No. 2

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 19

YUKON RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITE NO. 12

BRITANNIA DAM SITE

(MAP AND PRELIMINARY REPORT)

BY

E. B. OWEN

OTTAWA
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BRITANNIA DAM SITE

General Description

Britannia dam site is located on Yukon River immediately downstream from the mouth of Britannia Creek. It is about half way between the junctions of the White and Pelly Rivers with the Yukon. An alternative site is located near Selwyn about 21 miles upstream. The Selwyn site is described in Topical Report no. 18, site no. 11.

At the site Yukon River is flowing in a westerly direction along the north side of a valley some 2,400 feet in width. Along the right (north) side of the River a steep, rock bluff rises abruptly to a height greater than 1,000 feet above the river. The right abutment of the proposed rock-fill dam would be located in this bluff.

On the left side a level terrace extends 1,300 feet south to the toe of a steep, 60-foot, rock bluff which forms the lower part of the left abutment of the power house. This structure along with a concrete gravity section composes the southern portion of the proposed dam. South of the bluff ground surface slopes gradually upward for about 1,000 feet to the south edge of the map-area.

The terrace extending along the left side of the River has an average elevation of about 1,300 feet. It is covered throughout with a thick layer of moss and decayed vegetation and is swampy in its south part.

On the steep, right abutment slope overburden consists of a thin covering of talus. South of the River the results from seismic line no. 3 indicate bedrock to be within 12 to 13 feet of ground surface although 4 shot holes on this line encountered bedrock within 3 feet. Information from seismic lines nos. 1 and 2 indicates the elevation of bedrock surface decreases toward the River.

There is no topographic or geologic evidence to suggest the existence of a former course of Yukon River in the area. It is believed the River

was flowing in its present channel prior to the last glaciation and consequently the depth of the channel eroded into bedrock surface below the present River is relatively great compared to the Braden's Canyon, Wolverine and Five Finger Rapids sites further upstream. According to Bostock[1] Britannia dam site lies outside the limit of the last glaciation.

There is a lack of overburden suitable for construction purposes in the site area. Terraces of glacio-fluvial gravel, from which supplies of natural aggregate or pervious material can be obtained, are not present. A narrow, bedrock terrace, the elevation of which is approximately 1,370, occurs directly above the steep, 60-foot bluff south of the River. The terrace is covered with a thin layer of overburden the lower part of which is probably gravel. Similar gravel was exposed in several shot holes along the west end of seismic line no. 3. This gravel exposure has been identified on the accompanying geological map. It is believed the quantity of gravel available is not large.

Frozen ground was encountered in several places south of the River but was not observed on the north side. All holes dug on the lower terrace extending along the left side of the River encountered frozen, silty sand underlying an insulating layer of 4 to 18 inches of moss and decayed vegetation. Frozen ground was also encountered on the left abutment slope in the south part of the map-area. Some of the localities where frozen ground was seen have been indicated on the accompanying geological map.

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[1] Bostock, H.S.: "Carmacks District, Yukon"; Geol. Surv., Canada, Memoir 189, 1936.

Unconsolidated Deposits

Four types of unconsolidated deposits have been identified in the area about the proposed Britannia dam site. These are as follows:

1. Recent Alluvium: This material varies from a fine-grained, compact, silty sand to masses of cobbles and boulders up to 12 inches in diameter. It is a relatively unimportant deposit occurring along the left edge of the River.

2. Alluvium (silty sand): This is a compact, silty sand which covers most of the area south of the River. It was usually frozen when encountered and consequently little information was obtained concerning its thickness or the quality of the underlying material. In test pits, put down near the sandy gravel exposed on the left abutment slope, thicknesses as great as 4 feet were found to overlie the gravel. The silty sand is commonly stratified with alternating beds of silt and fine sand up to one inch in thickness.

3. Glacio-fluvial (sandy gravel): This material consists essentially of a loose, graded, sandy gravel with cobbles up to 8 inches in diameter. It also comprises minor quantities of coarse-grained sand with few pebbles. In the upper 2 to 3 feet, boulders of coarse-grained, intrusive rocks are often badly weathered and crumble when disturbed. The material is usually overlaid by a thin deposit of fine alluvium but is exposed in the left abutment area. It probably constitutes most of the overburden overlying bedrock south of the River as well as beneath the River.

4. Talus: A thin layer of talus covers much of the bluff along the right side of the River. It consists chiefly of small, micaceous fragments of weathered gneiss with a few boulders up to 12 inches in diameter. The percentage of fine material in the talus increases greatly in the lower part of the bluff adjacent to the River. Relatively small amounts of talus occur in the left abutment area. Here it consists of accumulations of boulders up to 24 inches in diameter located

immediately below exposures of bedrock occurring along the small bluff 1,300 feet south of the River.

