GRAND CANYON DAMSITE

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February 8, 1962

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Introduction

The site is located on the Fraser River about 1 mile below the upstream end of the 3½ mile long Grand Canyon. Access is by riverboat or winter logging road from Sinclair Mills, a sawmill located on the right bank of the Fraser River about 9 miles downstream from the site. Sinclair Mills is reached by dirt road from Hansard, a distance of about 11 miles, the route necessitating crossing the Fraser River by ferry near Hansard. The Canadian National Railway runs parallel to the river 3 miles northeast of the site. From January to March, 1961, seven drill holes totalling 1,135 feet were put down at the site to test foundation conditions for a dam of an approximate head of 100 feet. Only about 100 feet of this drilling was done in overburden. In addition, eight shallow test pits were put down on the left bank downstream from the proposed centreline and four short hand auger holes put down across an old, infilled river channel northeast of the site. This report summarizes the data obtained from the drilling, the test pit digging, and from geological mapping of the site.

The drill hole locations and test pits are shown on the accompanying geological plan (Fig. 1) and the formations encountered in the drill holes and the results of pumping tests on the accompanying sections (Fig. 2). Detailed logs of individual holes have been submitted separately to the Fraser River Board and do not accompany this report.

The geology of the Grand Canyon was mapped by J. W. McCammon of the Department of Mines in 1955 and is included in a larger report submitted to the Provincial Government Water Rights Branch in April, 1956. Copies of this report are on file with the Fraser River Board. Also, what is now known about the complex pre-glacial, glacial, and post-glacial history and consequently drainage history of the Fraser and McGregor Rivers in this general area has been discussed by the writer in three reports submitted to the Fraser River Board in November, 1959, May, 1960, and June, 1961. The reader is referred to the above four reports for a description of the regional geology of this area.

(A) Geology of the Damsite

(I) Bedrock

The rocks exposed along the Grand Canyon consist of a series of metamorphosed Lower Cambrian sediments which are similar in general to rocks exposed in the lower canyon of the McGregor River and at the Olsson Creek site. They lie on the south limb of an east-west trending anticline which possibly plunges gently westward, and form an apparently conformable succession, the oldest rocks being exposed at the downstream end of the canyon. Within the map-area (Fig. 1) the rocks strike approximately east-west and dip from 35 degrees to 65 degrees south or upstream. They form the canyon walls and extend, on the left bank to an elevation of almost 2,200 feet and, on the right bank, to an elevation of about 2,180 feet. Within the map-area they consist of a complex sequence of interbedded limestone, argillite, and quartzite with all gradations between. Limestone greatly predominates. The limestone is generally medium grey in colour, varies from thin bedded to massive, occurs in beds from less than an inch to many feet in thickness, and is locally ankeritic and/or pyritic. Locally it is argillaceous and grades through limy argillite to argillite. Argillite members are generally much thinner than limestone members, are locally quite fissile, and weather to a corrugated surface. Massive to thin-bedded, generally fine-grained quartzite members ranging in thickness from a few inches to several feet occur interbedded with the limestone and argillite. The lack of correlation of the quartzite members between even relatively closely spaced drill holes suggests that they are generally lenticular in shape. The quartzite grades into sandy argillite locally and some limestone beds contain sand grains. For a detailed description of the above complex rock types, the reader is referred to logs of individual drill holes.

All of the above rocks are cut by joints and faults and are locally folded. McCammon mapped three joint sets cutting the rocks forming the canyon. However, within the map-area only one major set, striking about north-south and dipping steeply east to vertical, was observed although highly irregular jointing is present within certain small areas. The joints are spaced from about 1 inch to over a foot apart, are generally much more closely spaced in the brittle quartzite than in the other rock types, and where encountered in drill holes are either clean or are coated with a thin film of calcite or limonite. The combination of relatively closely spaced joints, especially in the quartzite members, and the weak, thinly bedded character of some of the members has resulted in relatively fine talus along the river banks locally within the map-area. Minute gash veinlets filled with white crystalline calcite and minor white quartz also cut these rocks locally.

Faults of various widths and attitudes cut the rocks. Immediately downstream from the high canyon walls in the map-area, limestone breccia consisting of angular grey limestone fragments tightly cemented by white coarsely crystalline calcite is exposed on both banks near river level. Immediately downstream from the most northerly exposure of this material on the right bank, fissile, black limy argillite is exposed along the river; this latter formation underlies the main limy formation exposed in the map-area. Immediately to the north of the map-area on the left bank, a vertical northwest trending fault scarp occurs. The brecciated limestone apparently lies along a major fault zone separating the two formations. This fault zone appears to be wider on the right bank and on Figure 1 is shown between two fault lines. Upstream from the major fault several very small faults are visible along the canyon walls and most of the drill holes encountered a few generally very small faults.

