CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 11

YUKON RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

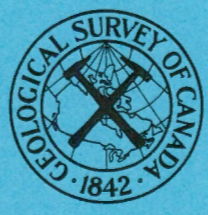
SITE NO. 5

FIVE FINGER RAPIDS DAM SITE

(MAP AND PRELIMINARY REPORT)

BY

E. B. OWEN



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FIVE FINGER RAPIDS DAM SITE

General Description

The Five Finger Rapids dam site at which it is proposed to develop hydro-electric power is located on Yukon River about 12 miles below the community of Carmacks. It is about 2,000 feet west of mile-post 116 on the Dawson-Whitehorse highway. The site is visible from the highway and is readily accessible.

A second site known as the Five Finger Rapids draw extension is located in a wide, shallow valley about two miles northwest of Five Finger rapids. This valley forms an area of potential leakage for water impounded behind the main power dam proposed for Five Finger rapids. The draw extension is described in topical report no. 12, site no. 6.

At the site of the proposed power dam the river is flowing in a northerly direction along the east side of a drift-filled valley some 4 miles in width.

Bedrock is exposed for several hundred feet on both sides of the present channel and on four small islands between the two abutments. On the right (east) abutment a 40-foot bedrock bluff rises abruptly from the river (approximate elevation 1,637 feet). Above the bluff ground surface slopes gradually upward for a distance of about 500 feet to a bedrock terrace with an average elevation of 1,740 feet. Farther east a second bedrock terrace with an average elevation of 1,880 feet extends almost to the Whitehorse-Dawson highway.

On the left side a bedrock bluff rises abruptly some 30 feet above the river's edge. Above the bluff, a terrace, 400 feet in width, extends west to the toe of a steep, 180-foot bluff which forms the left abutment of the proposed dam. A second higher terrace extends west from the top of this bluff for a distance of about one mile to a wide area of extremely irregular topography in which is located the Five Finger Rapids draw extension. The mass of material constituting the upper

terrace consists of glacio-fluvial sandy gravel covered with a veneer of silty, sandy alluvium. The glacio-fluvial material is exposed on the face of the bluff about 600 feet upstream from the left abutment.

The Yukon River has probably been flowing continuously in its present channel at Five Finger rapids since the last glaciation. Its present course is along the east side of a wide valley known as Yukon River Valley which, due to its confluence with the valley of Crossing Creek, is 4 miles wide at this point. Previous to the last glaciation, the course of the river may have been west of the proposed power site and it is possible it flowed through the area adjacent to the proposed draw extension. The uneven ground surface at the latter site indicates the river has not followed this course in post-glacial time.

The two seismic lines point out little that could not be inferred by comparing the topography with the bedrock exposures. Seismic line no. 1, located on a bedrock terrace east of the river, indicates bedrock is from 16 to 25 feet below ground surface. The elevation of this terrace is about 1,880 feet. Seismic line no. 2, located on the wide, gravel terrace west of the river, indicates the thickness of overburden in this area is greater than 275 feet.

Unconsolidated Deposits

Four types of soils have been identified in the area about the proposed dam site at Five Finger rapids. They are as follows:

1. Recent Alluvium: This material varies from a fine, compact, silty sand to masses of cobbles and boulders up to 12 inches in diameter. It is a deposit of the present river occurring in many places along the left bank. A large part of the

material was probably derived originally from glacio-fluvial gravels which constitute most of the overburden filling the wide valley of Yukon River.

2. Post-Lacustrine Alluvium (fine to coarse sand): This material consists of loose, graded, fine- to coarse-grained sand with a few scattered pebbles up to two inches in diameter. There is a predominance of fine sand particles in the material with some silt. The deposit occurs extensively on both sides of the river. It is thin and unimportant as a source of construction material.

3. Post-Lacustrine Alluvium (fine to coarse gravel): This material is a coarser phase of the sand described above in part two. It consists of a graded, fine- to coarse-grained gravel with pebbles up to three inches in diameter. It is a shallow deposit occurring extensively on the right side of the river.

4. Glacio-fluvial: This material constitutes most of the overburden in the area. Usually it is overlain by a thin deposit of alluvium but occurs extensively on ground surface along the bluff upstream from the left abutment. It consists of a loose, graded, sandy gravel with boulders up to 36 inches in diameter. It is almost silt-free and in this regard is similar to the glacio-fluvial gravels at the Big Salmon and Northwest Power Industries sites. These gravels are exposed in several borrow pits and road cuts along the newly constructed Whitehorse-Dawson highway where they were used extensively as base course and embankment material. The material occurring at higher elevations, for example on the tops of hills and knolls, is usually finer and more weathered.