Bedrock

General Description

Gneiss is the principal rock type in the dam site area. Numerous thin beds of grey quartzite, too small to be included on the accompanying geological map, are frequently interbedded with the gneiss. Small, irregular veins of white quartz intruding both gneiss and quartzite are common.

The gneiss is a massive, grey, fine- to medium-grained rock composed chiefly of quartz and biotite. Banding is evident throughout most of the gneiss but schistosity is rare.

Bedrock Structures.

Bedrock at Britannia site is more massive than that at Selwyn. Jointing is not common. One fairly prominent joint set strikes almost parallel to the centre line and dips steeply upstream. The strike of the bedrock strata is such that the beds intersect the proposed centre line at about 70 degrees. The dip is 40 to 50 degrees north toward the right abutment. There is no visible evidence of faulting in the rocks exposed at the site.

Quality of Bedrock

The gneiss, which constitues most of the rock exposed at the site, is massive and durable. It should provide satisfactory foundation and abutment material. Weathering is not extensive on the exposed surface of bedrock, however, about 6 inches of soft, badly weathered rock were encountered beneath the surficial material in several test pits. The specific gravity of gneiss is relatively high suggesting the rock would provide excellent riprap or rock fill.

Engineering Considerations

Depth of Overburden

Overburden on the right abutment slope consists of a thin covering

of talus which is believed to be less than 10 feet in thickness. The results of seismic line no. 3 indicate the depth of overburden on the left abutment slope is about 12 feet. This figure is probably correct. The surface of bedrock beneath the terrace extending along the left side of the River slopes to the north toward the River. This is indicated by the results of seismic lines nos. 1 and 2. The depth of overburden in the centre of the terrace is about 23 feet (seismic line no. 2) and varies from 64 to 72 feet along the left side of the River (seismic line no. 1). It is believed to be considerably greater beneath the River.

A buried stream channel, eroded into bedrock, possibly exists beneath the terrace between seismic line no. 2 and the bedrock bluff 700 feet to the south. If such a channel is present, it probably occurs within 200 feet of the base of the bluff. The elevation of bedrock surface obtained from proposed bore hole no. 4 should indicate the existence of a buried channel.

Abutments and Foundations

Bedrock exposed at the site should provide satisfactory foundations and abutments for the proposed dam structures. However, the elevation of bedrock surface beneath Yukon River is believed to be lower than indicated by seismic line no. 1 and consequently a much deeper excavation will be necessary to found the proposed rock-fill dam on bedrock. The possibility of a buried channel existing in bedrock beneath the site of the proposed power house should be investigated. The materials filling such a channel would probably be extremely permeable. Present construction plans call for the impervious core of the rock-fill dam to be extended down to bedrock surface. The core material would be placed in the dry between two coffer dams which would be later incorporated into the main dam. It should be pointed out the permeability of the materials upon which the coffer dams

will be built is high and there is a possibility large quantities of water will seep into the excavation during construction.

Construction Materials

Aggregate

The sandy gravel exposed in the left abutment area is a shallow deposit and would probably not prove a source of satisfactory, natural aggregate. Representative samples were taken of the gravel exposed in several prominent terraces along Yukon River and some of its tributaries. The samples were forwarded to the Soils Laboratory of the Water Resources Branch in Vancouver for mechanical analysis. Grain size analysis curves for these materials are included at the end of this report. The gravel is usually overlaid by a thin layer of silt and generally the upper 2 to 3 feet is badly weathered. It was reported by Company employees that gravel deposits, 95 feet or more in thickness, occur on the Canadian Creek Placer Company's property some 14 miles south of the site. This property is accessible by a recently constructed road over which trucks can be operated. Artificial aggregate might be obtained by crushing the gneiss exposed in the abutment areas. This, however, would be a relatively expensive method and should only be considered as a last resort.

Impervious Material

Material suitable for the impervious core of the proposed rock-fill dam was not found within the area mapped at the site. A small, dyke-like ridge extends across the mouth of a small valley immediately downstream from the right abutment. Suitable core material may be obtained from this ridge. The material consists of numerous, angular pebbles and cobbles up to 8 inches in diameter imbedded in a silty matrix. It resembles a dense, stony till.

Associated with the material is a lens of medium-grained, sorted sand about 6 inches in thickness. The ridge is about 30 feet high and extends across the valley mouth for a distance of about 175 feet. It has probably resulted from solifluction and/or local ice movement down the valley. Similar ridges occur across the mouths of several small, tributary valleys leading into the valley of Britannia Creek. A grain size analysis curve for similar material is included in the report on Selwyn dam site (Topical Report no. 18, site no. 11, sample no. 10).

