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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 57

PROPOSED SITE FOR AN EXPERIMENTAL MINE

BELLS CORNERS AREA, CARLETON COUNTY, ONTARIO

BY

E. B. OWEN

OTTAWA

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Proposed Experimental Mine,
Bells Corners Area,
Carleton County, Ontario.

Introduction

This geological report was prepared following an examination of bedrock exposures in the vicinity of the proposed experimental mine in November, 1961 and a subsequent examination of the core from seven test borings put down at the site during April, 1962. The locations and depths of the borings are indicated on an accompanying plan, scale 1 inch to 200 feet, on which is also drawn an outline of the proposed underground workings. A report by G.D. Hobson on the results of a seismic reconnaissance conducted in the area on December 6, 1961 is included at the end of this report.

General Description

The proposed experimental mine is located in lot 5, concession 1 (O.F.), Nepean township about 2 miles northwest of the community of Bells Corners. It is readily accessible from the Corkstown Road which is parallel to and about half way between Queens' Highways Nos. 15 and 17.

The site is located at the north end of a north-trending ridge, the relief of which is from 50 to 100 feet above the surrounding country. Bedrock, which is exposed almost continuously along the ridge, has for many years been the chief source of sandstone used for building

purposes in the Ottawa area. Similar rock in the Beauharnois, Quebec area has been crushed to provide fine and coarse aggregate and road building material. Overburden in the area consists chiefly of rubble and loose rock produced during the excavation of several, small, shallow quarries.

Bedrock - description

Bedrock exposed at the site consists of Nepean sandstone, a fine-grained, white to dark grey, quartz sandstone, containing narrow interbeds of blue-grey quartzite. It has been well described by A.E. Wilson.[1] The sandstone exposed in the walls of the shallow quarries near the site is thin-bedded with few beds greater than 14 inches in thickness.

Weathering has penetrated the upper part of the sandstone to depths ranging from 3.8 to 30 feet. Here the rock along the numerous joint and bedding planes is frequently coated with a thin, brown deposit of iron-bearing carbonate formed by circulating groundwater. Core recovery in this upper zone was poor. Below, bedrock consists of fairly massive to massive sandstone overlying granitic Precambrian rocks. A result of the test boring program indicates the elevation of the granite surface beneath the proposed limits of the experimental mine decreases southerly from 246 to 238 feet. Discontinuous beds of buff-coloured silty shale and conglomerate up to 5 feet in thickness immediately overlie the granite. With the exception of boring No. 2, bedrock adjacent

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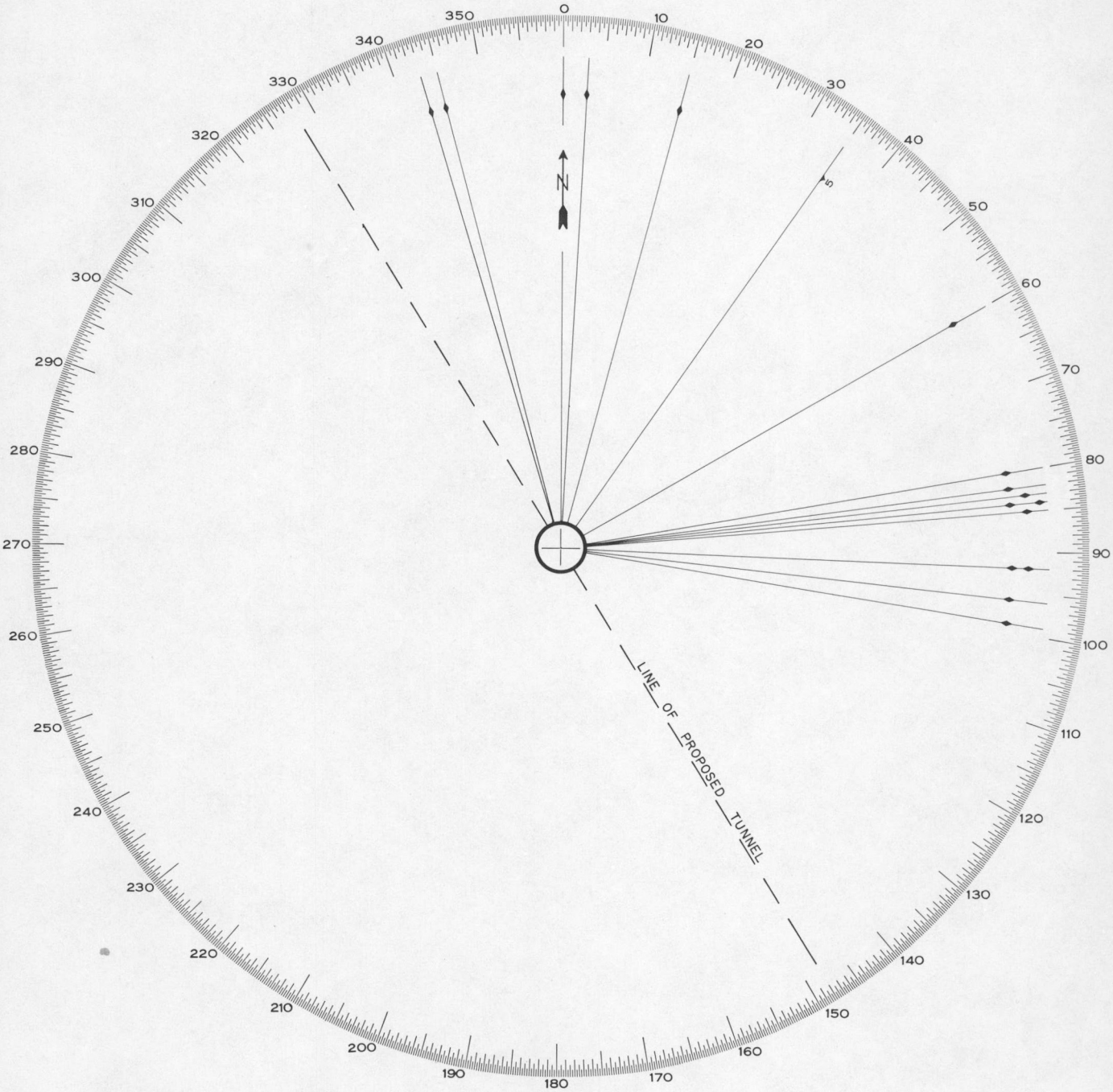
[1] Wilson, A.E.: Geology of the Ottawa - St. Lawrence Lowland; Geol. Surv., Canada; Memoir 241, 1946.

to the contact is solid and little groundwater should be encountered in this horizon. In boring No. 2 about 12 feet of the sandstone immediately overlying the granite is broken and weathered. The upper part of this shattered material will probably be intersected during construction of the mine. It is possible some groundwater will be encountered here.

