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GROUND WATER GEOLOGISTS
4421 PATTERDALE DRIVE
NORTH VANCOUVER, BRITISH COLUMBIA
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AFFILIATED OFFICES
TACOMA, WASHINGTON
PORTLAND, OREGON

Completion Report

WELL No. 13 and
REAMING OF WELLS 11 and 12

for
SIDNEY WATERWORKS DISTRICT

Sidney, B.C.

July, 1970

W.L. Brown, P.Eng.
R.B. Erdman
R.A. Dakin

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August 19th, 1970

Sidney Waterworks District
P.O. Box 41
Sidney, British Columbia

new address, P.O. Box. 2041

Attention Mr. S.R. Gibbs

Subject Groundwater Development
Wells 11, 12 and 13

Dear Sirs,

Attached please find three (3) copies of our completion report on the subject wells. If any section needs clarification or amplification please do not hesitate to contact us.

We are very pleased that the basic exploration concept of the existence of fracture zones capable of delivering substantial amounts of water to individual wells has been substantially proven. Of course many more years of your excellent records will be needed to give a clear picture. However, we believe that more water is available and that obtaining it from wells will be greatly more economical than the capital and operating costs of bringing in Greater Victoria water.

We would like to get a short article published on these wells and on the general groundwater concept if the Board gives its permission.

We would, of course, send the article to you for editing. If there are no objections, can you suggest an appropriate publication?

Yours truly,

W.L. Brown, P.Eng.

WLB/hb
encls.

INTRODUCTION

This report covers the drilling and testing of the new well, No. 13, and the reaming, lining and screening of existing wells Nos. 11 and 13.

No. 13 well is located on the Sidney Waterworks District property just off East Saanich Road (see Figure 1 at back of this report). The well was drilled to a depth of 317 feet and a pump test was run for 48 hours. The test results showed that the well is capable of sustaining a design discharge of 100 U.S. gpm and that the water is potable.

Existing wells No. 11 and 12 were originally drilled in 1968 using a 6 $\frac{1}{4}$ -inch drill bit. The reaming carried out during May and June, 1970 increased the diameter of the rock hole to 8 inches. Slotted casing 6 $\frac{1}{2}$ inches in diameter was then set to stabilize the rock walls.

With the addition of well No. 13 the well field has a pumping capacity of about 340 Imp. gpm or 410 U.S. gpm. This rate would be adequate to meet projected demands until 1974 provided the storage capacity is doubled to 320,000 Imp. gallons or 384,000 U.S. gallons.

GROUNDWATER GEOLOGY AND HYDROLOGY OF NORTHERN SAANICH PENINSULA

The groundwater geohydrology of the Saanich Peninsula is complex and at the present time data on sources of groundwater recharge and movement are limited. There is, however, sufficient evidence to enable a delineation of three major sources or storage areas of groundwater. These areas are: 1) fractured granitic rocks; 2) tilted sedimentary rocks; and 3) an area underlain by unconsolidated sand.

Fractured Granitic Rocks

This is the most extensive groundwater zone. The area extends beyond the southern boundary of the district of North Saanich and extends to within a mile of the northern tip of the peninsula. For this report we have considered the south boundary of North Saanich District as the southern limit of the groundwater zone which most affects the geohydrology of the Sidney Waterworks District. The intrusive rock mass is an altered granodiorite of late Jurassic or possibly early Cretaceous age. (This makes the rocks about 140 million years old). The rock is crystalline and brittle so that crustal movements have fractured the rock. An examination of aerial photographs giving a stereo coverage of the area have enabled us to delineate the major fracture zones. These are shown on Figure 4. There are, however, numerous other fractures of a smaller nature which are capable of both storing and transmitting groundwater. Thus the peninsula is underlain by several main and numerous

minor conduits capable of transmitting large amounts of water to properly located and constructed wells.

The source of groundwater recharge is difficult to determine but there is evidence to show that infiltration of rainfall on the peninsula could account for this recharge. In Figure 4 the potential catchment area for groundwater recharge to the fractured Granodiorite bedrock is shown as area (1). There are some regions where the bedrock is covered with a silty clay which prevents rain infiltrating into the ground. These regions are not extensive and, except for one area, have been ignored in the ensuing considerations. The only extensive impermeable area is shown on Figure 4 as area (3). A description of this zone will be given later.