Pervious Material

Material for the graded filter of the rock-fill dam could be obtained from the sandy 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

The specific gravity and durability of the massive gneiss at the site is higher than for most rocks. Weathering is not extensive. Consequently, the rocks exposed in either abutment should be an excellent source of riprap or rock fill. Most of the boulders in the talus are too small and weathered to make satisfactory riprap.

Ground Water

All the shot holes of seismic line no. 2 located on the terrace extending along the south side of the River were filled with water to within 12 inches of ground surface. The underlying material, however, is frozen and it is believed a perched ground-water table is indicated by the level of the water in these holes. Accurate information concerning the water table can be obtained only by a test boring program involving the installation of many ground-water observation holes.

Frozen Ground

Frozen ground exists beneath the lower terrace south of the River and in some localities in the left abutment area. At the time of the investigation (July 1, 1960) a large mass of ice still existed on the floor of the small, tributary valley on the north side of the River immediately below the area mapped. This is the only evidence of frozen ground in the vicinity of the right abutment. Localities where frozen ground was encountered have been noted on the accompanying geological map.

Further Investigations

It should be remembered the present geological investigation of the proposed Britannia dam site is a preliminary one designed to furnish the engineers with as much information as possible before any money is spent on an expensive subsurface investigation. If it is decided more information is required the following test borings along the proposed centre line are suggested as part of the program:

Hole Number	Location
1	Left abutment; 1,790 feet south of left side of River
2	Concrete, non-overflow structure; 1,590 feet south of left side of River
3	Concrete, non-overflow structure; 1,350 feet south of left side of River
4	Powerhouse structure; 1,150 feet south of left side of River
5	Powerhouse structure; 945 feet south of left side of River
6	Powerhouse structure; 735 feet south of left side of River
7	Spillway structure; 525 feet south of left side of River
8	Spillway structure; 318 feet south of left side of River
9	Spillway structure; 105 feet south of left side of River

Hole Number	Location
10	Rock-fill dam; 90 feet north of left side of River
11	Rock-fill dam; 330 feet north of left side of River
12	Rock-fill dam; 495 feet north of left side of River
13	Rock-fill dam; 700 feet north of left side of River
14	Rock-fill dam; 905 feet north of left side of River
15	Right abutment; 1, 200 feet north of left side of River
16	Right abutment area; 305 feet west of hole no. 15
17	Right abutment area; 290 feet east of hole no. 15

It is recommended the borings beneath the proposed sites for the powerhouse and spillway structures and the rock-fill dam be put down to elevation 1, 180 or 15 feet into bedrock whichever is greater and the remainder down to elevation 1, 250. Soil samples should be taken at 5-foot intervals or where a change in material occurs. Permeability tests should also be conducted and the elevation of the ground-water table noted. Borings should be vertical unless during the drilling program there is an indication of vertical fractures which could be caused by faulting or open jointing; in which case angle holes should be drilled.

Comparison between Selwyn and Britannia dam sites

The following comparisons are based entirely upon a preliminary geological examination of the two sites and an investigation into possible sources of construction materials in the areas about the sites.

1. Quality of Bedrock: Bedrock at both sites is a massive, durable gneiss with a relatively high specific gravity. It should provide excellent abutments and foundations for the proposed dam structures.

2. Bedrock Structures: At both sites the strike of the rock strata closely parallels the River, i.e. it is approximately at right angles to the centre line, and the dips are 40 to 50 degrees north toward the right abutment. Jointing is more common at Selwyn. There is no evidence of major faulting in the exposed portions of bedrock at either site. Some grouting will probably be required at both sites.

3. Depth of Overburden: Except for the data obtained from the seismic lines little is known concerning the thickness of overburden at either site. Test borings are required at each site to obtain more subsurface information.

4. Aggregate: Deposits of natural aggregate do not occur within the areas mapped. At both sites the nearest, potential aggregate is about 5 miles distant and not easily accessible.

5. Impervious Material: Deposits of suitable impervious material were not located for either site.

6. Riprap and Rock Fill: Suitable riprap and rock fill can be obtained from bedrock at both sites.

7. Frozen Ground: Frozen ground was encountered in many localities at both sites. It is possibly more extensive at Britannia.

8. Ground Water: The ground-water table may be higher at Britannia site than at Selwyn. There is a strong possibility, however, the water in the swamp south of Yukon River at Britannia is perched above the frozen ground.

Conclusions

The results of this preliminary investigation indicate that, geologically, there is little difference between Britannia and Selwyn dam sites. Consequently any decision regarding the choice of sites will have to be based on

some other criteria beyond the scope of this report.

Chemical Analyses of Yukon River Water

During the 1960 field season a sample of Yukon River water was taken from the centre of the River at a point about one mile upstream from the mouth of White River. The sample 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 tabulated on the following page. For comparison an analysis made of Yukon River water at Selwyn by the United States Geological Survey is included.

