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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
TOPICAL REPORT NO. 39

YUKON RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITE NO. 28

ROSS CANYON DAM SITE
(MAP AND PRELIMINARY REPORT)

BY
E. B. OWEN



OTTAWA
1961

Canada

Department of Mines and Technical Surveys

Geological Survey of Canada

Topical Report No. 39

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Dam Site Investigation

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Ross Canyon Dam Site

General Description

Ross Canyon dam site is situated on Ross River about 4 and one-half miles upstream from its junction with Pelly River. The Canol Road which connects the community of Johnson's Crossing at mile 837, Alaska Highway with Norman Wells in the Northwest Territories follows the right side of the River through the area mapped. The location of mile post 368 is indicated on the accompanying geological map. Ross River is not navigable except for that part extending upstream for about one mile from its mouth. Presently the site is accessible from the community of Ross River located at the junction of Ross and Pelly Rivers by walking along Canol Road. The occurrence of several slides which, in some places, have covered the Road with considerable thicknesses of debris prevent the use of vehicles. However, for the most part Canol Road is in excellent condition and with the removal of the slide material should provide satisfactory access to the proposed site from the community of Ross River. Here Pelly River can presently be crossed in the summer only by means of a foot bridge.

At the site the River is flowing in a southerly direction between two steep bluffs, 600 to 900 feet apart, which form the abutments of the proposed dam. The average width of the River is about 200 feet. The elevation of the surface of the water drops about 7 feet as the River passes through the canyon. The temperature of the water about 12

inches below the surface was 53 degrees Fahrenheit on July 6, 1961.

Bedrock, which is exposed only on the bluff along the right (west) side of the River consists of altered, basic, igneous rocks, chiefly andesite with some basalt.

Till constitutes the greater part of overburden exposed at the site. Ground surface along the base of the bluffs, especially west of the River near Canol Road, is covered with till-like, slumped material of sufficient thickness it was not possible to determine the character of the underlying material by test pitting. There is evidence a downslope movement of surface material is taking place on both abutment slopes. Open tensile cracks, up to 2 inches in width, frequently occur in the upper parts of both slopes. The cracks are usually parallel to the topography. Also the trunks of trees located on the bluffs are often curved upward.

On the left (east) side ground surface ascends steeply from the edge of the River to a height of about 180 feet (elevation 2,500). On the same side a narrow, discontinuous terrace some 30 feet above Ross River was probably formed by the River when it flowed at a higher elevation. Above the bluff a fairly level terrace covered in part with glacio-lacustrine silts extends eastward beyond the limit of the area mapped. A less pronounced terrace with a somewhat higher elevation occurs above the bluff west of the River.

Little is known regarding the thickness of overburden throughout the site area. It is believed to be relatively thin in the

vicinity of the bedrock exposures west of the River. Test borings will be required to accurately determine the elevations of bedrock surface throughout the site area.

Materials believed suitable for the impervious core of an earth-fill dam and for riprap and rock fill are readily available. There is a lack of natural aggregate.

Unconsolidated Deposits

Six types of unconsolidated deposits were identified in the area about the proposed Ross Canyon dam site. These are as follows:

1. Recent Alluvium (silt, sand, gravel): This material has been deposited by the present River. It consists chiefly of silt, sand and gravel with boulders up to 24 inches in diameter. It occurs as a narrow floodplain deposit along both sides of the River up to approximate elevation 2,318. The limited quantity available prevents the alluvium from becoming an important source of construction material.

2. Talus: A small quantity of talus occurs along the base of the north side of the rock knob which forms the right abutment. The rock fragments vary from sand-size particles to boulders several feet in diameter. The quantity presently available is not sufficient to provide riprap or rock fill for a dam; but the size and shape of the rock fragments indicates suitable material could be quarried from bedrock exposed at the site.

3. Alluvium (silt, sand, gravel): This material occurs along the right side of Ross River in the downstream part of the area mapped. It was probably deposited by the River at a time when it flowed at a higher elevation. The highest elevation at which the alluvium was identified was about 2,460.

The material consists of silt, sand and gravel containing boulders up to 10 inches in diameter. It is similar to the Recent Alluvium except for a slightly higher percentage of sand-size particles. In some places it is relatively dense and till-like in appearance. The alluvium is believed to be unimportant as a construction material.

4. Glacio-Lacustrine (sandy silt): This material consists of a yellowish-brown, thinly-bedded, sandy silt. It is considered to have been deposited in the bottom of a temporary lake formed by the impounding of silt-laden melt waters flowing from a waning ice sheet. The silt covers the terraces above the bluffs on both sides of the River. In some localities a thin layer of disturbed silt covers the abutment slopes. This material probably moved down the slope from the terrace and is not in place. The silt is a shallow deposit. It is believed it would provide suitable material for the impervious core of an earth-fill dam. However, the quantity available is relatively small compared to the volume of till present at the site.

5. Glacio-Fluvial (sand): This material consists of fine- to coarse-grained sand with minor quantities of gravel-size material. It

is exposed on the bluff east of Ross River in the upstream part of the area mapped. It frequently underlies the thin deposit of glacio-lacustrine, sandy silt which covers the upper terraces both east and west of the River. It probably directly overlies till. Small, irregular lenses of similar sand occur in the till exposed in the bluffs along both sides of the River. The permeability of the sand, computed in the field, was in the order of 10^{-3} centimetres per second (Sample No. 33-A). The high permeability is due to the poor grading of the material and the absence of silt- and clay-size particles.

6. Till: Till constitutes most of the material exposed on the two bluffs which parallel Ross River in the site area. It is a dense, grey, silty, clayey material which contains a large number of small, black, chert pebbles. The upper 24 inches of the till are usually weathered to a yellowish-brown color. The dry strength is high, indicating a relatively large clay content. The till directly overlies bedrock exposed in the right abutment area. It is believed the till is a potential source of material for the impervious core of an earth-fill dam. The quantity available is unlimited as the till extends for many miles along both sides of Ross River upstream from the site. A representative sample (No. 29) was forwarded to the Soils Laboratory of the Water Resources Branch in Vancouver for a grain size analysis. The resultant curve is included at the end of this report.