Bedrock - structures

Jointing and bedding are the most important structures in bedrock at the site. The potential aquifers encountered in the sandstone during drilling invariably occur along joint or bedding planes. Also the jointing and bedding represent planes of weakness in bedrock along which it will frequently break when blasted. The most pronounced jointing is a vertical set which intersects the tunnel at 50 to 68 degrees. This is an important geological consideration because, in general, it is undesirable to have persistant joints parallel or nearly parallel to a high, long wall. The more closely the strike of the joints approaches a direction that is normal to the surface the less effect the joints have in causing instability. The jointing is believed to extend from bedrock surface to the base of the sandstone. A joint rosette which indicates diagrammatically the relation of the jointing to the line of the proposed access tunnel accompanies this report. Bedding throughout the area is almost horizontal. However, the presence of minor, local undulations in the beds have resulted in shallow dips which vary from 10 degrees north to 5 degrees south. In the vicinity of the proposed access tunnel the beds dip 5 degrees southeast and the strike is such that they intersect the tunnel at about 60 degrees. It should be noted the dip of the bedding



JOINT ROSETTE

The above illustration presents diagrammatically the direction and dip of the jointing in bedrock exposed at the Experimental Mine, Bells Corners area, Carleton County, Ontario

is in the opposite direction to the proposed 3/4 of 1 per cent slope for the tunnel. There is no evidence of major faulting in bedrock exposed at the site. It is improbable the steep sides of the ridge are fault scarps.

Groundwater

It is believed hand specimens of the sandstone at Bells Corners have a low porosity and permeability. However, groundwater can circulate along both joint and bedding planes in the rock mass. Consequently the permeability of the rock mass will vary considerably from place to place depending upon the absence or presence of these planes. During construction of the experimental mine there should be very little inflow from most of the rock mass.

Several irregularly spaced horizons capable of carrying groundwater were observed in the core from the seven test borings. In most instances they were parallel to the horizontal bedding although at least two were along vertical joint planes. It was to investigate the presence of the latter that borings Nos. 2 and 4 were drilled at 45 degrees to the horizontal. These potential aquifers have been identified on the accompanying geological section by the letters "P.A.". A 12-foot zone containing at least 5 potential aquifers was encountered near the top of the tunnel and in the rock immediately above it by boring No. 1. A similar slightly smaller zone which may be a continuation of the other was encountered by boring No. 2 about 8 feet above the workings. Potential aquifers were not encountered near the tunnel by boring No. 4, however, several will be encountered near the intersection of the workings and boring No. 7 if, at some future date, the mine is extended

south to this point. The quantity of groundwater which might be encountered during construction of the mine is unknown. It is not believed to be great. There is no evidence of groundwater seeps or springs along the base of the ridge. During November, 1961 the groundwater table was 5 feet from ground surface in a diamond drill hole located on the ridge about 1,500 feet east of the site and at a similar depth in an abandoned well situated near station No. 3 at the foot of the bluff. Little groundwater will be encountered at the contact of the granite with the overlying sedimentary rocks.

Conclusions

The following conclusions are made as a result of this geological investigation:

1. Bedrock consists chiefly of a fine-grained, white to dark grey, quartz sandstone overlying granitic Precambrian rocks. With the exception of the sandstone at the intersection of the mine and boring No. 2, bedrock that will be encountered during construction is probably the most competent of all the rock penetrated during the boring program. The surface of the Precambrian rocks will occur about 6 feet below the floor of the proposed access tunnel and from 6 to 16 feet below the floor of the main part of the mine.

2. Jointing and bedding are the two most important structures in the sandstone. Both structures represent planes of weakness in the

rock and will influence the manner the rock will break when blasted.

3. Numerous, irregularly spaced potential aquifers occur in the sandstone chiefly along the horizontal bedding planes and vertical joint planes. As indicated on the accompanying geological section many potential aquifers exist immediately above the proposed workings. The quantity of groundwater which may be encountered is not known. It is not, however, believed to be large.

4. The information obtained from the test borings indicated the data derived from the seismic investigation was essentially correct. The third layer described by Mr. Hobson as a massive, dense, competent sandstone with a velocity comparable to granite was proved by the drilling to actually by granite.

Seismic Reconnaissance at Bells Corners

By G.D. Hobson

An experimental seismic survey was conducted at the proposed mine location at Bells Corners on December 6, 1961, using a portable hammer seismograph. Three refraction profiles were shot across the area of interest and one profile at a known location near a hole drilled to granite. The accompanying diagram sets out the profiles and certain results.

The purpose of the survey was to see whether the seismic method could determine the contact between the Nepean sandstone and granite. The Nepean sandstone outcrops at surface in this area. The seismic method is effective only if at the interface between two rock strata there is a definite change in the velocity of transmission of seismic waves within those strata. If two adjacent rock strata transmit seismic energy with the same velocity the interface between these two strata will not be detected even though the two layers may be of entirely different material. This latter fact was appreciated at the outset of this seismic survey since we knew we would be dealing with the very dense Nepean sandstone immediately overlying granite. Some interesting and possibly useful results may have evolved.

Considerable background information with respect to the velocities that we might expect in the Nepean sandstone was obtained in the Vaudreuil area Quebec, from a previous survey. The Nepean

sandstone in the Vaudreuil area is under a considerable thickness of overburden and would therefore, differ in some respects to the location at Bells Corners. However, it was felt that the velocity information at hand would be of considerable help in this survey. This was substantiated.