The results indicate the water of Yukon River near Britannia is medium hard but not highly mineralized. The reported value of the turbidity should be considered only as an indication of the amount of suspended matter. Flash floods may cause a very 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 Analyses of Yukon River Water

(parts per million)

Location	Date	River Discharge	pH	SiO_2	Ca	Mg	Na	K	Fe	CO_3	HCO_3	SO	Cl	F	Turbidity	Total Hardness as $CaCO_3$
One mile above White River; centre of River	July 7, 1960	Medium	7.6	5.7	19.9	5.7	1.2	0.6	0.6	0.0	73.6	12.6	0.2	0.1	4	73.2
Near Selwyn*	July 7, 1915	Medium	—	11	18	4.5	—	—	.02	0.0	71	9.6	Tr.	—	—	—

* Dole, R.B. and Chambers, A.A., "Chemical Character of some Surface Waters of Alaska"; U.S. Geol. Surv., W.S.P. 418-420, 1917, p. 12.

Grain Size Analyses Curves

The grain size analyses curves for potential aggregate included in this report were prepared in the Soils Laboratory of the Water Resources Branch in Vancouver. Each grain size 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 each 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 Analyses Curves

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (estimated)	Accessibility
13	Right side of Yukon River; 6.5 miles above site	Silty, sandy gravel; boulders up to 12 inches	2-3 feet of silt	30-40 feet	200 feet wide, 1,000 feet long	By Yukon River
15	East side of Issac Creek; 1,000 feet south of Yukon River; 25 feet above creek on side of terrace	Loose, sandy gravel; cobbles up to 6 inches; considerable weathering in upper 24 inches	12-18 inches of silt	50 feet	50 feet wide, 500 feet long	By Yukon River
16	East side of Ballarat Creek valley; 1 mile north of Yukon River; half way up side of terrace	Sandy gravel; cobbles up to 5 inches	12 inches of silt	30 feet	—	Abandoned road to Yukon hence by River to site
17	Right side of Yukon River; 1,500 feet below Pedlar Creek; 10 feet below top of bluff	Sandy gravel; cobbles up to 6 inches	3 feet of silt	40 feet	100 feet wide wide; 4,000 feet long	By Yukon River

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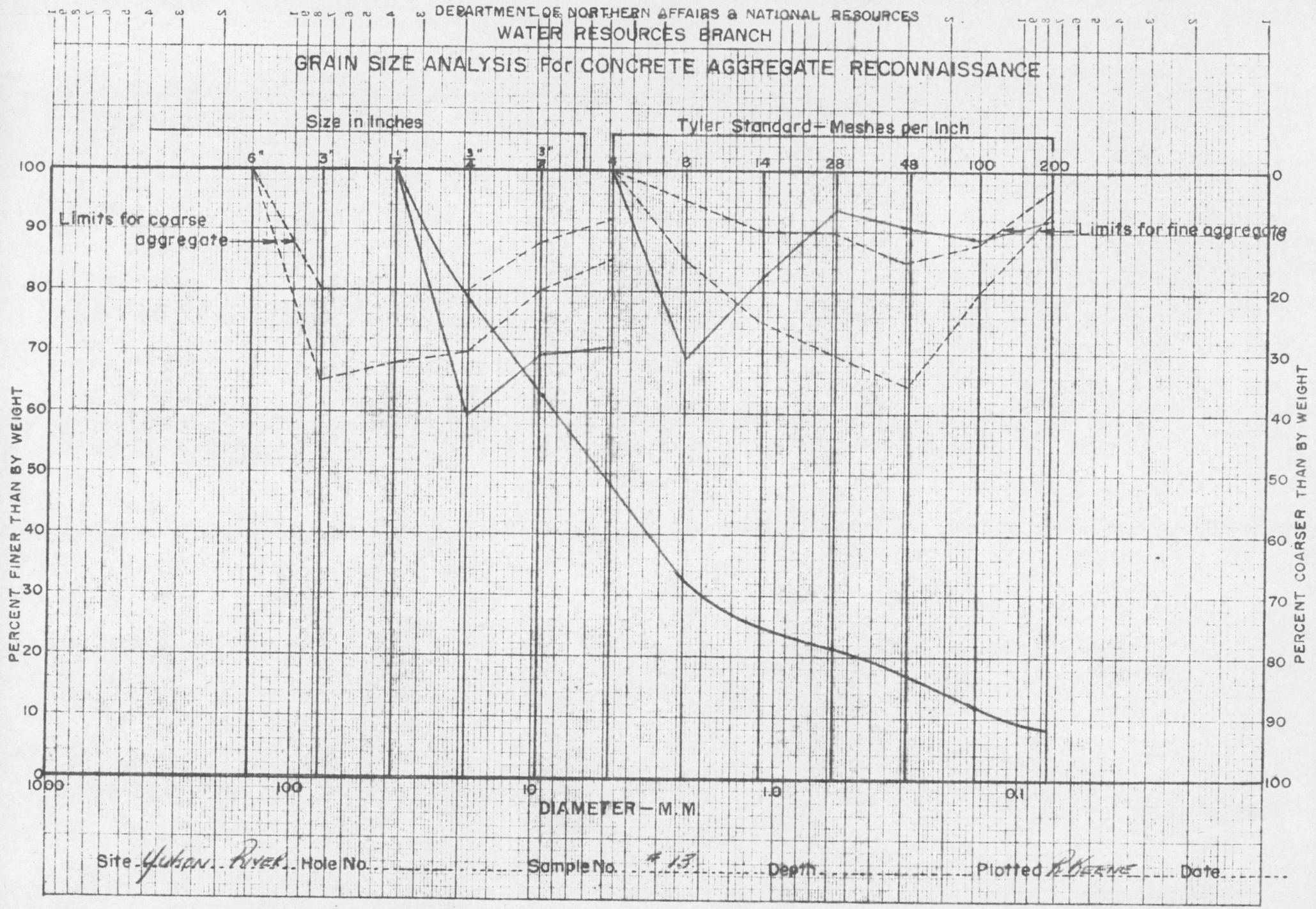
WATER RESOURCES BRANCH

GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE



Site Yukon River Hole No. ..... Sample No. # 13 Depth ..... Plotted K Verne Date .....

PLAN No. 659 G-1

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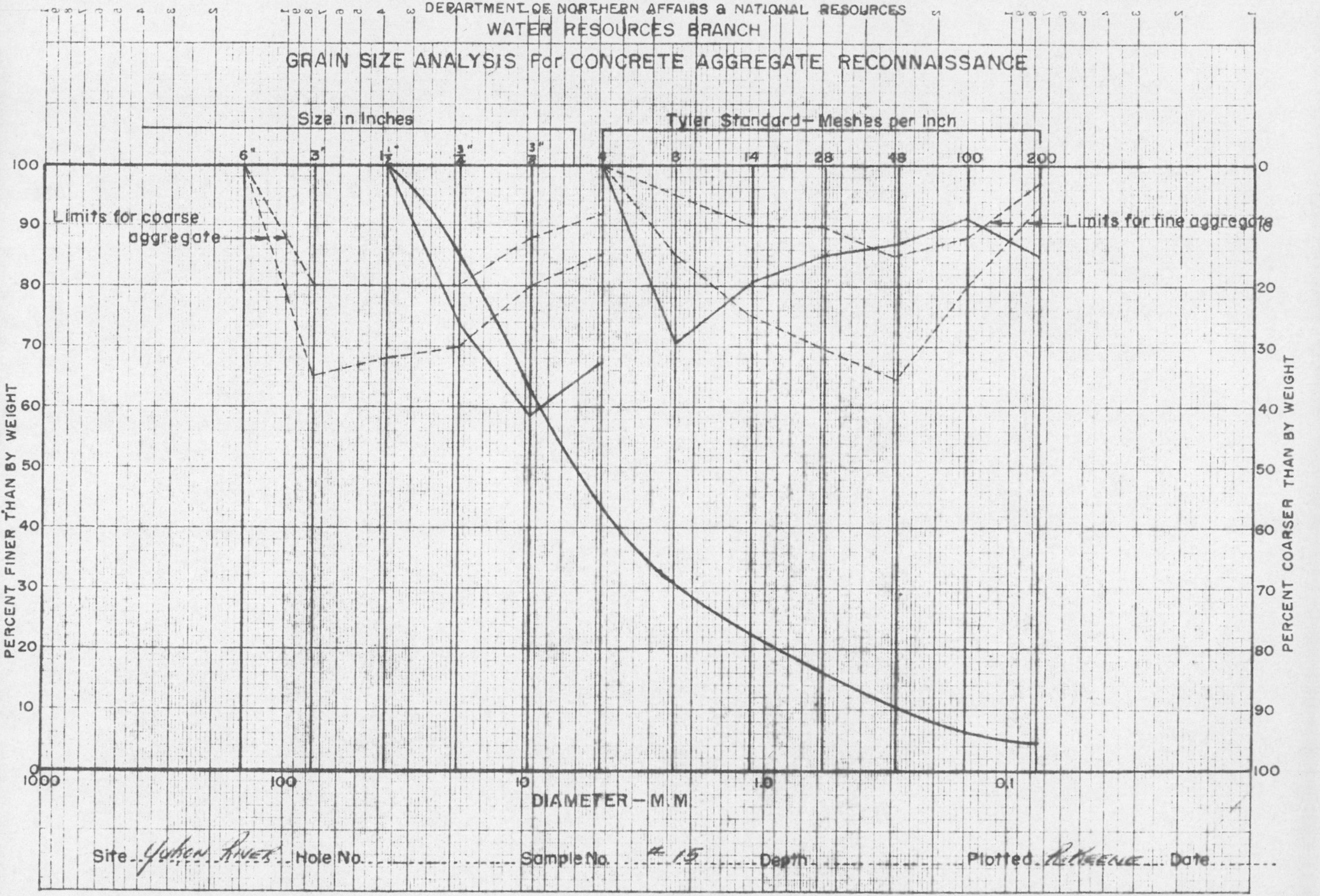
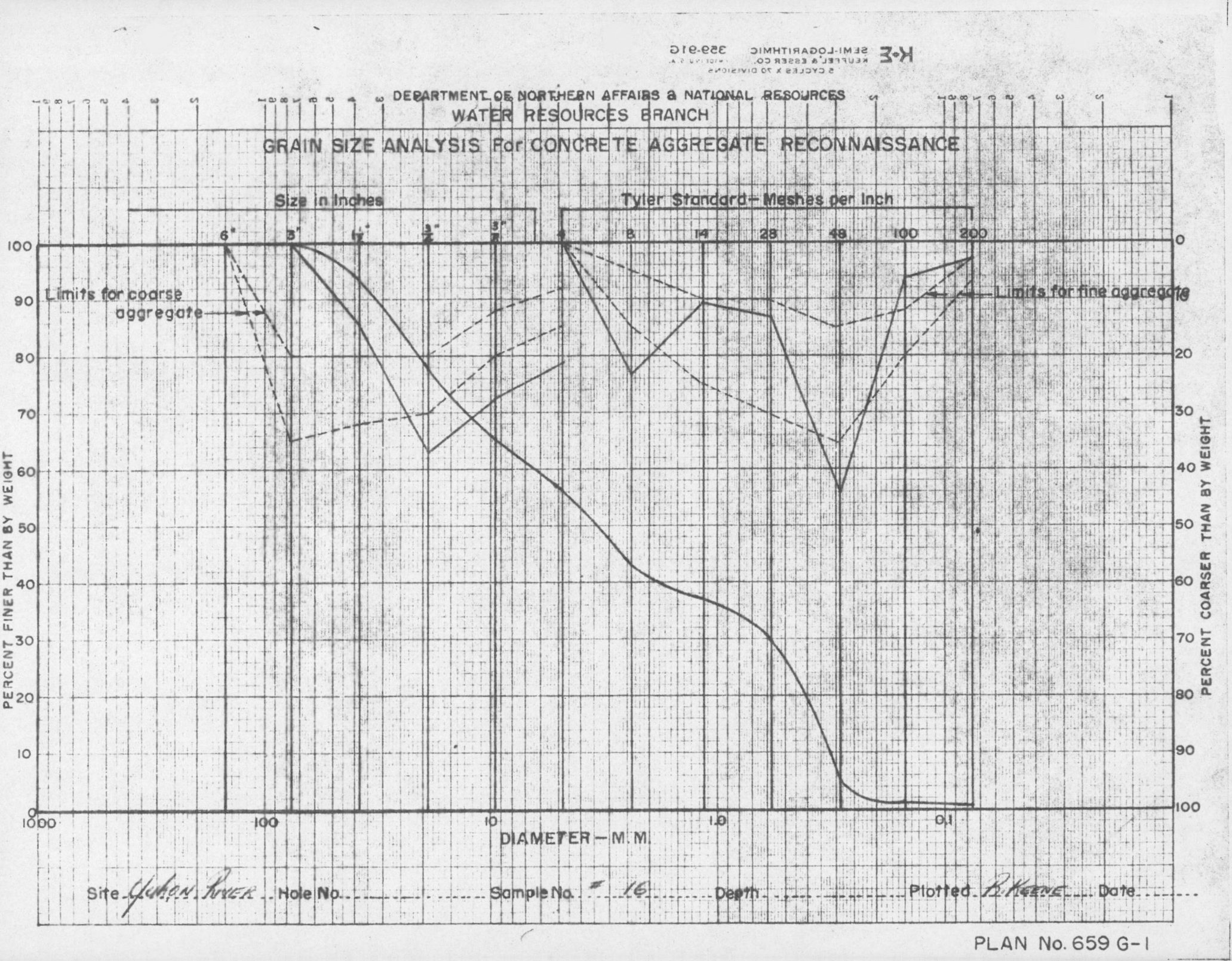
WATER RESOURCES BRANCH

GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE



Site Yukon River Hole No. Sample No. # 15 Depth Plotted Reference Date

PLAN No. 659 G-1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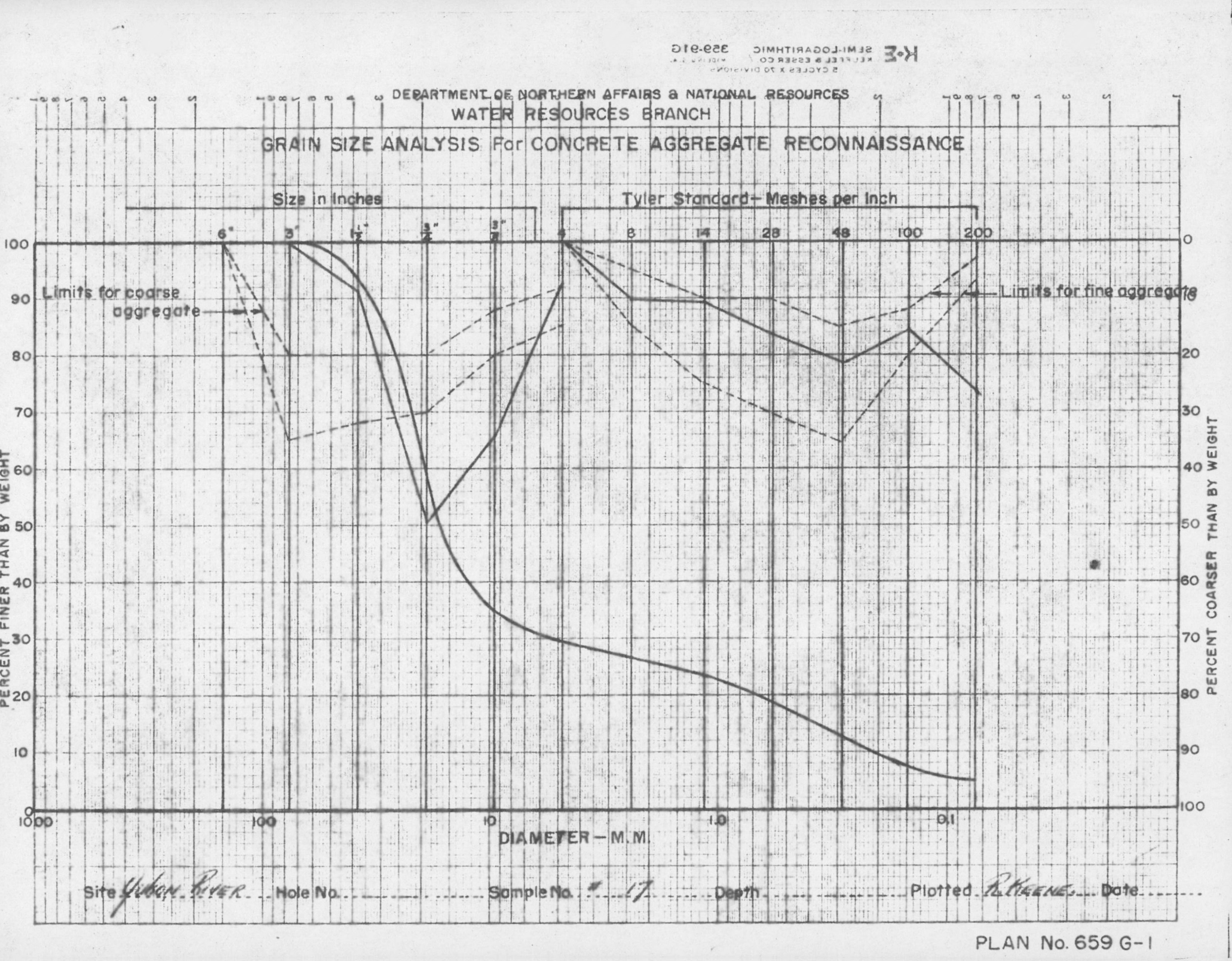
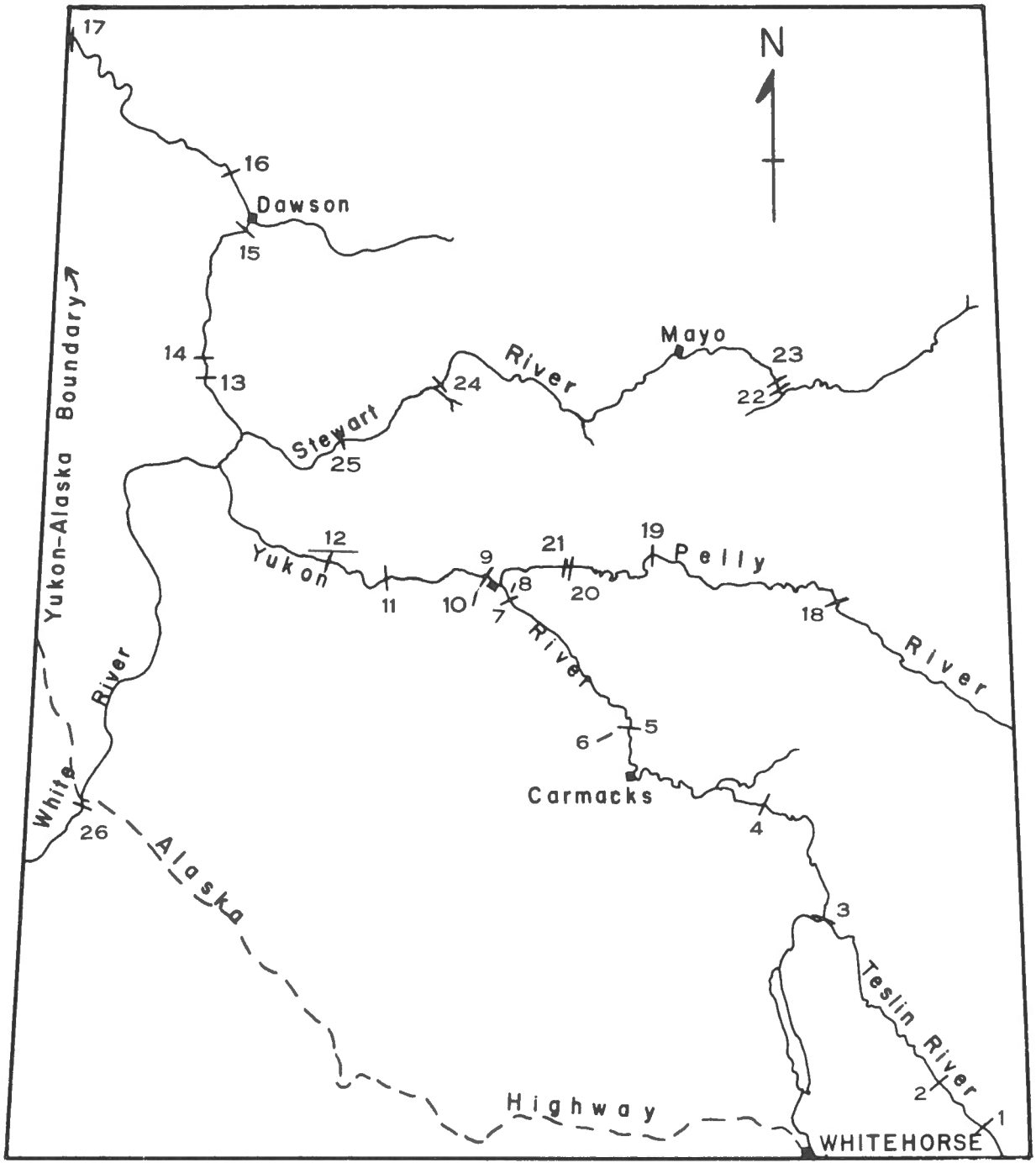
WATER RESOURCES BRANCH
GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE
Size in Inches
Tyler Standard – Meshes per Inch
6"
3"
1½"
¾"
3/8"
4
8
14
28
48
100
200
Limits for coarse aggregate
Limits for fine aggregate
PERCENT FINER THAN BY WEIGHT
PERCENT COARSER THAN BY WEIGHT
0
10
20
30
40
50
60
70
80
90
100
1000
100
10
1.0
0.1
DIAMETER – M.M.
Site Yukon River
Hole No.
Sample No. # 16
Depth
Plotted R. Keene
Date
PLAN No. 659 G-1


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
PERCENT FINER THAN BY WEIGHT
PERCENT COARSER THAN BY WEIGHT
100
90
80
70
60
50
40
30
20
10
0
1000
100
10
1.0
0.1
DIAMETER - M.M.
Site Yukon River
Hole No.
Sample No. # 17
Depth
Plotted R. Keene
Date
PLAN No. 659 G-1



LOCATION OF PROPOSED DAM SITES
YUKON RIVER DRAINAGE BASIN
Scale: 1 inch = 40 miles

Site No.	Name	Site No.	Name	Site No.	Name
1	Swift River	10	Fort Selkirk Draw	19	Granite Canyon
2	Northwest Power	11	Selwyn	20	Gerc
3	Hootalinqua	12	Britannia	21	Bradens Canyon
4	Big Salmon	13	Ogilvie no.1	22	Five Mile Rapids
5	Five Finger Rapids	14	Ogilvie no.2	23	Fraser Falls
6	Five Finger Draw	15	Upper Dawson	24	Independence
7	Wolverine	16	Lower Dawson	25	Porcupine
8	Wolverine Draw	17	Boundary	26	Lower Canyon
9	Fort Selkirk	18	Detour		