Bedrock

General Description

Bedrock is exposed only in the right abutment area. It is composed of fine-grained, greenish-black, basic, igneous rocks, chiefly andesite and basalt^{1,2}. Much of the rock has been altered to greenstone. The presence of numerous, small, irregular quartz veins and slickensiding indicate these rocks have been subjected to considerable fracturing. They are, however, believed to be competent. There is very little weathering.

Bedrock Structures

Bedrock exposures throughout the site area are not common. Consequently few attitudes on bedrock structures were obtained. In glaciated areas a common dam-site setting is a deeply filled valley having a rock abutment on one or both sides. At Ross Canyon site it is believed the rock knob situated about 200 feet west of the River should form the right abutment and as a consequence the direction of the dam axis would be about south 85 degrees east.

¹Johnstone, J.R.: "A Reconnaissance of Pelly River between Macmillan River and Hoole Canyon, Yukon", Geol. Surv., Canada, Mem. 200, 1936.

²Kindle, E.D.: "Geological Reconnaissance along the Canol Road, from Teslin River to Macmillan Pass, Yukon", Geol. Surv., Canada, Paper 45-21, 1945.

Jointing is the most important structure present in bedrock exposed at the site. The most prominent joint set, which is almost parallel to the River, would intersect the dam axis at about 75 degrees and dip steeply toward the left abutment. A second set is nearly at right angles to the first. It intersects the centre line at about 10 degrees and dips 47 to 66 degrees upstream.

A large fault zone, 3 feet in width, is visible on the north side of the rock knob. The faulting is almost parallel to the more prominent jointing. It strikes north 15 degrees east and dips 44 degrees east toward the left abutment. This fault zone is a potential aquifer and its presence could result in leakage of reservoir water through the abutment. Many of the rock fragments associated with the zone are stained brown due to the deposition of iron-bearing carbonates. The zone was dry at the time of this investigation (July 4, 1961).

According to Kindle, a large fault, striking at right angles to Ross River, may occur a short distance upstream from the site. It is not believed faulting in this area would be harmful to the proposed dam structures.

Quality of Bedrock

Bedrock exposed at the site is a fairly massive, competent rock and is believed to be satisfactory as abutment and foundation material. In places where the rock has been subjected to fracturing it has been firmly recemented. It should also provide satisfactory riprap and rock fill.

Engineering Considerations

Depth of Overburden

Overburden in the area consists of glacio-fluvial sand overlying till with minor quantities of glacio-lacustrine silt and alluvium. Bedrock is exposed in several places on the bluff west of the River and it is believed overburden adjacent to these outcrops is less than 10 feet in thickness. The till which forms the greater part of overburden exposed on both bluffs is extremely dense. It is probably sufficiently resistant to weathering to form the steep bluffs present at the site. Most of the till exposed on the bluff west of the River is believed to vary from 25 to 50 feet in thickness. The results of seismic lines Nos. 1 and 2, east of the River indicate the thickness of overburden varies from 127 to 136+ feet close to the River and 77 to 106+ feet above the bluff. It is believed these figures are a fair approximation of the depths of overburden in this area. The thickness of overburden directly beneath the River is at least 100 feet. The material probably consists of permeable sand and gravel overlying till which in turn directly overlies bedrock. Test borings will be required here to accurately determine the elevation of bedrock surface beneath the River and in both abutment areas.

Abutments and Foundations

The basic, igneous rocks exposed in the right abutment area are fairly competent and should provide satisfactory abutment

material. There is little weathering and only a small quantity of surface rock will have to be removed before fresh, solid rock against which concrete or dyke material can be placed will be exposed. It is believed a diversion tunnel could be constructed in bedrock. A lining will probably be necessary if faulted rock similar to that exposed on surface is encountered. Seepage of reservoir water might possibly occur along the joint planes. It is believed, however, the jointing could be readily grouted. The remaining dam structures will probably be founded on till unless, as a result of the test boring program, it is found the overburden is sufficiently thin that it can be excavated to bedrock. If the depth to bedrock is too great for economical excavation the till should be thoroughly sampled and tested and a careful analysis made of its shear and consolidation characteristics. The character, size, shape and location of any strata or lens of pervious sand and gravel associated with the till should be ascertained. The permeability of these materials should be determined during the test boring program.

Construction Materials

Aggregate

Deposits of natural aggregate are not common in the area adjacent to Ross Canyon dam site. Representative samples from 6 different deposits were taken and forwarded to the Soils Laboratory of the Water Resources Branch in Vancouver for grain size analyses. A field description of each sample and the resultant curves are included at the end of this report.

Impervious Material

The till which occurs extensively at the site and also along both sides of Ross River above and below the site will probably provide satisfactory impervious material for the core of an earth-fill dam. The larger boulders will probably have to be removed (as at Kluane Canyon site) before the material can be properly compacted. The quantity available is unlimited. Although the thickness of the till deposit is unknown, the results of the seismic investigation conducted at the site by Water Resources Branch indicate the greatest thickness occurs east of the River. It is believed the till directly overlies bedrock.

Pervious Material

Material suitable for the pervious shells, filters or drains of an earth-fill dam can be obtained from the gravel deposits described under the aggregate heading. The gravel would have to be washed, screened and reblended to obtain the coarse, granular material required.

Riprap and Rock Fill

Bedrock exposed at the site is tough and durable and should provide excellent riprap and rock fill. This is indicated by the large size and angular shape of the rock fragments in a small talus on the north side of the rock knob west of the River.

Groundwater

There is little information concerning groundwater conditions in the area about the proposed dam site. Seepages were not

observed in either abutment slope, although sand and gravel lenses associated with the till are frequently exposed. Many of the rock fragments in the fault zone visible in the north face of the rock knob have a brown coating of iron-bearing carbonates probably deposited by circulating groundwater. Accurate information concerning the water table can only be obtained by installing groundwater observation holes and measuring them at regular intervals.

Frozen Ground

Frozen ground was encountered on the bluff east of the River but only in those parts where glacio-fluvial and glacio-lacustrine materials occur. The till was nowhere found to be frozen. The frozen material usually occurs within 24 inches of ground surface and is overlaid by 4 to 8 inches of moss. Places where frozen ground was encountered (July 7, 1961) are indicated on the accompanying geological map.