Bedrock

General Description

Bedrock at the proposed dam site has been well described by H.S. Bostock[1].

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[1]Bostock, H.S.: Carmacks District, Yukon; Geol. Surv., Canada, Mem. 189, pp. 22-23 (1936).

The probable chief structural features of bedrock have also been described in figure 1 which accompanies the memoir.

Three different rock types (i.e. conglomerate, sandstone and shale) have been identified on the geological map which accompanies this preliminary report. A fault, 8 inches in width, occurs in the conglomerate about 1,500 feet upstream from the right abutment. The fault dips downstream at 45 degrees and strikes approximately parallel to the proposed centre line. On the foot-wall of the fault and parallel to it is a dyke of fine-grained, grey, siliceous rock. The width of the dyke is about 8 inches. It is too narrow to be plotted on the accompanying geological map. The conglomerate has been fractured for a distance of about two feet on each side of the fault. The broken rock is badly weathered and has much brown staining due to perculating ground water. Numerous narrow, irregular stringers of grey calcite also occur in the conglomerate adjacent to the dyke. A similar fault-dyke structure is located on the left bank of the river about 1,000 feet downstream from the map-area.

The geological map accompanying this report agrees closely with the map made by Bostock in 1936. The major difference is the lack of shale outcrops on the left side of the river upstream from the proposed centre line. It is possible the shale was covered with water at the time this investigation was made.

Quality of Bedrock

The quality of bedrock exposed at the site varies considerably. Much of the rock on the tops of the conglomerate outcrops on the left side of the river is badly weathered. As a result of the weathering some of the sandstone and also a large part of the sandy matrix of the conglomerate has become soft and friable. The

softness of the weathered rock is such that a hole, 24 inches deep, was dug by hand on top of a conglomerate outcrop on the left abutment. The conglomerate on the right abutment is less weathered.

The black shales exposed on the right side are soft and friable. The beds, which have an average thickness of about 1 inch, strike parallel to the proposed centre line. The dip is steeply downstream. There is a strong possibility the shale underlies the conglomerate at the site.

Bedrock Structures

According to Bostock the dam site is situated on the west limb of a northward trending syncline. A result of this is the shallow downstream dip of the conglomerate beds at the proposed centre line. The direction of dip of the bedding should not endanger the dam structure as the conglomerate is apparently free of shale, and should offer considerable shear resistance to the horizontal forces exerted by the dam. However, test borings should be made into the rock beneath the centre line and into the abutments to determine if there is shale interbedded with the conglomerate or if shale beds comparable with those exposed on the right bank underlie the conglomerate.

Several minor faults occur in the rock about the proposed site. They are small and not important. The zone of broken rock associated with the large fault located about 1,500 feet upstream from the right abutment could act as an acquifer and carry considerable ground water.

One strong, vertical joint set in the conglomerate strikes parallel to the river. This may be the reason for several elongated rock ridges which occur on both sides of the river and form part of the abutments. An extensive set of such joint planes could cause considerable leakage beneath the dam and through the abutments.

Engineering Considerations

Depth of Overburden

Except for the data obtained from the two seismic lines, little information is available regarding the thickness of overburden in the vicinity of the site. However, as indicated on the accompanying geological map there are large areas on the lower terraces near the river where the overburden is thought to be 10 feet or less in thickness. As both non-overflow sections are located on the lower terraces the quantity of overburden that would have to be excavated to found these two structures on bedrock will be relatively small.

The thickness of overburden beneath the river channel at Five Finger rapids is probably less than that beneath most of the other proposed dam sites in the Yukon River drainage basin. The chief reason for this is the relatively youthful age of the river in its present course. Consequently the power house and spillway structures can probably be founded on bedrock. Much of the unconsolidated material underlying the river is alluvium ranging in grain size from medium sand to coarse gravel. Test borings should be put down along the proposed centre line to determine the depth to solid bedrock and also to investigate the presence of large boulders in the overburden which might prevent driving steel sheet piling during construction of the cellular cofferdams.

Abutments and Foundations

The conglomerate bedrock exposed at the site should make a satisfactory foundation for the power intake, spillway and non-overflow sections and for the power-house. Exposed portions of bedrock are frequently deeply weathered. Consequently, in some parts considerable soft, weathered rock will have to be removed before a surface of fresh, solid rock is obtained against which concrete could be placed.