Computations indicate a definite three layer case. The accompanying diagram illustrates the thickness of these various layers in the form of isopachs. The top layer, from 20 to 35 feet thick, with a comparatively low velocity of approximately 4,000 feet per second is weathered probably through the severe jointing and bedding planes visible from the surface. This upper layer appears to thicken to the east although no control is available to the west. It may be that this layer thickens to the southwest but location two is already off the central high of the ridge and this possibility is doubtful.

The intermediate layer underlying the upper weathered layer is more massive and not weathered as indicated by the average velocity of 12,000 feet per second. This layer appears to vary from approximately 45 to 75 feet thick over the surveyed area and may be generally described as lenticular in shape with the thickest section located generally in the area of most interest. Optional contouring to the southwest due to lack of positive control, is indicated on the diagram.

The third layer is a massive, dense, competent sandstone with a velocity comparable to granite. The average horizontal velocity observed is 20,600 feet per second. Since this velocity is so similar to a granite

velocity no refracted energy can be detected from the sandstone-granite interface below. This third layer is at least approximately 70 feet below ground surface. If much work, such as drilling, excavating, etc. is anticipated within this material, it must be appreciated that costs may be increased.

In conclusion, the seismic method is unable to pick up the contact between the sandstone and the granite due to the lack of a velocity differential between these two strata. This survey has pointed up, however, the approximate thickness of the weathered layer near the surface, the presence of an intermediate layer some 45 to 75 feet thick which should not be too difficult to mine, and the presence of a lower very massive dense and competent layer of sandstone which may be of considerable thickness. This last layer may be of the order of 70 to 100 feet thick according to geological information and would provide a good floor for the mine. It is still necessary to drill a hole to the granite to correlate this seismic information with the geology on the site.

LOG OF TEST BORING NO. 1

Elevation of Ground Surface: 319.1
Elevation of Bedrock: 319.1
Elevation of Bottom of Hole: 230.0

Hole drilled at right angles to base line at an angle of 78 degrees to the horizontal.

Depth (feet)	Description
0	Ground and bedrock surface.
0 - 2.2	AX casing core; no recovery.
2.2 - 6.0	Sandstone: fairly massive; grey to buff; medium-grained; a few shaly partings usually along bedding planes; considerable brown weathering along bedding planes; core up to 4 inches.
6.0 - 9.3	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular, shaly partings; core up to 3 inches; no weathering.
9.3 - 14.4	Sandstone: fairly massive; grey; medium-grained; a few shaly partings up to 1/4 inch at 12.5; core up to 4 inches.
14.4 - 15.7	Sandstone: massive; dark grey; medium-grained; calcareous; core up to 11 inches; a distinctive bed.
15.7 - 16.8	Sandstone: fairly massive; dark grey; medium-grained; numerous shaly partings usually parallel to horizontal bedding.
16.8 - 22.8	Sandstone: massive; grey; medium-grained; very little shale; core up to 26 inches; 1-inch, brown, weathered seams at 17.7 and 18.0.
22.8 - 23.2	Sandstone: fairly massive; dark grey; medium-grained; numerous shaly partings; core up to 3 inches.

Depth (feet)	Description
23.2 - 29.9	Sandstone: fairly massive; grey; medium-grained; a few irregular shaly partings and minute inclusions; core up to 6 inches.
29.9 - 30.9	Sandstone: as 22.8 - 23.2
30.9 - 33.8	Sandstone: fairly massive; grey to dark grey; medium-grained; numerous irregular shaly partings; core up to 8 inches.
33.8 - 37.5	Sandstone: fairly massive; light grey; medium-grained; minor shale; core up to 7 inches.
37.5 - 37.9	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular, blue-grey, shaly partings; core up to 5 inches.
37.9 - 42.6	Sandstone: fairly massive; light grey; medium-grained; a few shaly partings up to 1/16 inch; core up to 6 inches.
42.6 - 46.7	Sandstone: fairly massive; grey; medium-grained; very few shaly partings; a vertical joint plane cut at 42.6 - 44.0 the surfaces of which are weathered brown; core up to 7 inches.
46.7 - 48.5	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular, shaly partings; considerable brown weathering between 47.5 and 48.5; core up to 5 inches.
48.5 - 52.0	Sandstone: fairly massive; grey; medium-grained; a few scattered shaly partings; core up to 4 inches; a 2-inch, soft, brown, horizontal, weathered seam at 50.3.
52.0 - 53.0	Sandstone: massive; dark grey; medium-grained; numerous irregular shaly partings; an 11-inch length of core.

Depth (feet)	Description
53.0 - 70.8	Sandstone: massive; grey to dark grey; fine- to medium-grained; a few scattered shaly partings; a 1-inch, brown, horizontal, weathered seam at 57.0; core up to 11 inches.
70.8 - 72.7	Shale: buff to grey; fine-grained; sandy in part; core up to 2 inches; 6 inches core lost.
72.7 - 91.0	Granite: massive; grey to reddish-brown; fine- to medium-grained; core up to 12 inches; no weathering.
91.0	Bottom of boring.
Note:	Considerable brown weathering along horizontal bedding planes in upper 6 feet of bedrock; from 6.0 to 52.0 feet rock is fairly massive and then becomes massive down to a 2-foot shale bed directly overlying the granite; a few brown weathered seams were encountered in the sandstone which are believed to be potential aquifers, they are usually along the horizontal bedding planes, one seam was along a vertical joint; the granite is massive and not weathered; the contact between the shale and underlying granite is tight; it is believed the granite is more weathered when it is overlaid by the basal conglomerate; per cent of core lost: 12.

LOG OF TEST BORING NO. 2

Elevation of Ground Surface:	320.8
Elevation of Bedrock:	320.8
Elevation of Bottom of Hole:	243.0

Hole is located 15 feet northeast of station No. 2. The azimuth was 15 degrees west of that of the base line and it was drilled south at an angle of 45 degrees to the horizontal.