Proposed Location of the Dam

It is suggested the rock knob located about 200 feet west of the River be considered as the right abutment of the proposed power dam and the dam axis extend directly across the River from this point at about south 83 degrees east. Till would probably form the left abutment. The suggested location of the dam is indicated by the line of proposed test borings included on the accompanying geological map.

If it is desired to construct a dam using local materials it is suggested the unlimited quantities of till available be considered. A

cut-off trench would have to be incorporated into the design of the dam to control seepage through the sand and gravel lenses associated with the till. A similar seepage problem would arise during construction of any cofferdam in the River. The density of the till is sufficiently great that it would probably refuse steel sheet piling driven to it.

Further Investigations

It should be remembered this geological investigation is a preliminary one designed to furnish the engineer with general geological information regarding the proposed dam site. The report is based upon an examination of the soils and bedrock exposed at the site. The test pits put down seldom reached depths greater than 4 feet. If it is decided more information is required at the site the following test borings are suggested as part of the program:

<u>Hole No.</u>	<u>Location</u>
1	Left abutment, 200 feet south of hole No. 2
2	Left abutment, on centre line, 400 feet east of east edge of River
3	Left abutment, 200 feet north of hole No. 2
4	Left abutment, on centre line, 200 feet east of east edge of River
5	Left abutment, on centre line, 100 feet east of east edge of River
6	On centre line, at east edge of River

<u>Hole No.</u>	<u>Location</u>
7	On centre line, middle of River
8	On centre line, at west edge of River
9	On centre line, 100 feet west of west edge of River
10	On centre line, 175 feet west of west edge of River
11	Right abutment, on centre line, 275 feet west of west edge of River
12	Right abutment, on centre line, 375 feet west of west edge of River
13	Right abutment, 300 feet south of hole No. 12
14	Right abutment, 300 feet north of hole No. 12

All borings should penetrate 15 feet below the lowest elevation of bedrock surface encountered; soil samples should be taken every 5 feet or where there is a change in material; permeability tests should be conducted and the elevations of the groundwater table noted. It is suggested hole No. 10 be drilled north 75 degrees west and at an angle of 45 degrees to intersect the fault zone visible on the rock knob forming the proposed right abutment.

Chemical Analysis of Ross River Water

One sample of Ross River water was taken during the 1961 field season. The sample was taken from the centre of the River near the proposed centre line. The water was analysed for its mineral

content by the Industrial Waters Section, Mines Branch, Department of Mines and Technical Surveys, Ottawa. The results of the analysis are included on the following page. The reported value of the turbidity should be considered only as indicative. Flash floods may cause a rapid increase in the sediment load. A proper sediment study, therefore, requires regular sampling; often in the case of flash flooding, at hourly intervals.

Chemical Analysis of Ross 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	Total Hardness as CaCO ₃
Ross Canyon dam site; 4 1/2 miles upstream from junction of Ross and Pelly Rivers; centre of River; 12 inches below water surface	July 6, 1961	Medium High	7.4	5.1	17.7	6.6	1.2	0.6	0.71	0.0	57.0	23.0	0.2	0.18	0.5	8.5	71.2

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. Each grain size sheet for potential aggregate shows the following information:

- (a) Limits of fine and coarse aggregate based upon a 6-inch, maximum size.
- (b) A cumulative grain size curve for each sample.
- (c) Curves showing the individual percentages of the coarse and fine fraction retained on each screen or sieve size.

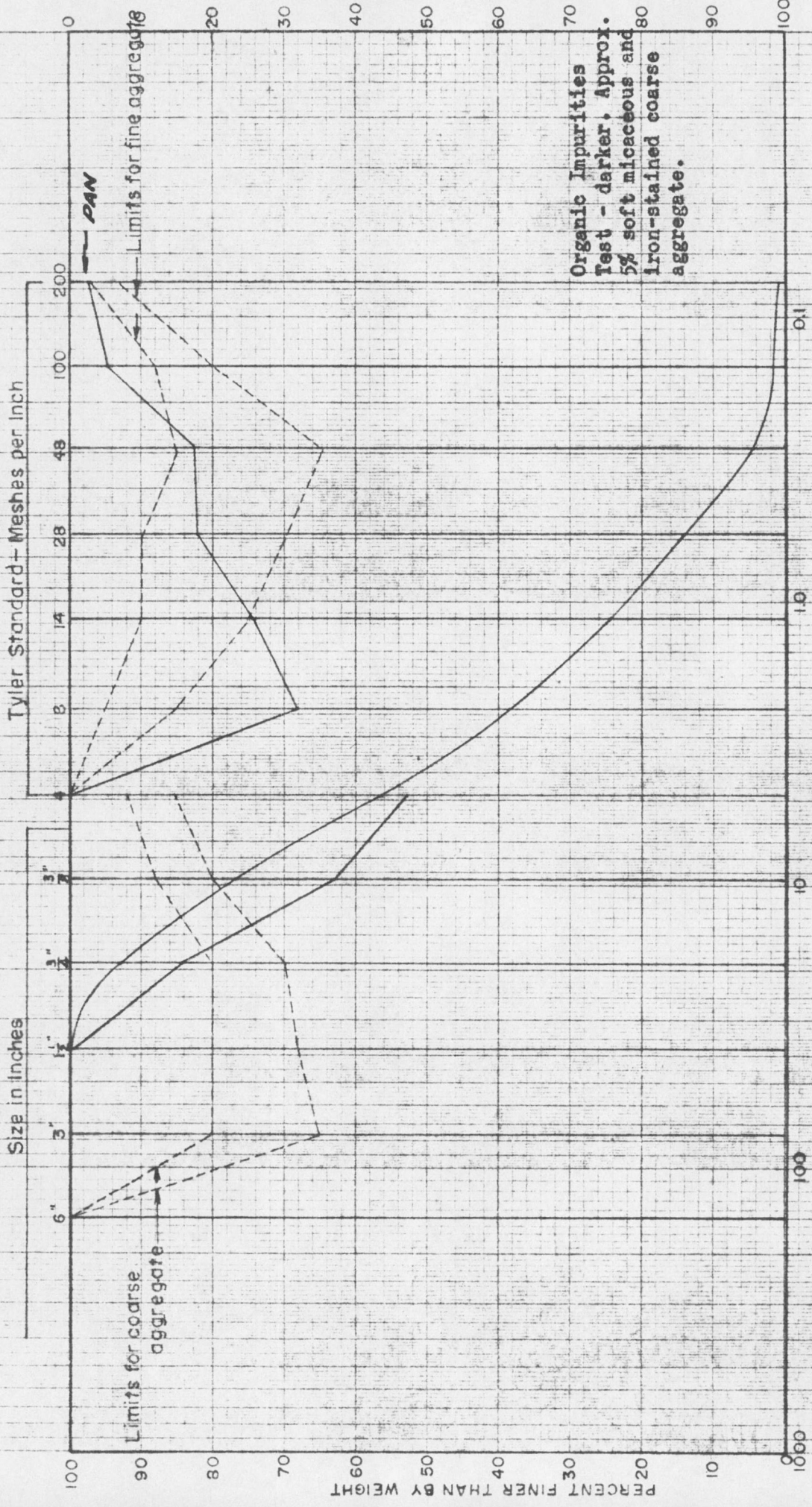
One sample (No. 29) was analysed as potential impervious material; the remainder as potential aggregate.