If 10% of the rainfall on area 1 is assumed to infiltrate into the ground and the average annual rainfall is 34 inches, then the average recharge to the area of 9.6 square miles would be 1050 U.S. gpm. The present rate of groundwater pumpage is estimated to be 120 U.S. gpm from small domestic wells and daily average based upon 1969 records projected to 1970, of 230 U.S. gpm from the Sidney Waterworks systems. Thus 700 U.S. gpm is the development potential for this zone.

However, there is also evidence to suggest that the groundwater at least in part comes from infiltration of precipitation into areas outside of Saanich Peninsula. The spring and Well No. 11 produced a total of 24 million Imp. or 29 million U.S. gallons in 1969. The area of Mount Newton available to recharge the spring and Well No. 11 cannot exceed 0.8 square miles above the static water level in the well. If a 10% infiltration rate is assumed, which is maximum for this type of topography and ground, only 30 million U.S. gallons of water is available to recharge the fractures feeding these two water sources. Since other springs and wells are tapping the same fracture zones it appears obvious that additional water must come from outside the area.

Records are limited so that the above must be considered conjectural until a few more years have elapsed. The new pumping rate of 50 U.S. gpm for Well No. 11 will mean that a total of almost 35 million U.S. gallons will be extracted from these two sources in 1970.

There is also very limited evidence that annual water level patterns of 1969 correspond to the annual precipitation pattern of 1963. This also suggests a long travel distance for the water. However, again several more years of records are needed to substantiate this speculation.

Tilted Sedimentary Rocks

This area consists of a sequence of sandstones which dip towards the sea and are situated around the "crest" of the Saanich Peninsula. The potential recharge zone is shown in Figure 4 as area (2). Assuming that 10% of the annual rainfall becomes recharge, the average rate of recharge would be 190 U.S. gpm over the 1.7 square miles of recharge area. The present drawoff is estimated to be 40 U.S. gpm which leaves 150 U.S. gpm for potential future development. While this zone is completely isolated hydrologically from the present Sidney Waterworks groundwater system and is remote from its present boundary, it is well worth noting that the water potential is there, and should be considered in future plans for the development of the North Saanich Peninsula.

Sand Aquifers

These aquifers are generally 9 to 10 feet thick, are composed of medium- to fine-grained sand and underlie 10 to 25 feet of surface clays and glacial tills. The sand overlies silts, clays, till or bedrock. The general location of this zone is shown as area (3) in Figure 4. The aquifers are only partially connected to the bedrock aquifers beneath and in some instances show indications of having a perched water table.

Recharge to these aquifers is from a combination of seepage in the overburden from a point near the foot of Mount Newton and the up-welling of artesian water from the fractured bedrock below. The latter can only occur where the lower clay and till sequence is absent or eroded. Figures 2 and 3 illustrate two schematic sections of the geology in the area around the Sidney Waterworks District main well field. The present rate of drawoff, an average of 120 U.S. gpm, does not appear to be causing any serious depletion in this aquifer. (Assuming 75% of capacity of all sand wells).

In summary, therefore, the groundwater bearing zone beneath the northern part of the North Saanich Peninsula should be capable of sustained yields of

Fractured bedrock	1,050 U.S. gpm
Sandstone	190
Sand	120

Total 1,360 U.S. gpm, if we assume that the only recharge available is from direct precipitation onto the peninsula. Of the 1,360 U.S. gpm, an estimated 390 U.S. gpm is presently being used. Therefore 970 U.S. gpm is available for exploitation. This is equivalent to 1.38 million gallons per day. With suitable storage this could satisfy the needs of approximately 17,000 people.

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If the fracture system is fed from an external source as will be proven or disproven by the next five years of records, then many more people can be accommodated.

Economic common sense and prudence dictates that the maximum amount of groundwater be developed from the peninsula before extremely costly mains are extended from the Victoria Waterworks system. Sidney and Saanich in general will be tag end users of any regional waterworks system. The experience of similar users shows that such a position can cause serious concern and inconvenience to the users.

OPERATIONS

The drilling operations carried out by Rural Well Drillers Ltd., began on Well No. 13, on April 14th, 1970. The overburden material was drilled and cased with 8-inch casing to the top of the bedrock. Using the cable tool drilling rig and site forged drilling bits the Granodiorite rock was then drilled with an 8-inch bit. Before drilling proceeded very far the 8-inch casing was driven tightly into the top of the bedrock to prevent pollution of the well from surface waters. The drilling of the bedrock was fairly slow when the rock was non-fractured but faster when fractures were encountered. The average drilling rate was approximately two feet per hour. The water-bearing fractures encountered are indicated in Figure 7 at the back of this report. When drilling operations were complete a string of 6 $\frac{1}{2}$ -inch liner was run into the hole. Inverted sections of Roscoe-Moss louvered screen were positioned opposite the fractured zones. The last section was not inverted; see Figure 7. Slots were cut in the 6 $\frac{1}{2}$ -inch casing opposite the two minor fracture zones in the shallower region. In between all the slotted and louvered sections the 6 $\frac{1}{2}$ -inch casing was left blank.