Depth (feet)	Description
0	Ground and bedrock surface.
0 - 2.5	AX casing core; no recovery.
2.5 - 3.8	Sandstone: massive; grey; medium-grained; core up to 10 inches long; considerable brownish weathering and carbonate coatings along vertical joint planes.
3.8 - 11.4	Sandstone: massive; grey; medium-grained; core up to 16 inches; very little shale.
11.4 - 20.5	Sandstone: fairly massive; grey to dark grey; medium-grained; core up to 6 inches; numerous dark grey, shaly partings up to 1/8 inch in thickness, some parallel to bedding; 9 inches of core lost at 13.3; considerable carbonate in matrix.
20.5 - 21.4	Sandstone: fairly massive; shaly; dark grey to black; fine- to medium-grained; sandy shale interbeds up to 1/2 inch in thickness; core up to 5 inches.
21.4 - 24.7	Sandstone: fairly massive; grey to dark grey; medium-grained; thin-bedded; considerable brown weathering between 22.5 - 24.0; numerous irregular shaly partings up to 1/8 inch; longest core is 7 inches; minor carbonate in matrix.

Depth (feet)	Description
24.7 - 32.0	Sandstone: massive; grey; medium-grained; minor brownish mottling; minor shale as irregular partings; core up to 17 inches; 9 inches of core lost.
32.0 - 35.4	Sandstone: fairly massive; light grey; fine- to medium-grained; minor shaly partings and minute shale inclusions; core up to 3 inches in length; core broken and not in good condition.
35.4 - 36.8	Sandstone: fairly massive; grey; medium-grained; numerous irregular shaly partings some parallel to bedding; core up to 8 inches; 6 inches of core lost at 34.5
36.8 - 41.0	Sandstone: fairly massive; light grey; fine- to medium-grained; a few irregular shaly partings; core up to 4 inches; core broken; 10 inches of core lost between 36.8 - 38.0.
41.0 - 46.5	Sandstone: fairly massive; grey to dark grey; medium-grained; alternating beds of grey and dark grey sandstone up to 12 inches in thickness; dark beds have a higher shale content; core up to 7 inches; matrix is partly carbonate.
46.5 - 51.6	Sandstone: fairly massive; light grey; medium-grained; no shale; a few small, brown, weathered spots; core up to 9 inches; 10 inches of core lost between 47.2 - 48.8.
51.6 - 53.2	Sandstone: massive; dark grey; medium-grained; some brown mottling; numerous black, shaly partings.
53.2 - 67.0	Sandstone: fairly massive; grey to dark grey; medium-grained; core up to 9 inches; a few shaly partings up to 1/8 inch chiefly along bedding planes; considerable brown carbonate coatings and weathering between 59.5 - 60.5 and 64.5 - 65.0; probably a good aquifer at 60.0.

Depth (feet)	Description
67.0 - 68.8	Sandstone: fairly massive; greyish-brown; medium-grained; considerable brown weathering; numerous, irregular, shaly partings; core up to 3 inches; a probable aquifer at 68.0 in a joint plane at 90 degrees to bedding.
68.8 - 72.3	Sandstone: massive; medium grey; medium-grained; core up to 15 inches; shale as irregular, hair-thin partings.
72.3 - 74.9	Sandstone: fairly massive; grey; medium-grained; core up to 5 inches; minor shale as irregular, hair-thin partings.
74.9 - 80.0	Sandstone: massive; grey to dark grey; medium-grained; core up to 22 inches; numerous irregular, shaly partings.
80.0 - 81.7	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular, shaly partings; a 1/2 inch, grey shale interbed at 81.2; bedrock is massive above and below shale bed.
81.7 - 92.8	Sandstone: massive; light grey to grey; medium-grained; minor shaly partings up to 1/8 inch; frequently parallel to bedding; core up to 10 inches; 12 inches of core lost probably between 92.8 - 94.0.
92.8 - 101.0	Sandstone: core badly broken; grey to brownish-grey; medium-grained; longest core is 3 inches; considerable brown weathering indicates presence of groundwater; 5.2 feet of core lost.
101.0 - 105.5	Conglomerate: core badly broken; granitic and quartz pebbles and cobbles up to 4 inches imbedded in medium-grained sand; firmly cemented; longest core is 3 inches; 4.0 feet of core lost.
105.5 - 111.0	Granite: fairly massive; pink; fine- to medium-grained; fairly fresh; no weathering; core up to 5 inches; 12 inches of core lost; some groundwater along joint planes at 45 degrees to core.

Depth (feet)	Description
111.0	Bottom of boring.
Note:	Bedrock is generally fairly massive with few massive beds. Several potential aquifers are present which could carry considerable groundwater. There was no indication if they presently carry water. The sandsone and conglomerate immediately above the granite is badly broken and weathered. This broken material is also a potential aquifer. The hole is located on the floor of an abandoned quarry and is probably 6 to 8 feet beneath the original bedrock surface. Consequently, there is less weathered rock near ground surface. Drilling water was lost in first 2 feet. Per cent of core lost: 15.

LOG OF TEST BORING NO. 3

Elevation of Ground Surface:	319.5
Elevation of Bedrock:	319.0
Elevation of Bottom of Hole:	223.0

Depth (feet)	Description
0 - 0.5	Overburden.
0.5 - 1.5	AX casing core; no recovery.
1.5 - 6.0	Lost core.
6.0 - 8.0	Sandstone: fairly massive; grey to buff; medium-grained; no shale; core up to 3 inches; considerable brown weathering.
8.0 - 13.5	Sandstone: fairly massive; grey; medium- to coarse-grained; no shale; core broken; core up to 2 inches.
13.5 - 24.0	Sandstone: fairly massive; grey; medium-grained; a few shaly partings usually parallel to bedding; core up to 7 inches; 3 1/2 feet core lost between 13.5 - 19.0.
24.0 - 24.6	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular, shaly partings.
24.6 - 31.3	Sandstone: as 13.5 - 24.0
31.3 - 31.6	Sandstone: fairly massive; grey-black; fine-grained; shaly; a distinctive bed.
31.6 - 31.8	Sandstone: fairly massive; dark grey; fine-grained; calcareous (as in hole 7); a distinctive bed.
31.8 - 34.0	Sandstone: fairly massive; grey; medium-grained; numerous irregular, shaly partings; core up to 2 inches.