Description of Potential Aggregate 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
28	Borrow pit on Canol Road at mile 370.3; 2 feet below ground surface	Well graded, sandy gravel; a few rounded boulders up to 18 inches in diameter; stratified; upper 18 inches of gravel is weathered. <u>Pebble Lithology</u> Igneous (granitic, volcanic, quartz) - 50% Chert - 20% Shale - 10% Arkose, greywacke - 10% Metamorphic - 10%	18 inches of silt	5+ feet	Large	Alluvial deposit; used during construction of Canol Road
30	Cut bank on southwest side of Pelly River 8 miles down stream from community of Ross River; 6 feet below ground surface	Well graded sandy gravel; a few rounded boulders up to 12 inches in diameter; about 10% by volume of the material is larger than 6 inches in diameter; minor weathering; no stratification. <u>Pebble and Cobble Lithology</u> Igneous (granitic, volcanic, porphyry, quartz) - 60%	2 feet of silt	20 feet	Length - 1/4 mile Depth - 20 feet Width - 500+ feet	Probably glacio-fluvial material

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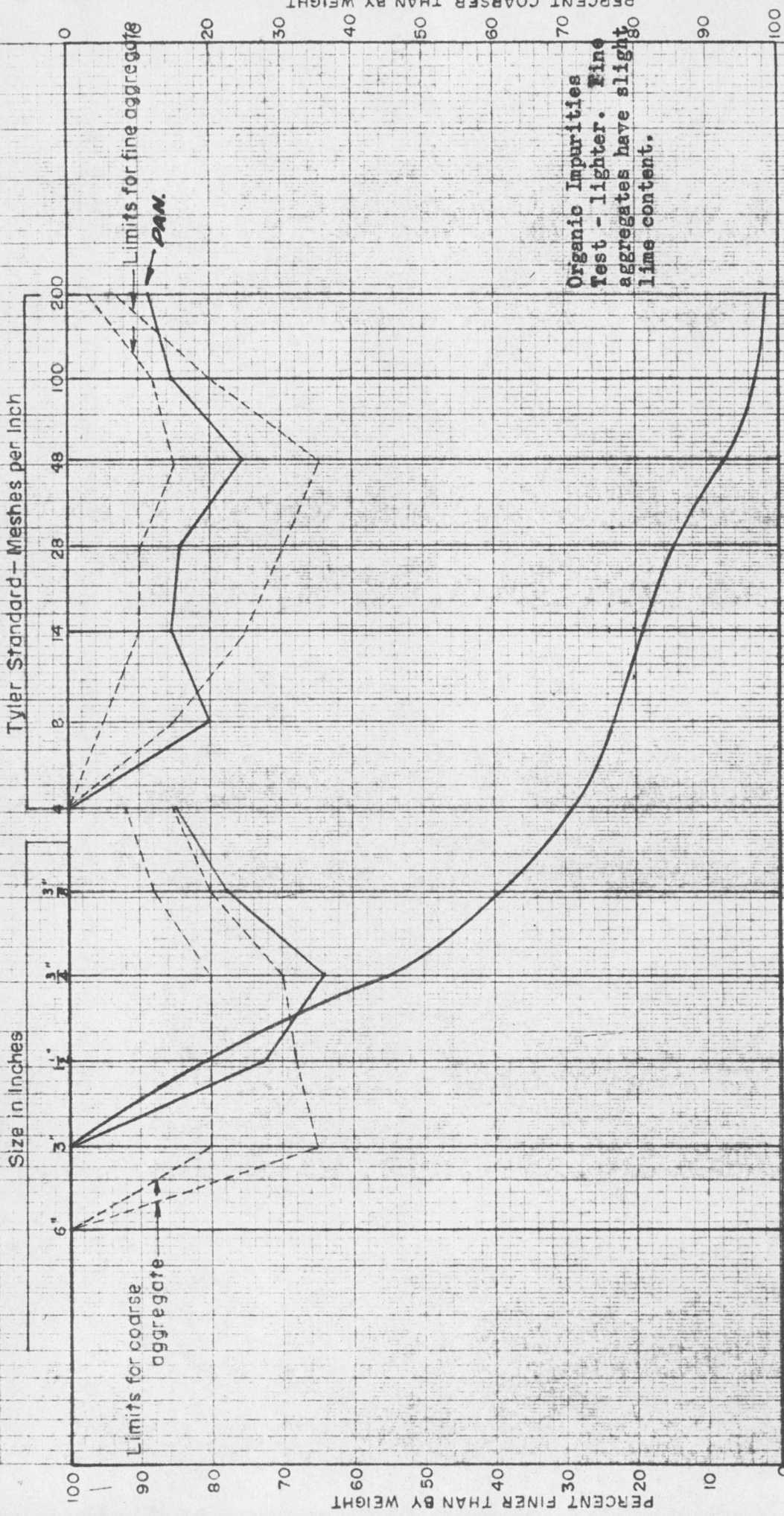
GRAIN SIZE ANALYSIS FOR CONCRETE AGGREGATE RECONNAISSANCE



Organic Impurities
 Test - darker, Approx.
 5% soft micaceous and
 iron-stained coarse
 aggregate.

