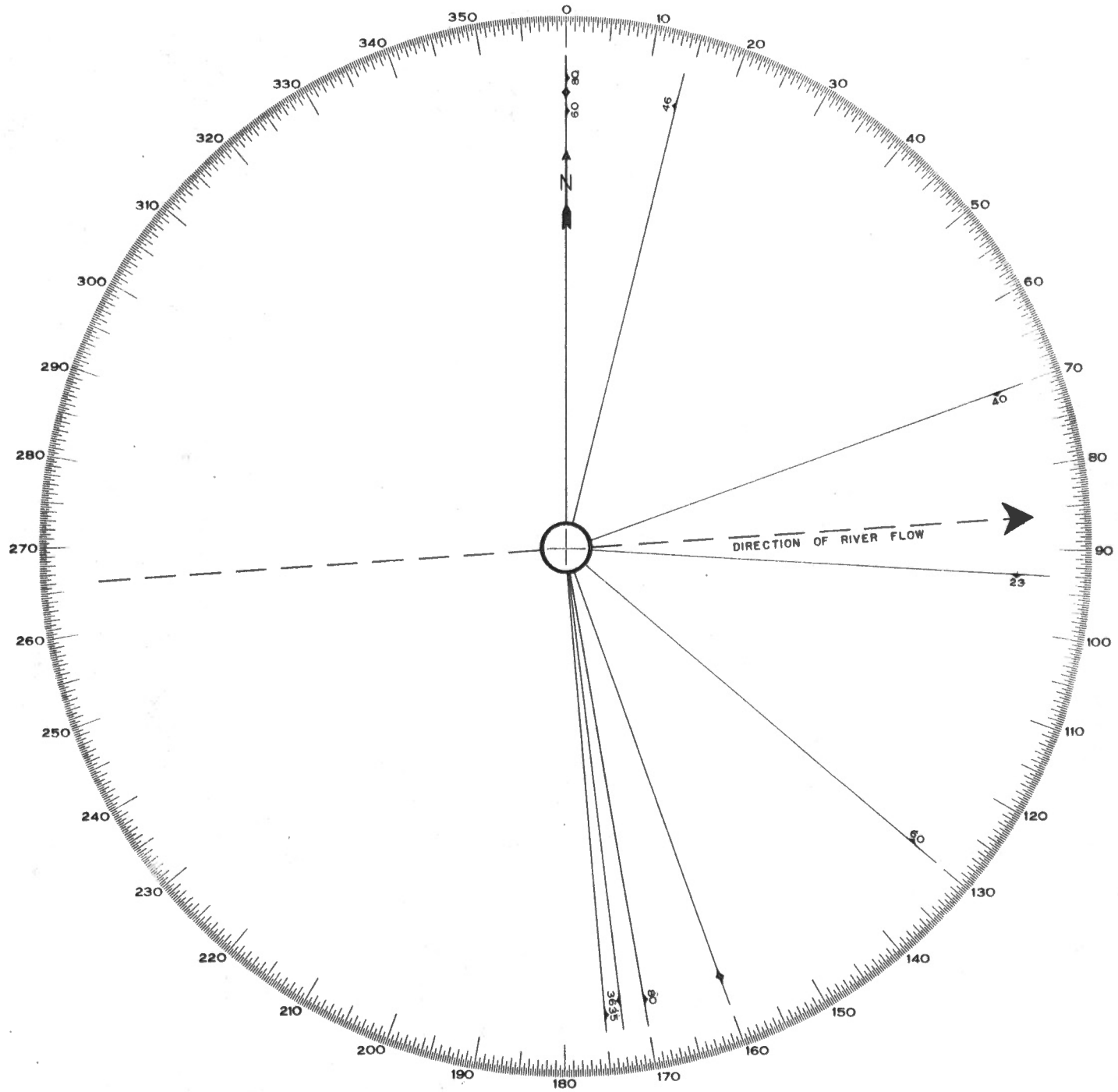
JOINT ROSETTE

The above illustration presents diagrammatically the direction and dip of the jointing in bedrock exposed at Upper Canyon site, Frances River



BEDDING ROSETTE

The above illustration presents diagrammatically the direction and dip of the bedding in bedrock exposed at Upper Canyon site, Frances River



FAULT ROSETTE

The above illustration presents diagrammatically the direction and dip of the faulting in bedrock exposed at Upper Canyon site, Frances River

have come from the till although some of the larger may be from glacio-fluvial deposits overlying the till.