Depth (feet)	Description
34.0 - 35.5	Sandstone: massive; grey to buff; medium-grained; no shale; considerable brown weathering; core up to 5 inches; 2-inch weathered seam along horizontal bedding at 34.1.
35.5 - 36.2	Sandstone: as 34.0 - 35.5 with no weathering.
36.2 - 41.7	Sandstone: massive; grey; medium- to coarse-grained; no shale; pitted with small (1/4-inch) solution cavities between 36.0 - 36.3; core up to 7 inches.
41.7 - 46.0	Sandstone: fairly massive; grey to dark grey; medium-grained; a few shaly inclusions and partings up to 1/8 inch sometimes parallel to bedding; core up to 4 inches.
46.0 - 50.5	Sandstone: fairly massive; grey; medium-grained; a few shaly partings; core up to 3 inches; 12 inches of core lost.
50.5 - 52.8	Sandstone: fairly massive; dark grey, medium-grained; numerous shaly partings; core up to 3 inches.
52.8 - 58.7	Sandstone: fairly massive; light grey; fine-grained; quartzitic; pitted with a few small solution cavities; no shale except for a 1/4-inch bed at 53.6; core up to 4 inches.
58.7 - 59.1	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular, shaly partings.
59.1 - 64.9	Sandstone: fairly massive; light grey; medium-grained; no shale except for some small partings at 63.9; a 1-inch, brown, horizontal seam at 63.5; core up to 5 inches.
64.9 - 66.2	Sandstone: massive; dark grey; medium-grained; numerous irregular, shaly partings; core up to 7 inches.

Depth (feet)	Description
66.2 - 69.0	Sandstone: fairly massive; grey; medium-grained; a few irregular, shaly partings; 1-inch, brown, weathered, horizontal seams at 66.8 and 69.0 indicate possible aquifers; core up to 3 inches.
69.0 - 88.5	Sandstone: massive; grey; medium- to coarse-grained; a few irregular, greenish-grey, shaly partings; core up to 10 inches.
88.5 - 94.6	Sandstone: fairly massive; dark grey to buff; fine-grained; shaly; thin-bedded; core badly broken; 4 feet of core lost; bad drilling.
94.6 - 95.5	Sandstone: fairly massive; grey; coarse-grained; a few rounded, sand grains up to 1/4 inch; no shale; core up to 2 inches.
95.5	Bottom of boring.

Note: Weathering has penetrated the upper 7.5 feet of rock; below, rock is fresh but only fairly massive down to 69.0 where it becomes massive for about 19.5 feet; granite was not encountered but the upper part of the basal conglomerate was penetrated; several potential aquifers were encountered as were several small solution cavities; per cent of core lost: 28.

LOG OF TEST BORING NO. 4

Elevation of Ground Surface:	328.5
Elevation of Bedrock:	327.5
Elevation of Bottom of Hole:	234.0

Hole was drilled parallel to base line toward station No. 5 and an angle of 45 degrees to the horizontal.

Depth (feet)	Description
0.0 - 1.0	Overburden.
1.0 - 6.0	AX casing core; no recovery.
6.0 - 30.0	Sandstone: core badly broken; grey to buff; medium-grained; considerable brownish weathering; core cuts bedding at 45 degrees; minor irregular, shaly partings; longest core is 4 inches; 13 1/2 feet of core lost.
30.0 - 40.0	Sandstone: fairly massive to massive; grey; medium-grained; longest core is 6 inches.
40.0 - 50.5	Sandstone: fairly massive; grey to dark grey; medium-grained; numerous irregular, shaly partings; considerable shale at 45.0 - 45.3, 47.0 - 48.4 and 50.0 - 50.5; longest core is 15 inches; 15 inches of core lost; matrix is probably a mixture of carbonate and silica.
50.5 - 50.8	Sandstone: brown; a weathered horizon along the bedding; a potential aquifer.
50.8 - 59.8	Sandstone: fairly massive; grey to dark grey; medium-grained; longest core is 8 inches; numerous irregular, shaly partings and minute inclusions.
59.8 - 64.0	Sandstone: fairly massive; light grey; medium-grained; longest core is 4 inches; a 1/2-inch shale bed at 62.9.

Depth (feet)	Description
64.0 - 65.1	Sandstone: fairly massive, dark grey, medium-grained; numerous irregular, shaly partings and minute inclusions; longest core is 3 inches.
65.1 - 67.4	Sandstone: massive; light grey; medium-grained; excellent crossbedding; longest core is 6 inches.
67.4 - 69.3	Sandstone: as 64.0 - 65.1; longest core is 4 inches.
69.3 - 74.7	Sandstone: core badly broken; grey to dark grey; medium-grained; longest core is 4 inches; 4.8 feet of core lost.
74.7 - 89.3	Sandstone: fairly massive; grey; medium-grained; minor shaly partings up to 1/8 inch usually parallel to bedding; core up to 10 inches.
89.3 - 89.8	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular, shaly partings.
89.8 - 94.6	Sandstone: fairly massive; grey; medium-grained; some brown, weathered mottling; minor shaly partings; longest core is 5 inches; considerable carbonate in matrix.
94.6 - 100.1	Sandstone: fairly massive; medium to dark grey; medium-grained; minor shaly partings; core up to 16 inches.
100.1 - 105.5	Sandstone: fairly massive; grey to dark grey; medium-grained; a few irregular, shaly partings; longest core is 9 inches; very little cohesion between 100.2 - 101.7.
105.5 - 107.0	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular shaly partings; longest core is 6 inches.
107.0 - 120.0	Sandstone: fairly massive; grey; medium-grained; minor shaly partings chiefly parallel to bedding; longest core is 6 inches; core lost between 116.2 - 119.0.

Depth (feet)	Description
120.0 - 127.0	Sandstone: fairly massive; light grey; fine- to medium-grained; numerous, blue-grey shale interbeds up to 2 inches in width; excellent cross-bedding; 3 feet of core lost.
127.0 - 128.4	Conglomerate: rounded quartz and granitic pebbles up to 2 inches in diameter in a firmly cemented quartz sand matrix.
128.4 - 129.6	Sandstone: massive; light grey; medium-grained; no shale; core up to 3 inches.
129.6 - 129.9	Conglomerate: as 127.0 - 128.4 except there are no pebbles greater than 1 inch in diameter.
129.9 - 133.0	Granite: pink; medium-grained; fairly fresh and massive; minor alteration to chlorite; 6 inches of core lost.
133.0	Bottom of boring.