Site: Yukon Basin Study 1961
 Hole No. _____
 Sample No. 28
 Depth _____
 Plotted _____
 Date _____

GRAIN SIZE ANALYSIS FOR CONCRETE AGGREGATE RECONNAISSANCE



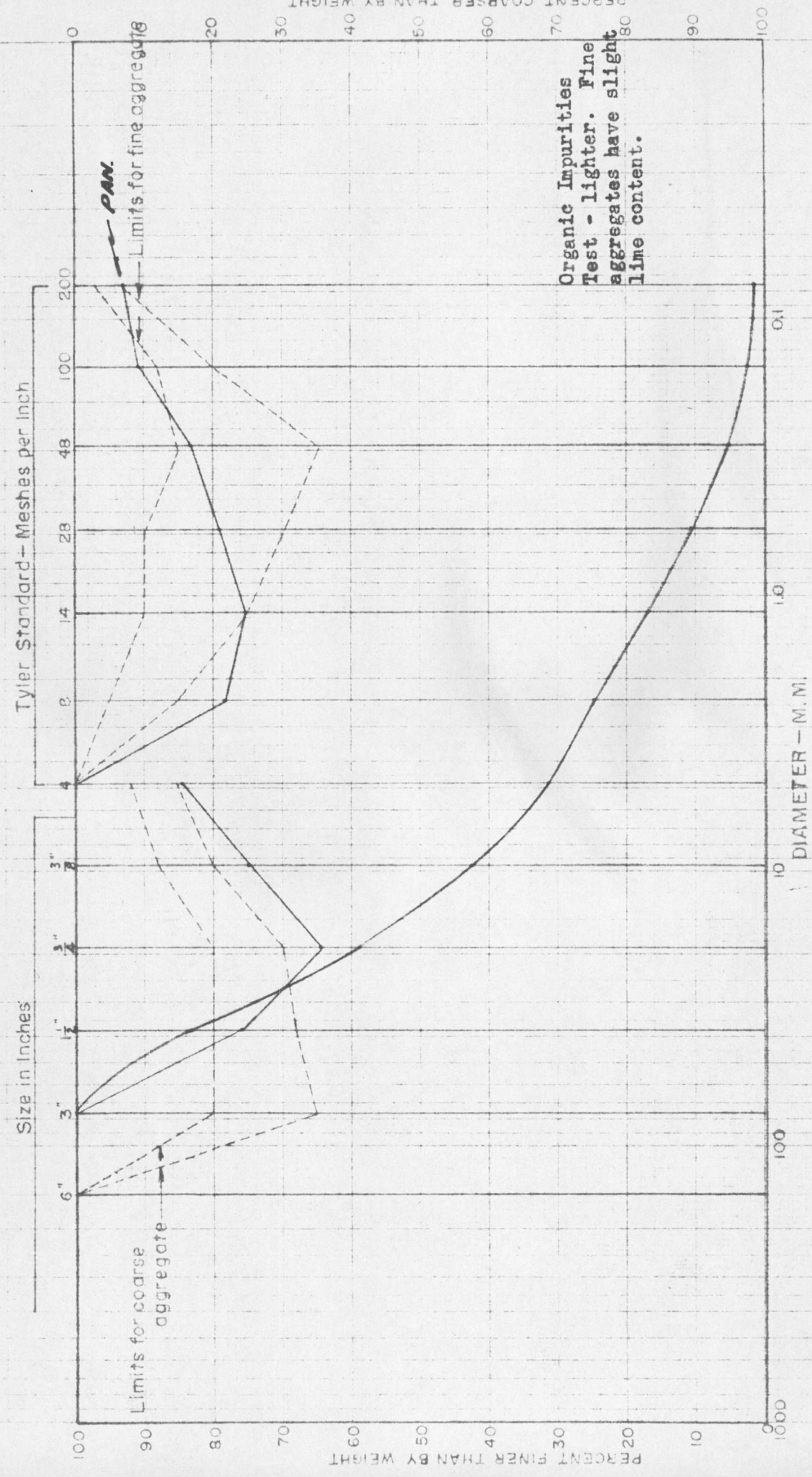
Site: Yukon Basin Hole No. _____ Depth _____ Plotted _____ Date _____
 Study 1961

Description of Potential Aggregate 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
30 (Cont'd)		Metamorphic (schist, gneiss) - 15%				
31	Cut bank on north-east side of Pelly River 11.5 miles downstream from community of Ross River; 5 feet below ground surface	Fairly well graded gravel; very little silt and clay; rounded boulders up to 10 inches in diameter; about 10% by volume of the material is greater than 4 inches in diameter. Pebble and Cobble Lithology Igneous (granitic, volcanic, quartz) - 50% Metamorphic (schists, gneiss) - 20% Sedimentary (grey-wacke) - 20% Shale - 5% Chert - 5%	3 feet of stratified silt	15 feet	Length - 1/4 mile Depth - 15 feet Width - 200+ feet	Alluvial deposit; several higher terraces north-east of River contain glacio-fluvial gravel

DATE: 10/10/61
BY: J. H. [unclear]

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GRAIN SIZE ANALYSIS FOR CONCRETE AGGREGATE RECONNAISSANCE



Site Yukon Basin Study 1961 Hole No. _____ Plotted _____ Date _____
Sample No. 31 Depth _____