The till at Upper Canyon dam site consists of a fairly dense, silty, sandy material containing rounded to subrounded boulders up to 30 inches in diameter. It is exposed along the top of the left abutment slope where it overlies bedrock. Most of the boulders consist of light grey, medium-grained granodiorite and quartz monzonite with lesser amounts of dark quartzite and local schist. The permeability of the till mass is believed low. There is no evidence that sand or gravel deposits exist either in the material or along its contact with bedrock.

The till is an extensive deposit and there are unlimited quantities available close to the dam site. About 25 per cent by volume consists of boulders greater than 12 inches in diameter. It is believed the till will produce an impervious material with satisfactory shearing strength but removal of the boulders will be necessary in order to compact the soil satisfactorily.

The thickness of the overburden at the dam site varies from 2 to 3 feet on the terraces where alluvial sand directly overlies bedrock to 80+ feet in the upper parts of the abutment slopes where till occurs. The talus is believed to be nowhere greater than 10 feet in thickness. Bedrock is exposed as small rocky islands in the river indicating the depth of overburden in the present channel of the river is not great.

Construction Materials

There is a shortage of coarse-grained, pervious materials suitable for aggregate, blankets, filters and drains in the dam site area. The nearest deposits observed occur along the Canada Tungsten Mines road between the bridge over Frances River and the road joining the communities of Watson Lake Wye and Ross River. Similar materials may exist above the right abutment south of the

site area. The till at the site could be used for embankment or core material. There are unlimited quantities available close to the site. It is doubtful if suitable riprap or rock fill could be obtained from bedrock exposed at the site.

Conclusions

The following conclusions have been made as a result of this preliminary geological investigation of Upper Canyon dam site on Frances River:

1. Bedrock consists of metamorphosed sedimentary rocks of which a silvery-grey, quartz schist is the most common.

2. The surface rock is badly broken and highly weathered. This is due to the presence of many, closely spaced joint fractures and to several faults which intersect the jointing.

3. More information is required before the competency of the rock can be determined. Bedrock in the upstream part of the site area is believed to be the most competent and it is here that any test borings put down to determine the quality of the rock at depth should be first located.

4. The location and depth of the test borings should be designed to obtain the following information: (a) The presence and extent of any soft, black, graphitic schist zones. These rocks are slippery and could cause sliding in the foundations or abutments. (b) The depth to sound, fresh rock. The presence of numerous joints and faults has facilitated rock decay and may have occasioned much unsound rock. (c) The extent of the competent limestone beds which outcrop along the right edge of the river and dip beneath the left abutment.

5. It is doubtful if suitable riprap or rock fill could be obtained by quarrying bedrock at the site. Satisfactory aggregate could not be obtained by crushing the rock.

6. The till at the site could be used as embankment or core material for an earth dam.

7. It is believed the nearest place to prospect for natural aggregate is in the area south of the right abutment.

8. Overburden at the proposed site is relatively thin and consequently the dam will be founded on bedrock. If the dam is higher than bedrock surface in the abutments the overlying till should be satisfactory as abutment material.

9. There is little information concerning groundwater conditions in the dam site area. In no place were seepages or springs observed in the walls of the canyon. Many of the rock fragments in the fault zones have a thin coating of iron-bearing carbonate which may have been deposited by circulating groundwater. A similar deposit frequently occurs on rock surface exposed in open joint fractures.

10. The frost line was encountered from 8 to 24 inches below ground surface in several test pits dug on the terrace on the right abutment (August 25, 1963). This is a north-facing slope. It usually occurred beneath several inches of moss and decayed organic material.

11. It is possible a control dam similar to that proposed for Kathleen Lake (Topical Report No. 27) could be constructed at the south end of Frances Lake to regulate the flow of water to the power dam at Upper Canyon. There is no lack of overburden suitable for construction of a low-head dike in this area. The right abutment could be located in bedrock which outcrops along the edge of the river where it leaves the lake.

Chemical Analyses of Frances River Water

On August 25, 1963 a sample of Frances River water was taken from the centre of the river in the downstream part of the dam site area. The sample was analyzed by the Industrial Waters Section, Mines Branch, Department of Mines and Technical Surveys, Ottawa. The results of this analysis along with similar analyses of Frances River water taken in 1961 at False Canyon and at Upper and Lower Canyon sites are included in the following pages.