Note: The upper 30 feet of bedrock is believed to be badly broken and highly weathered. The rock below is fairly massive with the exception of a 3-inch potential aquifer at 50.5 and between 89.9 - 94.6 where considerable brown weathering exists. The sandstone-conglomerate-granite contact is relatively tight with little weathered rock present. The core seldom broke along bedding planes or shaly partings. All drilling water was lost in the upper 15 feet. Per cent of core lost: 31.

LOG OF TEST BORING NO. 5

Elevation of Ground Surface:	329.3
Elevation of Bedrock:	329.3
Elevation of Bottom of Hole:	229.3

Depth (feet)	Description
0.0 - 2.0	AX casing core: no recovery.
2.0 - 13.2	Sandstone: fairly massive; grey to buff; medium-grained; very few shaly partings; considerable brown weathering along horizontal bedding planes; core up to 7 inches; 12 inches of core lost.
13.2 - 21.6	Sandstone: as 2.0 - 13.2 but no brown weathering; 12 inches of core lost.
21.6 - 23.8	Sandstone: fairly massive; light grey to grey; medium-grained; very few shaly partings; core up to 8 inches.
23.8 - 30.8	Sandstone: fairly massive; grey to dark grey; medium-grained; numerous irregular, shaly partings; core up to 9 inches.
30.8 - 31.8	Sandstone: fairly massive; light grey; medium-grained; no shale; core up to 3 inches.
31.8 - 32.4	Sandstone: fairly massive; dark grey to black; fine-grained; calcareous; a distinctive bed.
32.4 - 34.1	Sandstone: massive; dark grey; medium-grained; slightly calcareous matrix; numerous irregular, shaly partings up to 1/8 inch; a 1-inch, horizontal, brown seam at 34.1, a definite aquifer; core up to 13 inches.
34.1 - 40.4	Sandstone: fairly massive; grey; medium-grained; a few irregular, shaly partings; core up to 7 inches.

Depth (feet)	Description
40.4 - 46.3	Sandstone: fairly massive; light grey; fine- to medium-grained; a few very thin, shaly partings and minute shale inclusions; core up to 12 inches.
46.3 - 49.0	Sandstone: fairly massive; dark grey; medium-grained; numerous thin, shaly partings and inclusions; core up to 5 inches.
49.0 - 59.0	Sandstone: as 40.4 to 46.3; core up to 5 inches.
59.0 - 59.5	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular, shaly partings and inclusions; core up to 3 inches.
59.5 - 64.2	Sandstone: massive; light grey; fine- to medium-grained; numerous shaly partings between 61.2 and 61.5; horizontal, brown, weathered seam at 62.6; a 1-inch, sandy, shale interbed at 61.5; core up to 12 inches.
64.2 - 65.1	Sandstone: as 59.0 - 59.5; core up to 5 inches.
65.1 - 69.0	Sandstone: massive; light grey; fine- to medium-grained; very few shaly partings; core up to 9 inches.
69.0 - 80.5	Sandstone: fairly massive; light to medium grey; fine- to medium-grained; greenish shale inclusions at 69.0 and between 80.2 and 81.0; core up to 7 inches.
80.5 - 81.9	Shale: buff to grey; sandy in part; core up to 3 inches.
81.9 - 84.3	Sandstone: massive; light grey; medium- to coarse-grained; a few rounded grains up to 1/4 inch; minor shale as irregular partings; core up to 14 inches.
84.3 - 86.4	Sandstone: as 81.9 - 84.3 but with considerable brownish weathering.
86.4 - 90.3	Sandstone: as 81.9 - 84.3; core up to 4 inches; 6 inches of lost core.

Depth (feet)	Description
90.3 - 91.0	Sandstone: as 84.3 - 86.4
91.0 - 96.6	Lost core: rock missing; probably consists of about 2.6 feet of conglomerate and 3.0 feet of granite.
96.6 - 100.0	Granite: fairly massive; reddish-brown; fine- to medium-grained; gneissic; considerable weathering; core up to 2 inches.
100.0	Bottom of boring.

Note: Considerable weathering exists in the upper 13.2 feet of bedrock especially along the horizontal bedding planes. Below, the rock consists of fairly massive to massive sandstone with small, horizontal, weathered seams at 34.1 and 62.6 which may act as aquifers. Bedrock at the sandstone-granite contact is believed to be highly weathered, about 5.6 feet of core was lost here. Per cent of core lost: 14.

LOG OF TEST BORING NO. 6

Elevation of Ground Surface:	343.7
Elevation of Bedrock:	343.7
Elevation of Bottom of Hole:	236.7

Depth (feet)	Description
0	Ground and bedrock surface.
0 - 0.5	AX casing core; no recovery.
0.5 - 21.5	Sandstone: fairly massive; grey to buff; medium-grained; considerable brownish weathering; longest core is 6 inches; minor shaly partings and minute inclusions; 9 feet of core lost; 3 feet lost between 18.0 - 21.5.
21.5 - 23.0	Sandstone: fairly massive; medium grey; medium-grained; thin-bedded; numerous shaly partings along bedding planes up to 1/8 inch; core up to 3 inches.
23.0 - 27.0	Sandstone: core badly broken; light grey; medium-grained; a few shaly inclusions up to 1/16 inch; 18 inches of core lost.
27.0 - 34.2	Sandstone: fairly massive; dark grey; medium-grained; numerous irregular, shaly partings; longest core is 6 inches; 1/2-inch, shale interbed at 31.5.
34.2 - 37.0	Sandstone: fairly massive; grey to medium grey; medium-grained; numerous irregular, shaly partings; core up to 5 inches; minor buff-coloured weathering.
37.0 - 39.5	Sandstone: fairly massive; grey; medium-grained; a few shale inclusions up to 1/8 inch; core up to 2 inches.
39.5 - 41.2	Sandstone: massive; dark grey; medium-grained; numerous irregular, shaly partings; longest core is 11 inches; minor buff-coloured weathering.