Description of Potential Aggregate for the following Grain Size Analyses Curves

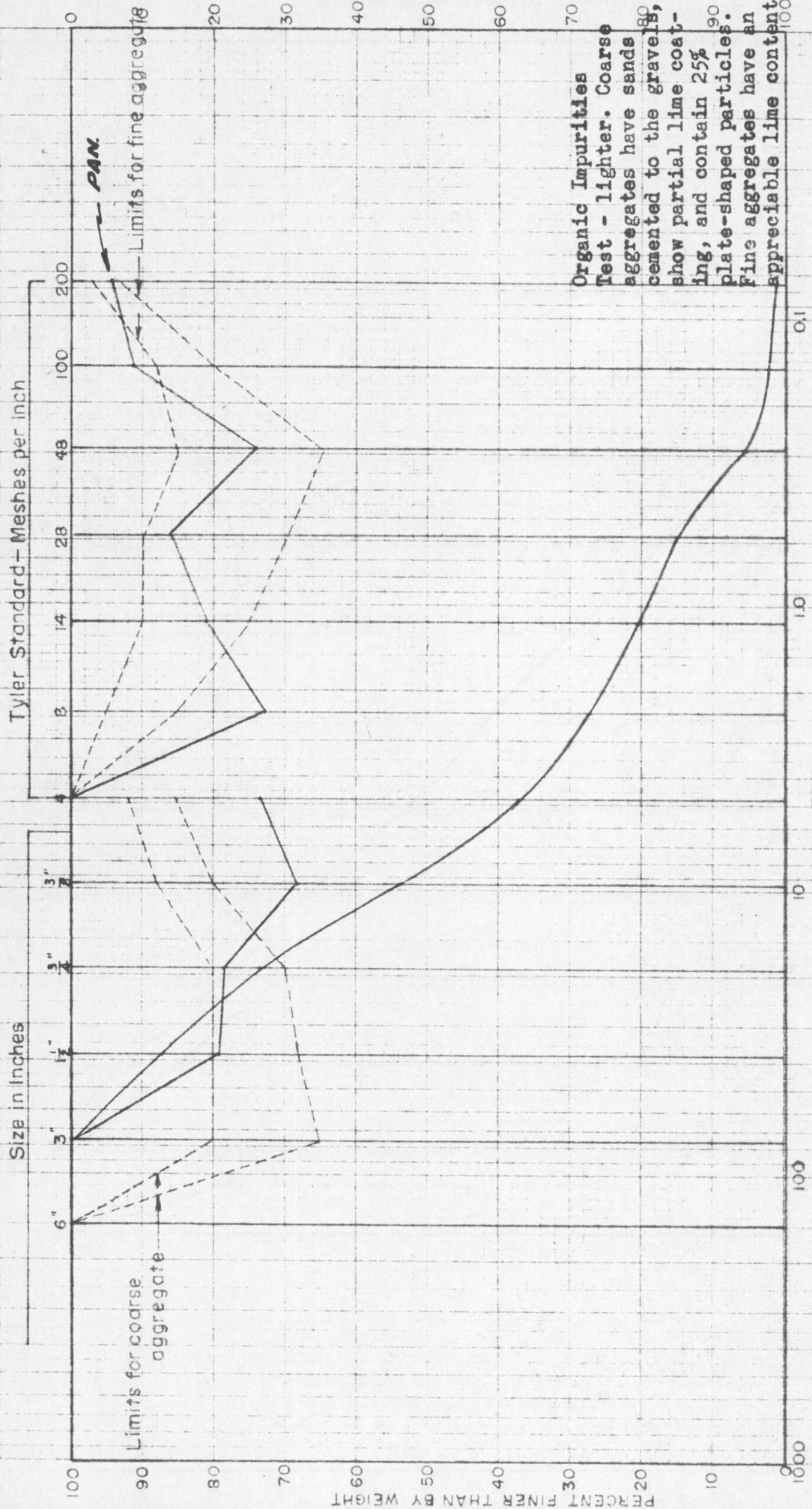
Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
32	Cut bank on southwest side of Pelly River 16.5 miles upstream from community of Ross River; 4 feet below ground surface	Well graded gravel; a few rounded boulders up to 18 inches; considerable white carbonate on lower surfaces of pebbles in upper few feet; very little weathering; minor silt, chert and shale. Pebble and Cobble <u>Lithology</u> Igneous (granitic, volcanic, quartz) - 65% Sedimentary (grey-wacke, arkose) - 25% Metamorphic (gneiss, schist) - 10%	18 inches of silt	60+ feet	Length - 1/3 mile Depth - 55 feet Width - 1/3 mile	Glacio-fluvial material
33	Cut on Ketzakey mine road 6.1 miles from Canol Road; a representative sample from the upper 6 feet of material	Well graded sandy gravel; rounded boulders to 9 inches in diameter; considerable white carbonate on lower surfaces of pebbles in upper 4 feet; negligible silt; minor weathering.	18 inches of silt	20+ feet	Unlimited	Glacio-fluvial material

Description of Potential Aggregate for the following Grain Analyses Curves

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
33 (Cont'd)		Pebble and Cobble <u>Lithology</u> Igneous (volcanic, quartz) - 60% Sedimentary (arkose, greywacke) - 20% Metamorphic (gneiss, schist) - 20%				

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GRAIN SIZE ANALYSIS FOR CONCRETE AGGREGATE RECONNAISSANCE



Organic Impurities Test - lighter. Coarse aggregates have sands cemented to the gravels, show partial lime coating, and contain 25% plate-shaped particles. Fine aggregates have an appreciable lime content.

Site - Yukon Basin - Hole No. - - - - - Plotted - - - - - Date - - - - -
 Sample No. 32 - - - - - Depth - - - - -