The analyses indicate that Frances River water is not hard and the main mineralization is bixcarbonate salts of calcium and magnesium. There are no salts present in sufficient quantity to be harmful to the concrete parts of the structures. The mineral content shows a gradual increase downstream. As no large streams enter the river along its course between Frances Lake and Liard River, this increase is probably due to the addition of groundwater which usually has a higher mineral content than surface water. The analyses of the samples taken during the month of August in 1961 and 1963 at Upper Canyon dam site are similar. This suggests there is little yearly change in the mineral content of the water.

Chemical Analyses of Frances 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 $CaCO_3$
Lower Canyon dam site; centre of river; 12 inches beneath surface of water	July 23, 1961	Medium ——— Temp. 56°F.	7.6	6.5	20.7	4.9	1.1	0.5	0.04	0.0	74.5	12.6	1.0	0.11	0.4	0	71.8
False Canyon dam site; centre of river; 12 inches beneath surface of water	Aug. 9, 1961	Medium low ——— Temp. 60°F.	7.5	5.3	20.1	4.5	1.2	0.4	0.01	0.0	70.9	11.4	0.4	0.05	Tr.	0	68.9
Upper Canyon dam site; centre of river; 12 inches beneath surface of water	Aug. 12, 1961	Medium low ——— Temp. 57.5°F.	7.5	5.4	19.3	4.8	1.0	0.4	0.01	0.0	67.5	11.2	0.3	0.05	0.0	0	67.9

Chemical Analyses of Frances 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 $CaCO_3$
Upper Canyon dam site; centre of river; 12 inches beneath surface of water	Aug. 25, 1963	Low ——— Temp. 59.5°F.	7.7	4.7	19.1	4.9	0.9	0.4	Tr.	0.0	68.0	12.6	0.2	0.11	Tr.	0	68.0

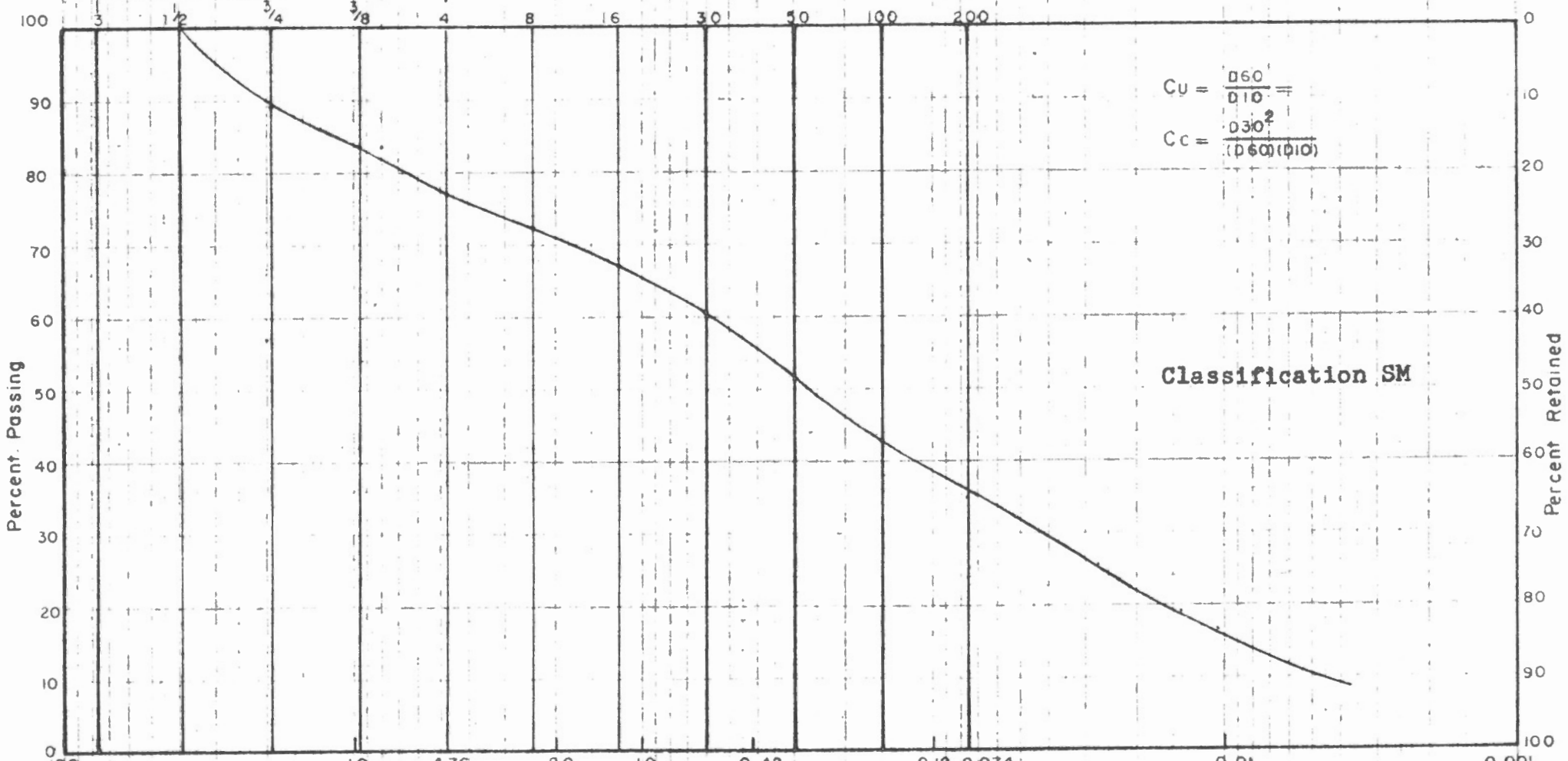
Description of Potential Impervious Material for the Following Grain Size Analyses Curve