Depth (feet)	Description
41.2 - 48.0	Sandstone: fairly massive; grey to medium grey; fine- to medium-grained; considerable brown weathering between 41.2 - 41.6 and 45.0 - 45.4; 1/2-inch, black, shale interbed at 45.4; core up to 3 inches.
48.0 - 50.7	Sandstone: fairly massive; medium to dark grey; medium-grained; numerous shaly partings; minor buff-coloured weathering; longest core is 2 inches; 4 inches of core lost.
50.7 - 63.8	Sandstone: fairly massive; light grey to grey; medium-grained; minor buff-coloured weathering; shale as irregular partings some parallel to bedding; core up to 5 inches.
63.8 - 67.7	Sandstone: fairly massive; grey to brown; medium-grained; considerable brown weathering throughout; a potential aquifer parallel to bedding; core up to 6 inches.
67.7 - 75.0	Sandstone: massive; grey; medium-grained; a few irregular, shaly partings; 3 inches of brown weathering at 71.5; core up to 12 inches.
75.0 - 76.6	Sandstone: fairly massive; grey to dark grey; medium-grained; numerous irregular, shaly partings; considerable brown weathering; core up to 6 inches.
76.6 - 81.3	Sandstone: fairly massive; light grey; fine- to medium-grained; no weathering or shale; core up to 3 inches.
81.3 - 86.5	Sandstone: fairly massive; grey to buff; medium-grained; considerable buff-coloured weathering; 1/2-inch, black shale interbed at 82.5; 18 inches of core lost.
86.5 - 87.0	Sandstone: argillaceous; buff-coloured; fine-grained; a 6-inch interbed.

Depth (feet)	Description
87.0 - 98.2	Sandstone: fairly massive; grey; medium- to coarse-grained; very little shale; core up to 7 inches; no weathering.
98.2 - 98.7	Conglomerate: granitic and quartz pebbles and cobbles up to 4 inches; firmly cemented; 1-inch, brown, weathered zone at 98.7 immediately above granite contact; rock here is fairly solid; contact is tight.
98.7 - 106.7	Granite: fairly massive; pink; medium-grained; minor weathering; some alteration to soft, green chlorite; core up to 4 inches; 12 inches of core lost.
106.7	Bottom of hole.

Note: Upper 21.5 feet of rock is weathered and sufficiently fractured to act as an excellent intake for groundwater; below rock is fairly massive with more massive material between 67.7 and 75.0; brownish weathering scattered throughout bedrock indicates circulating groundwater probably along joint and bedding planes; the sandstone-granite contact is tight except for a 1-inch aquifer immediately above granite. Per cent of core lost: 32.

LOG OF TEST BORING NO. 7

Elevation of Ground Surface:	333.8
Elevation of Bedrock:	333.3
Elevation of Bottom of Hole:	220.8

Depth (feet)	Description
0.0 - 0.5	Overburden.
0.5 - 1.2	AX casing core; no recovery.
1.2 - 9.7	Sandstone: fairly massive; grey to buff; medium-grained; a few scattered, shaly partings usually parallel to bedding; core up to 14 inches; considerable brown weathering.
9.7 - 26.0	Sandstone: fairly massive; grey; medium-grained; a few scattered, shaly partings usually parallel to bedding; core up to 12 inches; 2 inches of brown weathering at 20.0; 24 inches of core lost chiefly at 24.2.
26.0 - 27.6	Sandstone: fairly massive; dark grey; medium-grained; numerous dark, irregular, shaly partings; core up to 4 inches.
27.6 - 33.1	Sandstone: fairly massive; grey to dark grey; medium-grained; numerous irregular, shaly partings up to 1/4 inch, some parallel to bedding; core up to 5 inches; core frequently breaks across bedding.
33.1 - 34.4	Shale: grey-black; calcareous; hard; sandy; a distinct interbed.
34.4 - 35.0	Sandstone: as 26.0 - 27.6
35.0 - 36.9	Sandstone: massive; grey; medium-grained; numerous irregular, shaly partings; core up to 17 inches; brown, weathered zone between 35.0 - 35.3, a potential aquifer.

Depth (feet)	Description
36.9 - 42.5	Sandstone: fairly massive; grey to dark grey; medium-grained; numerous shaly inclusions and irregular shaly partings, a few of which are parallel to bedding; core up to 8 inches.
42.5 - 47.8	Sandstone: fairly massive; grey; medium-grained; numerous minute, shaly inclusions; core up to 4 inches; 1-inch, brown, weathered seams at 44.0 and 44.8; 6 inches of core lost.
47.8 - 50.7	Sandstone: massive; dark grey; medium-grained; numerous irregular, shaly partings; core up to 14 inches.
50.7 - 51.6	Sandstone: fairly massive; grey; medium-grained; a few shaly partings and inclusions; core up to 4 inches.
51.6 - 52.1	Sandstone: as 47.8 - 51.6
52.1 - 55.6	Sandstone: fairly massive; grey; medium-grained; a few shaly partings usually parallel to bedding; core up to 6 inches.
55.6 - 56.3	Sandstone: fairly massive; dark grey, medium-grained; core up to 5 inches; brownish weathering along bedding at 55.7 indicates groundwater.
56.3 - 63.9	Sandstone: massive; grey; medium-grained; a few shaly partings up to 1/8 inch along bedding; core up to 13 inches; no core loss.
63.9 - 65.8	Sandstone: fairly massive; grey to buff; medium-grained; numerous irregular, shaly partings; considerable brown weathering at 64.0 - 64.4 and 65.2 - 65.8; core up to 10 inches.
65.8 - 72.2	Sandstone: fairly massive; grey and buff; medium-grained; numerous irregular, shaly partings up to 1 inch; considerable brown weathering at 67.2 - 67.7; core up to 5 inches; rock is massive but weathered.