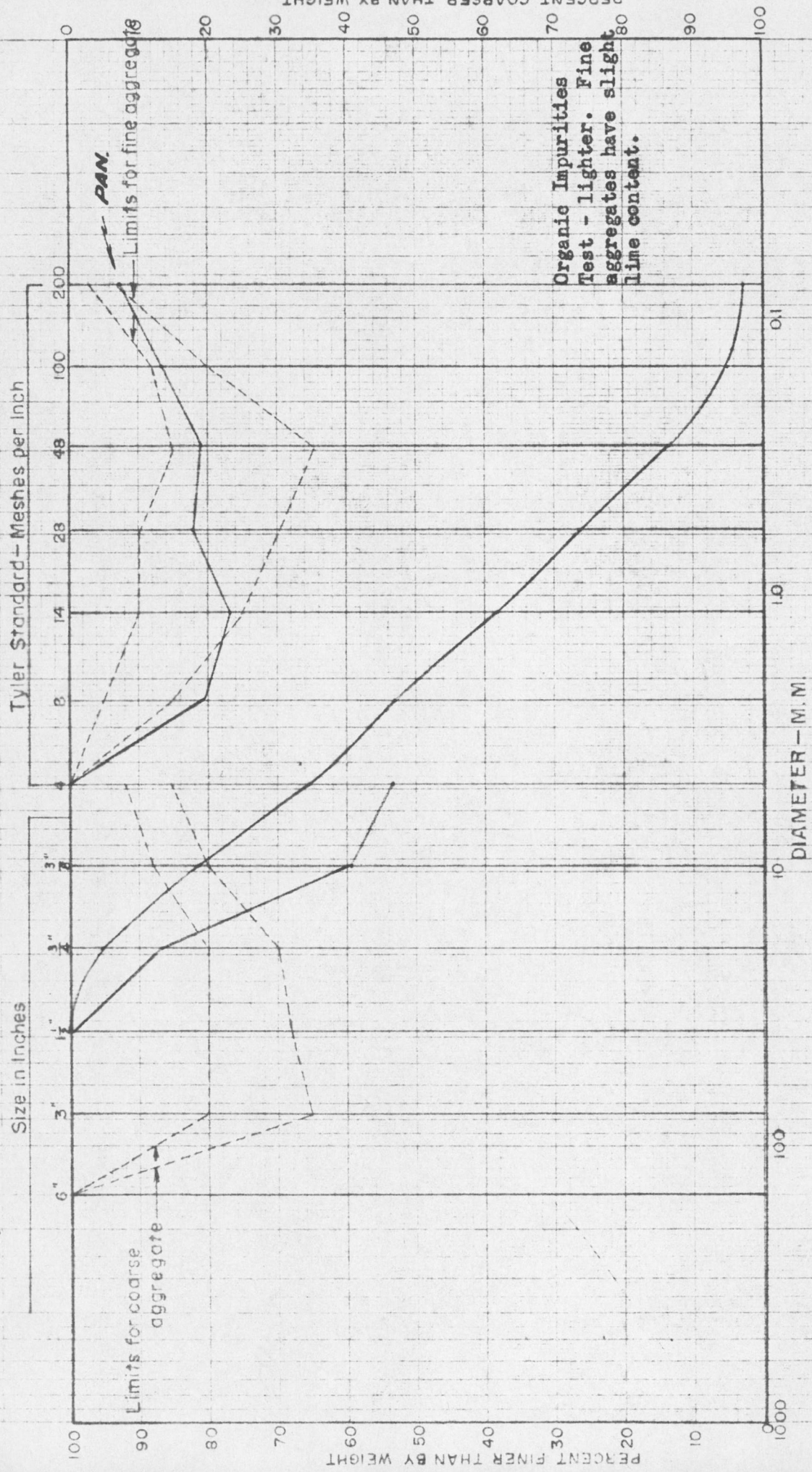
Description of Potential Aggregate for the following Grain Size Analyses Curves

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Permeability* (cm/sec.)
33-A	Cut bank on Canol Road 1/4 mile north of dam site area; 10 feet above road surface	Medium- to coarse-grained sand; minor gravel; very little silt or clay; material occurs as narrow, irregular lenses in till (sample No. 29)	-	1 to 4 feet	Limited	10^{-3}

*Permeability computed in the field using a Soiltest Permeameter, Model K-620

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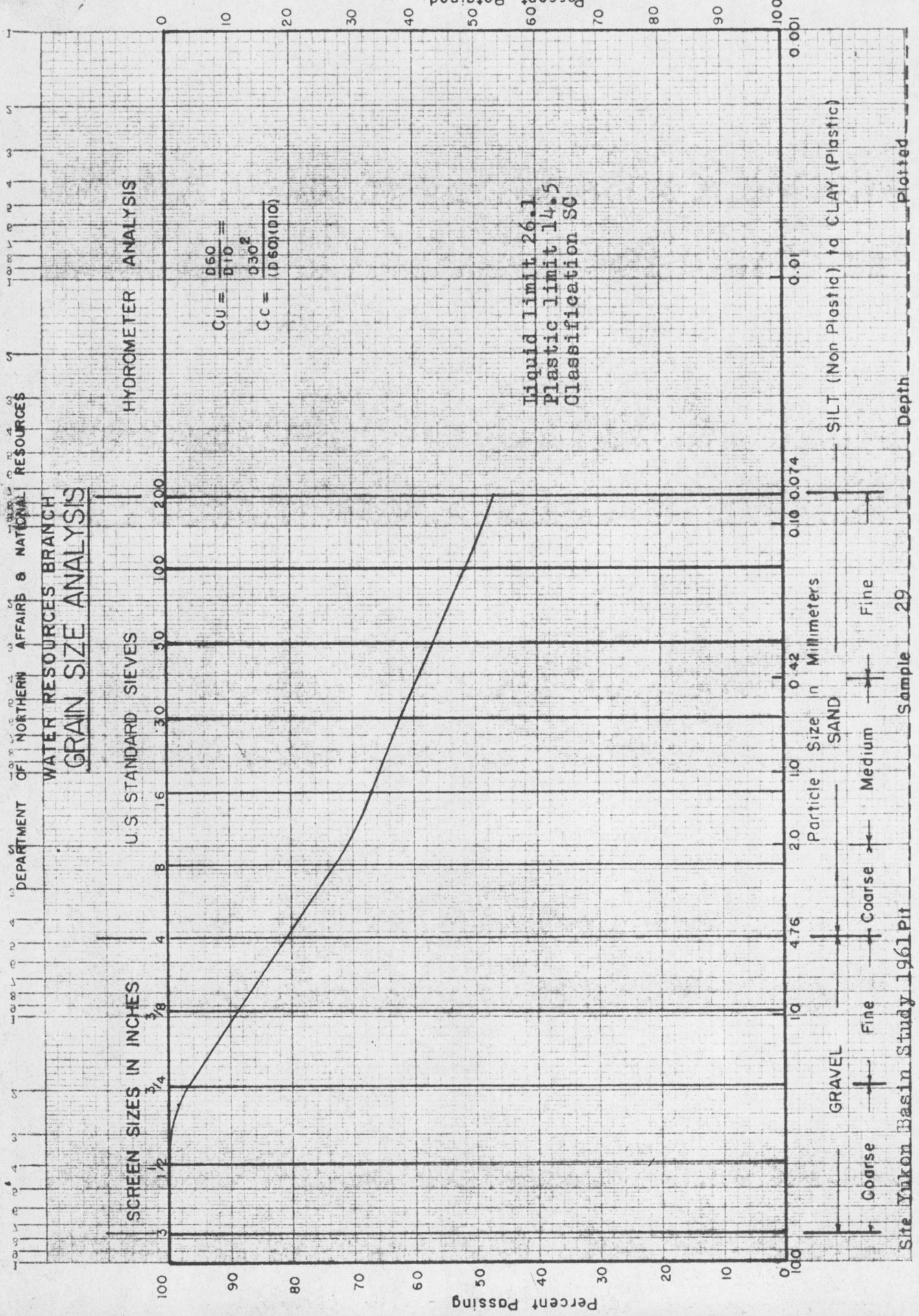
GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE



Site: Yukon-Basin... Hole No. Depth: Plotted: Date:

Description of Potential Impervious Material 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
29	Cut bank on Canol Road 1/4 mile north of dam site area; 5 feet above road surface	Dense, silty, clayey till; a few boulders up to 24 inches in diameter; high dry strength; minor brown weathering in upper 24 inches; contains a few narrow, irregular, sand lenses (sample No. 33-A); till contains a high percentage of black, chert pebbles	12+ inches of silt	100+ feet	Unlimited	Till extends for many miles along both sides of Ross River upstream from site



Liquid limit 26.1
Plastic limit 14.5
Classification SC

$CU = \frac{D_{60}}{D_{10}} = \frac{0.30}{0.075}$
 $CC = \frac{D_{30}^2}{(D_{60})(D_{10})} = \frac{0.15^2}{(0.30)(0.075)}$

Site Yukon Basin Study 1961 Pit

Sample 29

Depth

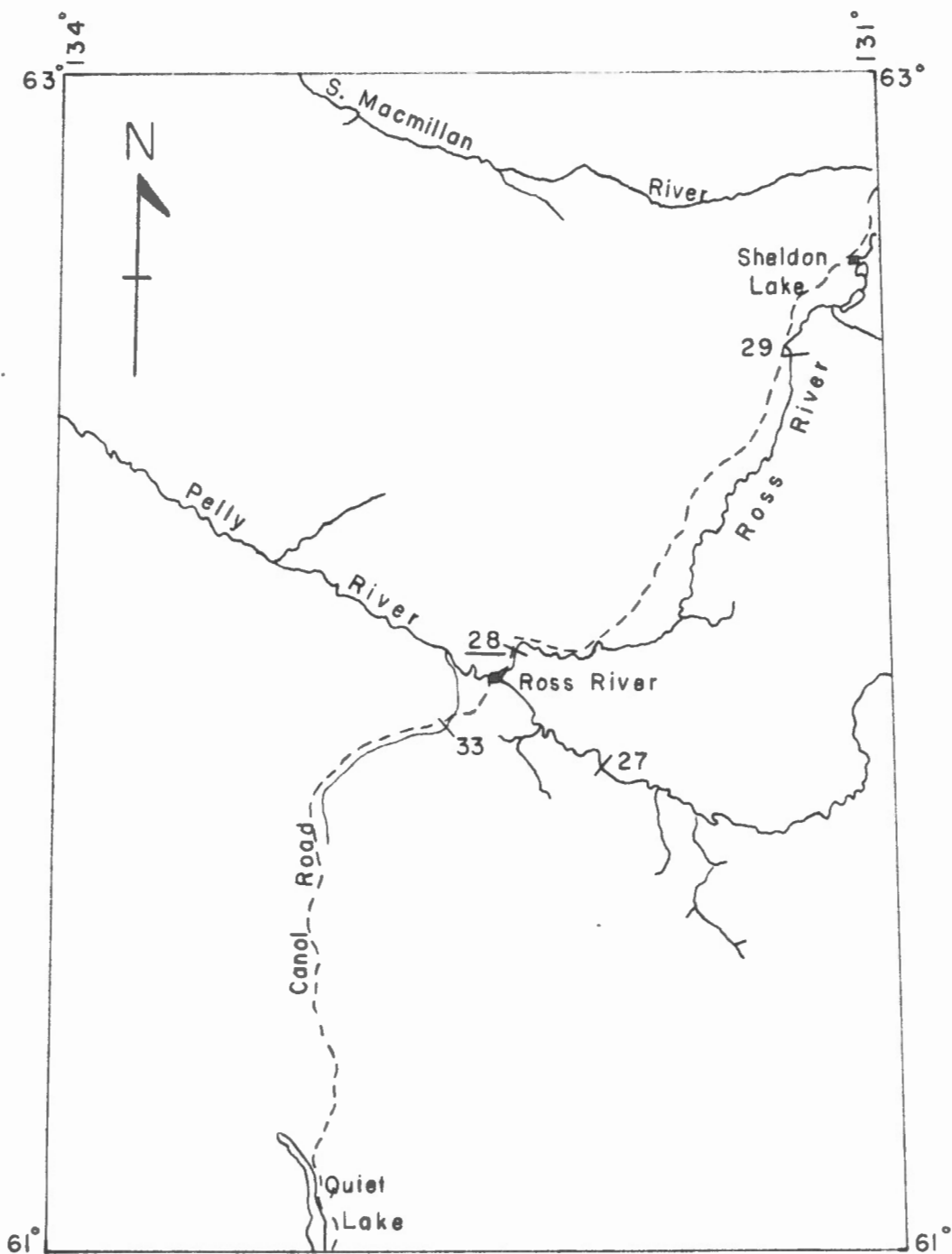
Plotted



Plate 1

View looking east along proposed dam axis from right abutment. Steep, till bluff forming left abutment rises 180 feet above Ross River. Elevation of terrace above bluff is about 2,500.

G. S. C. 3-7-61



LOCATION OF PROPOSED DAM SITES
YUKON RIVER DRAINAGE BASIN

Scale: 1 inch = 20 miles

<u>Site No.</u>	<u>Name</u>	<u>River</u>
27 —	Hoole Canyon	Pelly
28 —	<u>Ross Canyon</u>	Ross
29 —	Prevost Canyon	Ross
33 —	Lapie Canyon	Lapie