The shallow downstream dip of the bedding is not serious unless shale is present in the rock underlying the proposed site. Test borings should be put down to investigate this possibility. The shale would be similar to that exposed along the right edge of the river upstream from the site.

Bedrock here is not of the soluble type and large openings in the rock beneath the site should not be expected. A strong set of vertical joints striking parallel to the river may cause leakage through both the right abutment and the foundations. Another potential leakage area is the left abutment which consists chiefly of permeable, glacio-fluvial sandy gravel. The unweathered, sand matrix of the conglomerate is sufficiently impervious to prevent the passage of large quantities of reservoir water.

Construction Materials

Aggregate

The extensive deposits of glacio-fluvial sandy gravel which constitute the wide terrace commencing 400 feet west of the river are a potential source of natural aggregate. The quantity is unlimited. A program of test pitting and sampling would be necessary to determine the quality. It will probably be necessary to screen and reblend this material to obtain a satisfactory aggregate. The silt content is very low. Similar gravel, exposed in several cuts along the Dawson-Whitehorse highway, was used during construction of the road.

In a borrow pit at the intersection of Tatchum Creek road and the highway the proportion of rock types in the gravel size material was as follows:

(1) Intrusive igneous (granite, etc.) - 60 per cent
(2) Extrusive igneous (andesite, etc.) - 30 per cent
(3) Sedimentary (sandstone, etc.) - 10 per cent

Weathering was negligible and confined almost entirely to the sandstone and conglomerate. Rocks such as shale and chert, deleterious in aggregates, are seldom present.

The gravel occurring at higher elevations usually has a greater proportion of sand and frequently the larger boulders are badly weathered. In some localities, such as along Tatchum Creek road, numerous, partly disintegrated shale boulders occur in the gravel.

Impervious Material

A potential source of impervious material is the till which occurs in several places near the dam site area. The till was used as surface material during construction of the Dawson-Whitehorse highway and is presently being used by the Yukon Territorial Government for the same purpose as part of its road maintenance program.

Usually it is a greyish, fairly dense, sandy till containing numerous pebbles and boulders up to 10 inches in diameter. About 15 per cent of the boulders in the upper 3 feet of the till are badly weathered. Generally it directly overlies bedrock.

The exposure nearest to the site is in a steep bluff on the right edge of Yukon River about 1,500 feet below its junction with Tatchum Creek. Here a deposit of sandy-clay till, 20 feet in thickness and dipping steeply upstream, occurs in the face of a bluff which rises abruptly from the river to a height of over 100 feet. The till has a distinctive reddish-brown colour. Above the till and extending to ground surface is a thick deposit of thin-bedded, lacustrine silts which dip gently upstream (south). Flat-lying beds of glacio-fluvial sands and gravels underlie the till.

Till is exposed in a pit operated by the Yukon Territorial Government on the east side of the Whitehorse-Dawson highway at mile-post 122. This till is being used as surfacing material for the highway. Till is also exposed in several cuts along the highway between mile-post 115 and Carmacks.

Pervious Material

Material for the pervious shell required for the left abutment can be readily obtained from the extensive glacio-fluvial deposits of sandy gravel which constitute the bulk of the material in the terrace west of the river.

Riprap

Bedrock exposed at the site is relatively soft and has an apparent low durability. It is doubtful if any of these rocks would make satisfactory riprap or rock fill. Conglomerate similar to that at Five Finger rapids is presently being placed as riprap for the abutments and approaches of the new bridge over Yukon River at Carmacks. The sandy matrix of this conglomerate is extremely friable and according to the contractor it was difficult to blast, load, transport and place large pieces of the rock without many of them breaking down into smaller fragments.

Ground Water

Little is known regarding the ground-water table in the vicinity of the proposed site. It is thought to be low in the vicinity of the left abutment and beneath the wide terrace west of the river. This would increase the danger of leakage in this area following construction of the dam. On the right side a small pond at approximate elevation 1,725 feet above sea level and two sloughs at elevations 1,740 and 1,855 are probable indications of the water table. Accurate