Depth (feet)	Description
72.2 - 83.4	Sandstone: massive; grey; medium- to coarse-grained; core up to 32 inches; a small, 1/4-inch, brown seam at 75.5 parallel to bedding.
83.4 - 86.9	Sandstone: fairly massive; grey to buff; fine-grained; argillaceous; thin-bedded; relatively soft; core up to 3 inches; 4 inches of core lost.
86.9 - 95.3	Sandstone: fairly massive; grey; fine- to medium-grained; very little shale; little cohesion between 90.0 - 92.0 where 18 inches of core was lost; core up to 9 inches.
95.3 - 97.2	Sandstone: fairly massive; grey; coarse-grained; a few, small conglomerate beds up to 2 inches; no shale.
97.2 - 99.3	Conglomerate: rounded granitic and quartz pebbles up to 1 inch; fairly well cemented; cohesion not good.
99.3 - 113.0	Granite: fairly massive; reddish-brown; medium-grained; slight weathering in upper part near contact; some alteration to soft, green chlorite; a 1-inch, quartz vein cuts core at 60 degrees at 102.4; core up to 6 inches; hole was drilled along a vertical joint which resulted in broken core.
113.0	Bottom of boring.

Note: Upper 9.7 feet of rock badly weathered along vertical joint and horizontal bedding planes; below, rock is in general fairly massive with some massive beds; several potential aquifers encountered along horizontal bedding planes; the occurrence of a 15-inch, calcareous sandstone bed is unusual; sandstone-conglomerate-granite contact is believed to be fairly tight with some evidence of groundwater in the lower part of the conglomerate. Per cent of core lost: 13.

Plate 1

Topographical Survey engineers established the base line and located the test borings.

G.S.C. 1-2-62

Plate 2

Diamond drilling test boring No. 4
G.S.C. 1-3-62

Plate 3

Nepean sandstone exposed in the face of a small quarry in which test borings Nos. 1 and 2 are located.

G.S.C. 1-5-62

Plate 4

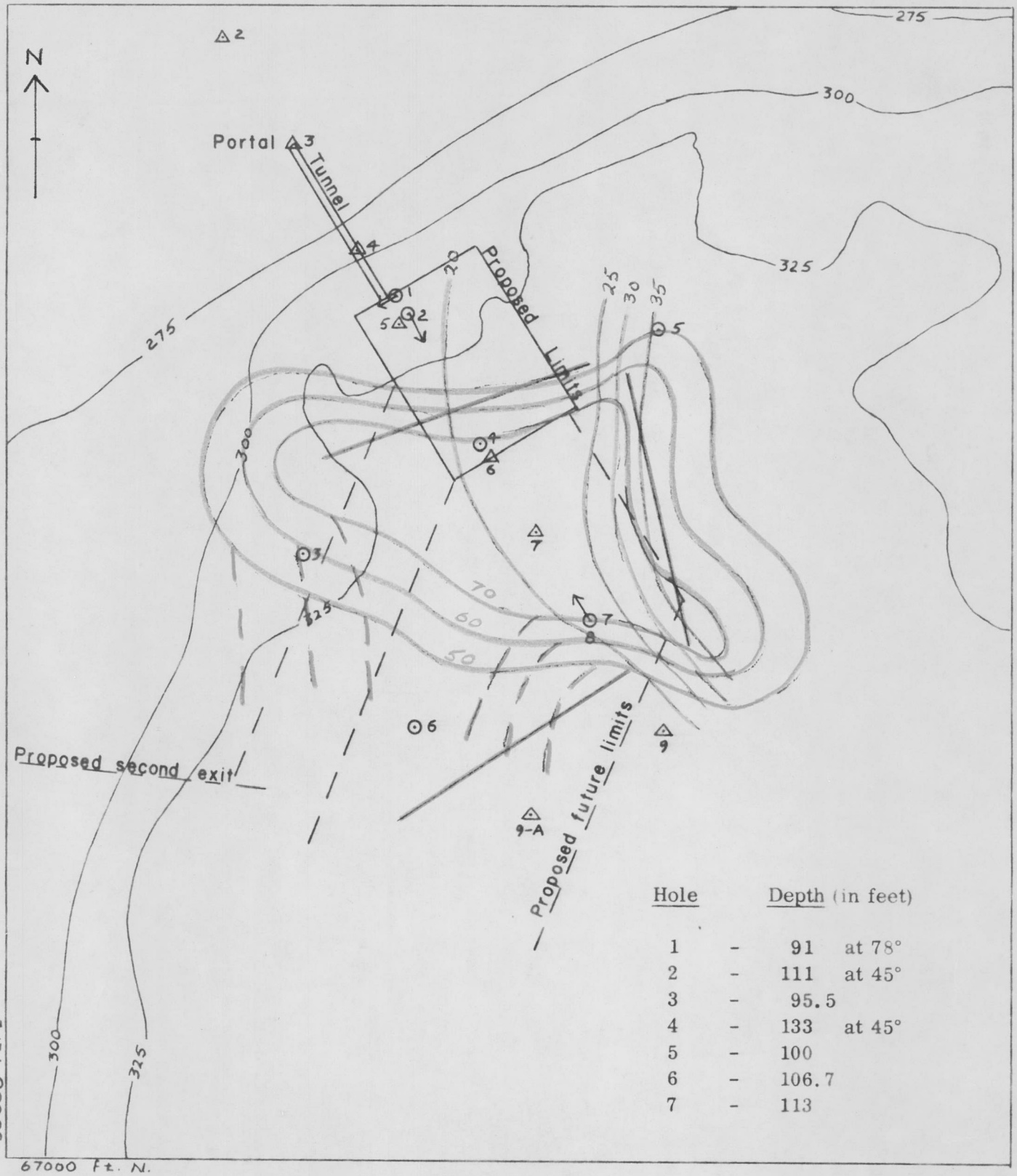
Prominent vertical jointing visible on bedrock surface intersects the line of the proposed tunnel at angles between 50 and 60 degrees.

G.S.C. 1-7-62

Plate 5

Joint fractures on bedrock surface are sufficiently large to support plant growth.

G.S.C. 1-6-62



Hole		Depth (in feet)	
1	-	91	at 78°
2	-	111	at 45°
3	-	95.5	
4	-	133	at 45°
5	-	100	
6	-	106.7	
7	-	113	

LOCATION OF TEST BORINGS

Experimental Mine

Bells Corners Area, Carleton County,

Ontario

Scale: 1 inch to 200 feet

Test Boring..... ⊙ 5

Survey Station..... △ 7

Seismic profile

Thickness in feet of upper, weathered layer $V_0 \approx 4{,}000$ ft/s

Thickness in feet of intermediate layer $V_1 \approx 12{,}000$ ft/s