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
41	15 feet from top of left abutment directly above station G-3; 36 inches beneath ground surface.	Till: silty, sandy, minor clay; dense; numerous rounded to subrounded cobbles and boulders up to 30 inches, chiefly granitic, dark quartzite and schist; larger boulders are granitic; very little weathering.	None at point of sampling.	40 feet at point of sampling.	Unlimited in area adjacent to dam site.	Till directly overlies bedrock.

DEPARTMENT OF NORTHERN AFFAIRS & NATIONAL RESOURCES

WATER RESOURCES BRANCH

GRAIN SIZE ANALYSIS

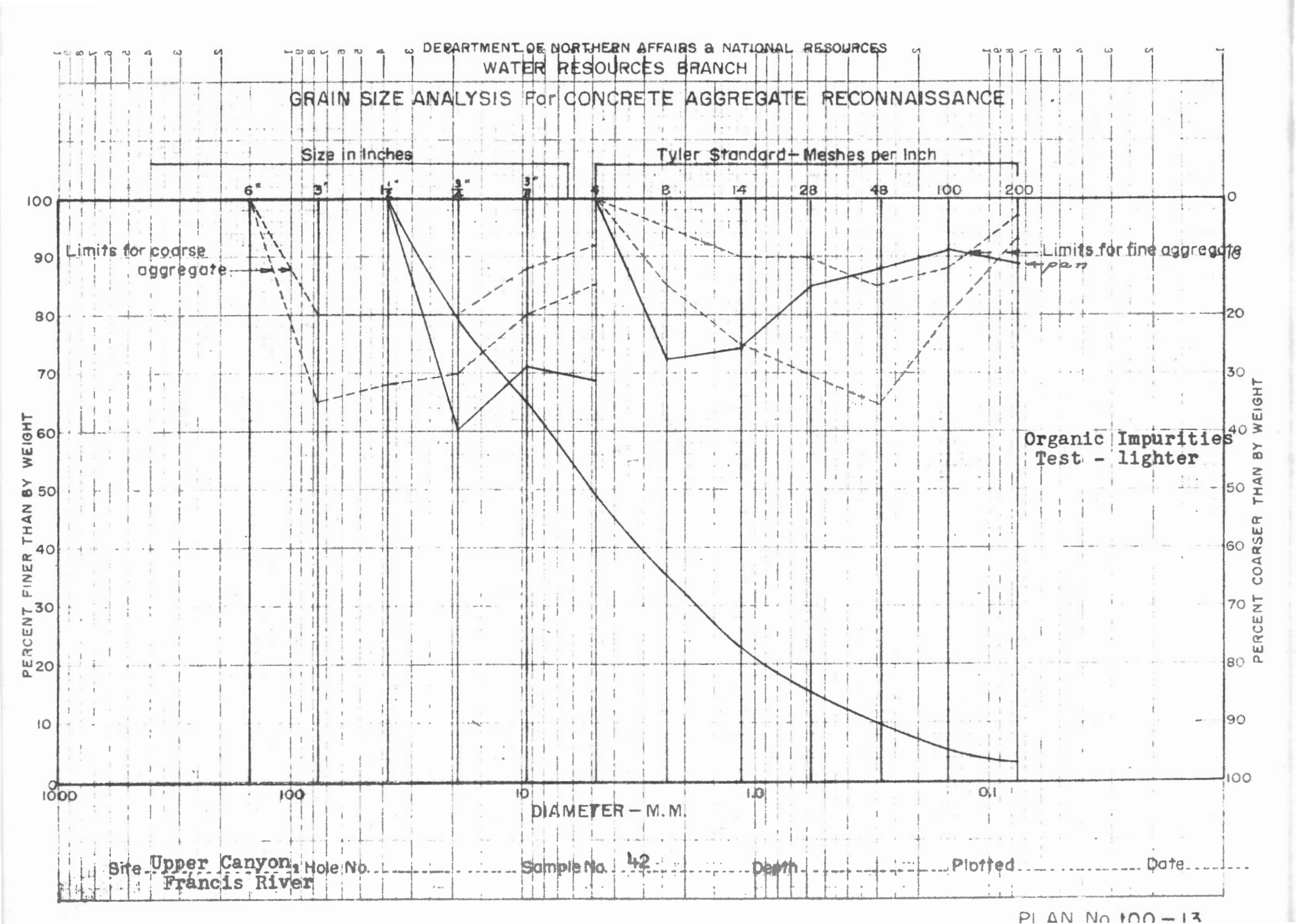


Site Upper Canyon, Francis River Pit Sample 41 Depth Plotted

PLAN

Description of Potential Aggregate for the following Grain Size Analyses Curve

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
42	200 feet south of Canada Tungsten Mine Road, 3/4 mile east of Watson Lake-Ross River road; 5 feet beneath ground surface.	Gravel: sandy, minor silt, well graded; largest rock fragments are about 6 inches in diameter; indistinctly stratified. Pebble and cobble lithology Quartz, granitic..60% Limestone, chert, shale.....25% Quartzite, schist, gneiss.....15%	0-8" - moss 8-11"- volcanic ash. 11-36"- gravel, highly weathered. 36"+ - gravel, fresh.	6 feet visible in road cuts.	Unlimited	Upper 18 inches highly weathered.



PLAN No 100 – 13

Plate 1

Bridge over Frances River on Canada Tungsten Mines Road about one mile downstream from Upper Canyon dam site.

G.S.C. 9-8-63

Plate 2

View looking upstream toward lower end of Upper Canyon, Frances River.

G.S.C. 10-1-63

Plate 3

View looking upstream into Upper Canyon from its lower end.

G.S.C. 10-2-63

Plate 4

View looking upstream through Upper Canyon from station G-2 located on the left abutment near the centre of the dam site area.