With the exception of a fault of unknown attitude encountered for a length of about 6 feet in one drill hole, the clayey gouge zones of the faults seldom exceed an inch or so in width and there is little brecciation of the wallrock near faults.

Within the map-area, a very few small dragfolds were seen in the rocks forming the canyon walls. However, immediately north of the map-area, larger, more open folds are exposed in the underlying limy argillites. Very minute folds were observed in drill core in a few places.

(II) Soils

Silts and sands, locally containing minor clay or gravel, form a generally thin veneer over bedrock on the right bank within the map-area (see Sections A-A' and B-B', Fig. 2). Similar fine-grained sediments were encountered overlying gravel in test pits put down on the left bank about 300 feet downstream from the proposed centreline, are exposed in road cuts immediately to the east of the site, and form cut banks, locally up to about 50 feet high, along the river for many miles upstream and downstream from the site. These sediments were deposited into the large post-glacial lake which centred around Prince George and which extended for many miles southeastward along the Rocky Mountain Trench.

Drill hole 3, put down on the left bank on the proposed centreline about 100 feet above river level, encountered a complex glacial till composed mainly of sandy clay from the collar to a depth of about 51 feet where it overlies bedrock. The till is blue-grey in colour, very dense, and eight pumping tests done in it indicate that it is essentially impervious. Brown, generally silty clay till was encountered up to an elevation of about 2,080 feet in three of the seven test pits put down on the left bank downstream from the proposed centreline. In the test pits, a thin layer of gravel lies between the till and the overlying glacial lake sediments; this gravel possibly was formed by the reworking of the till by running water. The shaded area on Figure 1 roughly indicates where this gravel is exposed on the ground surface. Glacial till is also exposed along the left bank near river level immediately upstream from the site and probably also underlies the deeply gullied hillside immediately upstream from drill hole 3 (see Fig. 1).

Recent river alluvium consisting mainly of reworked glacial lake silts and sands overlies bedrock in the present river channel at the site and forms bars in the river upstream and downstream from the site. The bars are locally capped by a thin veneer of coarse, well-rounded gravel. Drill hole 2, put down in the river about 80 feet from the left bank and 150 feet downstream from the proposed centreline (see Section C-C', Fig. 2) encountered 16 feet of loose, fine sand overlying bedrock. It is expected that the river alluvium is probably somewhat shallower at the proposed centreline (see Section A-A', Fig. 2) than in the vicinity of drill hole 2 or in the deep pool which was detected by river soundings a few hundred feet downstream from the centreline.

(B) Foundation Problems

(I) Bedrock

The three drill holes put down in the river (*see* Sections A-A' and C-C', Fig. 2) indicate a considerable variance in the water conducting properties of the rock underlying the river bed in this immediate area. Drill hole 1 and the upper half of the angle hole 7, drilled near the right bank and under the right part of the river channel respectively, recorded generally high water losses during pumping tests, apparently mainly through open joints, whereas drill hole 2 and the lower section of drill hole 7, drilled near the central and left part of the river channel, recorded no to low water losses during pumping tests. Although several small faults and one relatively wide fault (drill hole 7, -252 feet to -258 feet) were encountered in these holes, the faults are apparently mainly filled with clay gouge and do not appear to offer open channels for the passage of water. No cavernous areas were detected in any of the limy rocks penetrated by these holes.

Except for sections of rock penetrated by drill hole 3, put down on the left bank, the three holes drilled into the proposed abutment areas (*see* drill holes 3, 4, and 5, Section A-A', Fig. 2) recorded no or, locally over short sections, low water losses during pumping tests although relatively severely fractured rock and a few small faults were encountered locally. In the river holes and in the abutment holes drill runs tended to be shorter and core recoveries much lower in the more brittle, badly fractured quartzite members. In all three abutment holes the upper sections showed no water losses during pumping tests. However, drill hole 6, drilled on the right bank about 250 feet upstream from the proposed centreline, recorded moderately high water losses in its upper 70 feet, although over 92 per cent of the core was recovered in relatively long drill runs. As in the river holes, no cavernous areas were detected in the limy rocks of the abutments.

From the drilling done at the site and from an examination of the canyon walls it appears that these rocks are of sufficient structural competence to support a concrete gravity dam of the height proposed. One of their more unfavourable structural properties as far as strength is concerned is the presence of the thin, often somewhat fissile argillite partings between the other members of the formation but, as the formation dips at moderately steep angles upstream, weakness along these partings is not considered particularly important. However, it is probable that a certain amount of consolidation grouting of the rocks will be necessary under the dam, especially in areas of intense fracturing such as encountered near surface in drill hole 1. Due to the considerable variation in the intensity of fracturing within the foundation area, the areal extent of this type of grouting cannot be accurately determined with the information presently at hand. The depth of the primary grout curtain required under the heel or core wall of the dam is also difficult to predict but the drilling done to date suggests that it may need only be shallow in the abutments but possibly about 70 to 80 feet deep under the river section.