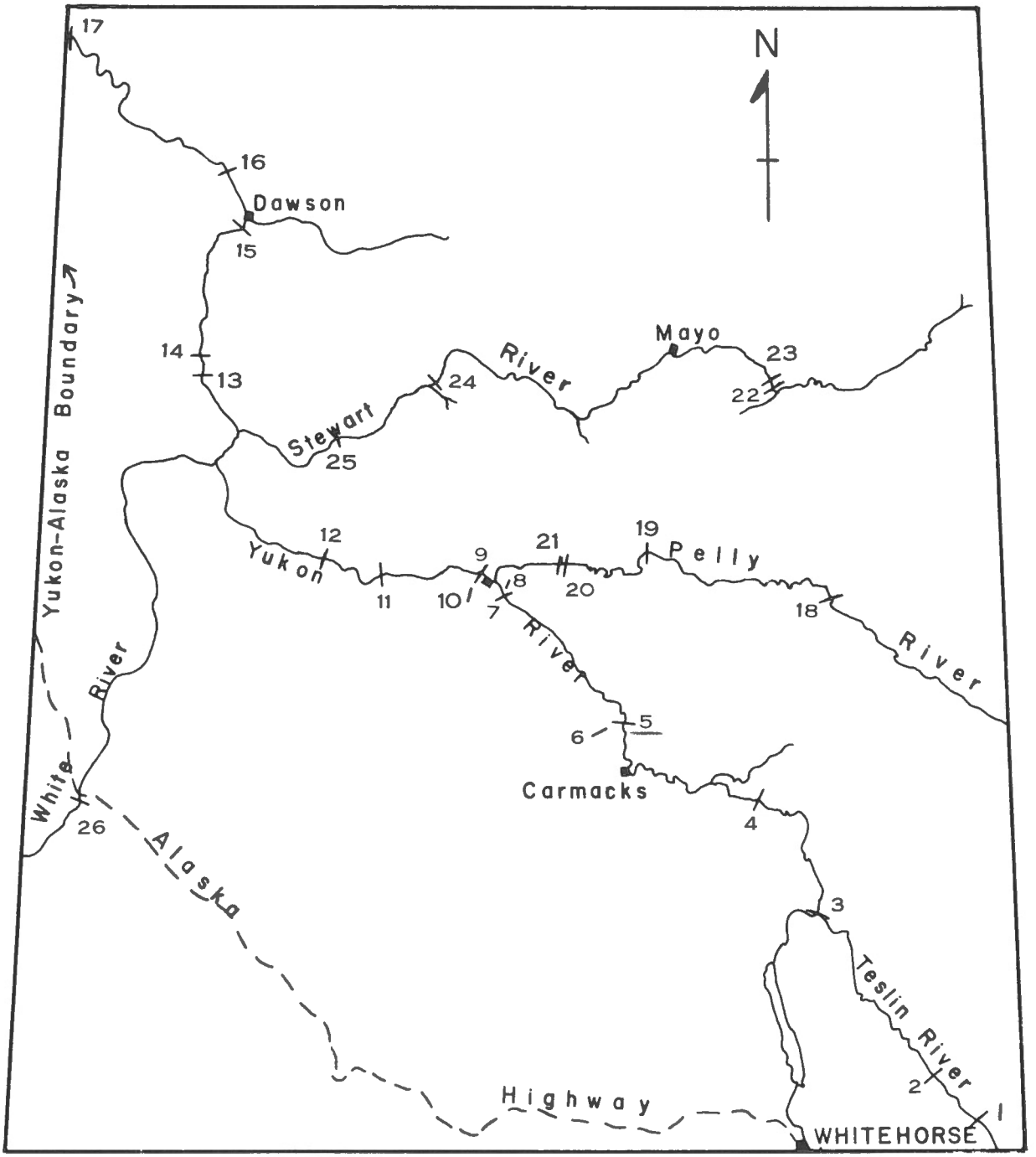
information regarding the water table can only be obtained by an expensive drilling program involving the installation of many ground-water observation holes.

Further Investigations

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

	Location	Approximate Elevation	Depth	Remarks
1.	Non Overflow Section, on centre line, 1,075 feet east of river	1,795	15 feet into bedrock	Soil samples taken every five feet or where there is a change in material, permeability tests conducted, ground-water table noted.
2.	Non Overflow Section, on centre line, 550 feet east of river	1,730	"	"
3.	Power-House Section, on centre line, 10 feet east of river	1,640	15 feet below grade of power-house	"
4.	Power-House Section, on centre line, centre of small island	1,660	"	"
5.	Non Overflow Section, on centre line, 10 feet west of river	1,640	"	"

	Location	Approximate Elevation	Depth	Remarks
6.	Non Overflow Section, on centre line, 500 feet west of river	1,695	15 feet into bedrock	Soil samples taken every five feet or where there is a change in material, permeability tests conducted, ground-water table noted
7.	Embankment Section, on centre line, 800 feet west of river	1,890	"	"
8.	Embankment Section, 150 feet north of hole no. 7.	1,890	"	"
9.	Embankment Section, 150 feet south of hole no. 7	1,890	"	"



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		