G.S.C. 10-3-62

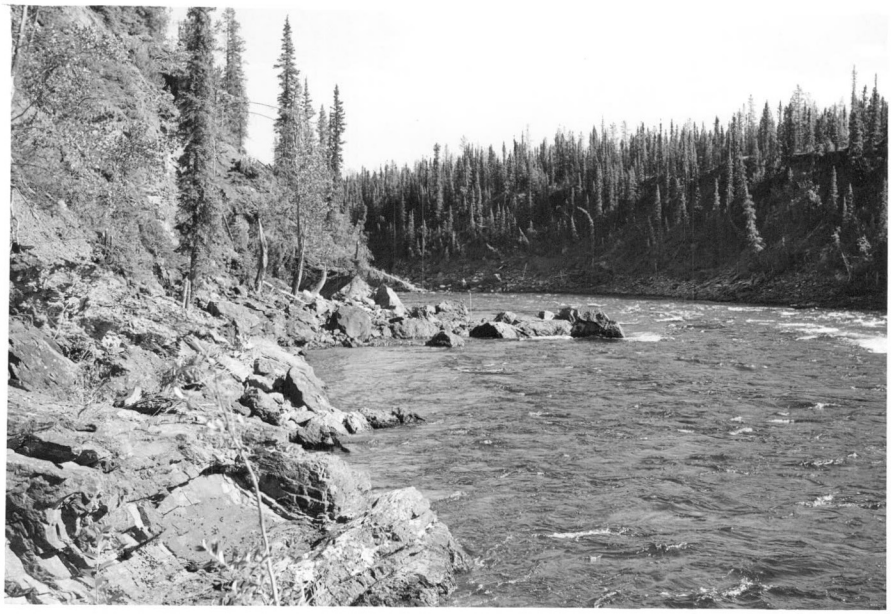
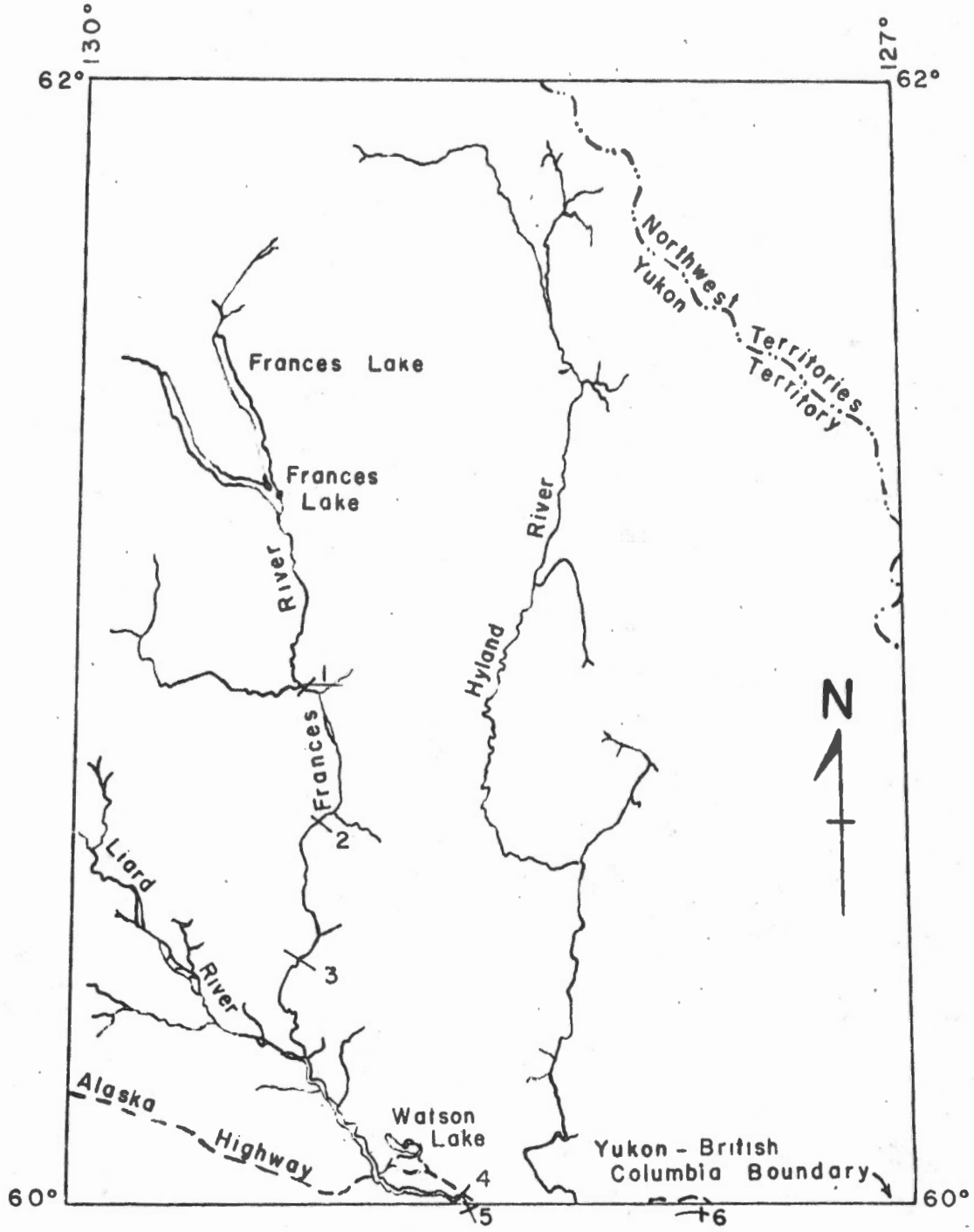


Plate 5

View looking downstream along rocky toe of left abutment, Upper Canyon dam site.

G.S.C. 10-4-63



LOCATION OF PROPOSED DAM SITES
MACKENZIE RIVER DRAINAGE BASIN
Scale 1 inch = 20 miles

Site No.	Name	River
1 —	Upper Canyon	Frances
2 —	False Canyon	Frances
3 —	Lower Canyon	Frances
4 —	Liard Canyon(upper)	Liard
5 —	Liard Canyon(lower)	Liard
6 —	Contact Creek	Liard