It is not expected that tunnelling in these rocks would offer any particular difficulty although some support, especially in the more brittle, highly fractured areas, will be required during driving. Power tunnels would probably have to be lined at this site.

(II) Soils

The chief problem associated with the soils at the site is the depth and extent of the glacial till in the left abutment area. The bedrock surface is approximately 70 feet lower than the proposed dam crest at drill hole 3 (see Section A-A', Fig. 2) and appears to slope toward the river at about 7 degrees below horizontal in this immediate area. A steep cliff composed of the same formation as that exposed at the site occurs about 2,000 feet northwest of drill hole 3. Until further pre-construction drilling is done on the flat immediately above and to the west of drill hole 3, it must be assumed that the bedrock surface under this flat is at the same general elevation as encountered in drill hole 3 or rises very gradually to the base of the cliff mentioned above. As previously stated, till was encountered in several of the test pits put down about 300 feet downstream from drill hole 3 and is exposed upstream from drill hole 3, indicating that it is of relatively wide extent in this area. The till is of very high shear strength and essentially incompressible and the founding on it of an abutment of an earth-fill dam or of an earth-fill section connected to a concrete structure would probably offer no problems as regards stability or seepage.

The surface elevation of the till west of drill hole 3 under the flat is not known, and the thin, no doubt permeable gravel deposit overlying till and underlying glacial lake sediments exposed downstream from drill hole 3 below the proposed H.W.L. of 2,120 feet may extend at the same general elevation southwest around drill hole 3 into the reservoir. If this is so, filling of the reservoir would cause seepage to flow through this gravel and emerge flowing over till and bedrock in the shaded area shown on Figure 1. Even if the above condition does exist, which is not too likely, it is not considered serious as the gravel bed involved appears to be very thin and could probably be readily treated by minor blanketing in the reservoir. Nevertheless, it is a matter which must be investigated prior to construction.

Prior to Pleistocene time, the Fraser River flowed in a channel to the northeast of the present Grand Canyon. This pre-glacial channel, between where it meets the present river upstream and downstream from the canyon, is about 12 miles long. It is now infilled with glacial and post-glacial sediments and its surface is generally flat and swampy. A topographic survey was run for a length of about 1,600 feet across the apparently lowest saddle on this swampy surface to check if any point of this saddle area was below the proposed H.W.L. of 2,120 feet. The lowest point was found to be 2,123 feet (Plan No. F-111-2, prepared by the Federal Government Water Resources Branch does not accompany this report) and the ground to slope gently north and south from this saddle. In view of this, a low dyke will probably have to be constructed across this saddle to allow sufficient freeboard against wave action within the reservoir. Four short hand auger holes were put down across this saddle to test foundation conditions for such a dyke. Glacial lake silts, silty sand, and permeable clean sand overlain by about 3 feet of organic top soil, were penetrated to a depth of 24 feet. Soft, very weak and compressible silt with low plasticity generally underlies the top soil for an average depth of about 7 feet at the site. It may prove economic to strip off this silt layer in order to establish a more steeply sloping fill on the firmer underlying sands. Assuming a maximum reservoir H.W.L. of 2,120 feet, seepage paths from the reservoir under this fill will be very long and significant seepage losses or dangerous excess seepage pressures are not likely to develop in this area.

(C) Construction Materials

No gravel deposits of sufficient size or quality to provide relatively large quantities of concrete aggregate were detected either by the writer or by J. W. McCammon in the general site area or for many miles upstream or downstream along the river. However, the most probable sources of gravel would be from buried deltas built out into the long lake which occupied this area in early post-glacial time. Initial prospecting, using hand augers, would possibly be most profitable along the sides of the main valley in areas where present streams, many of which also existed in early post-glacial time, enter the main valley. Clean sand, suitable for the finer fraction of concrete aggregate or for filters could be obtained in the area to be dyked, or probably anywhere between it and the site.

The glacial till exposed on the left bank near the proposed centreline would be an excellent, readily available source of impervious core material. It is very dense, probably well graded, and apparently contains very few large boulders.

Large quantities of limestone talus, probably of sufficient quality for rock-fill or rip-rap, occur along the base of the steep cliffs about one-half mile northwest and one-half mile northeast of the site. If more resistant rock is required, the quartzite forming the canyon walls about one-half mile upstream from the site could be quarried. This quartzite occurs in 6-inch to 2-foot thick beds separated by thin, sheared, soft and crumbly argillite interbeds. The argillite would need be wasted if the rock were used in a rock-fill, which would necessitate some form of sorting of the quarried material. Test blasting of this formation would have to be carried out prior to opening a quarry in it to see if the argillite would readily separate from the quartzite.

F.R.B. Dwg. No. 111-112

FIG. 2

GRAND CANYON DAMSITE, FRASER RIVER
— SECTIONS —