The reaming operations carried out by Drillwell Enterprises Ltd. were begun on Well No. 12 on April 14th, 1970. The top 250 feet of the rock hole was reamed out from its original 6 $\frac{1}{2}$ -inch diameter to an 8-inch diameter hole. The reaming progressed at an approximate operating rate of five feet per hour. On completion of the reaming operation the hole was cleaned out and a perforated casing liner was set into the hole. The liner used has a 6 $\frac{1}{2}$ -inch diameter and a 1/8-inch thickness. This was slotted at intervals corresponding to the fracture zones in the rock. The perforations were made using an acetylene torch and slots were cut

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6 inches long and $\frac{1}{8}$ inch wide. These were spaced vertically at one foot centres (see Figure 6 at the back of this report).

Reaming on Well No. 11 started after Well No. 12 was completed. The operations were similar to Well No. 12. The hole was reamed out to 8-inch diameter for the top 350 feet. A slotted $6\frac{1}{4}$ -inch casing was then set to this depth. The lower 150 feet of the well was left as a $6\frac{1}{4}$ -inch rock hole (refer to Figure 5 at the back of this report).

TESTING

Well No. 13 when completed, was cleaned out and a turbine test pump was set. The pump suction was set at a depth of 150 feet and run at a rate of 100 U.S. gpm. The pumping test was run continuously for 48 hours during which time the drawdown was measured. The maximum depth to water measured at the end of the test was 121 feet.

An analysis of the test results shows that the well is capable of sustaining a continuous discharge of 100 U.S. gpm for 100 days of pumping, assuming no groundwater recharge. The estimated depth to water after pumping during these drought conditions would be 154 feet. If a pump was set with a suction at a depth of 310 feet, the design discharge of 100 U.S. gpm would therefore have a safety factor of $156/143 = 110\%$.

If a pump capable of 150 U.S. gpm was set in the well, the well could be pumped at this rate for short periods. The expected depth to water after two days pumping at this rate would be about 165 feet below ground.

A sample of the pumped water was analysed and found to meet the drinking water standards of the American Public Health Association (see enclosed water analysis submitted by Can-Test Ltd.).

The chemical content of the waters from the three bedrock wells, 11, 12 and 13, are very similar except for sodium chloride. The content of these ions are

<u>Well</u>	<u>Sodium</u>	<u>Chloride</u>
11	7.5 ppm	6.0 ppm
12	24.5	54.5
13	92	110

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We do not believe that this trend indicates that sea water has access to the system. The trend might be caused by the longer route needed for the water to reach Well No. 13 and therefore it would have more time available to dissolve these easily dissolvable ions.

PRESENT WATER CONSUMPTION AND FUTURE DEMANDS

Present Capacity of Well System

With the addition of Well No. 13 and improvements to Wells 11 and 12, the present average pumping capacity of the whole well field will be about 410 U.S. gpm (340 Imp. gpm). This rate is based on the estimated pumping capacity of the well field for the month of August which appears to be the critical month of the year. For short term peak pumping rates the field could deliver about 460 U.S. gpm. A full description of available data on all existing wells is given in Table No. 1.

Present Consumption Rates

a) The average annual consumption

The annual consumption rates are available for monthly increments for the years 1964-69. The annual average consumption rates were plotted on the central curve in Figure 8 to the end of 1969. The well field has not been the only source of water outside the Dean Park system. For example the following are the sources of consumed water in 1969:

Main well field	186 U.S. gpm
Dean Park system	16
Central Saanich system	7
Total	<u>209 U.S. gpm</u>

b) Peak flows

We do not possess data on peak flows for the Sidney Waterworks system. There are, however, figures available for similar water supply systems which have enabled us to make estimates of probable flows during the peak day and peak hour. Considering the figures for 1969 as an example, the peak consumption rates outside the Dean Park system were estimated as follows.

Maximum monthly average	257 U.S. gpm
Maximum daily average	370 U.S. gpm
Maximum hourly average	600 U.S. gpm.

The main well system, as it was in 1969, was capable of delivering a peak pumping rate, during the summer, of about 240 U.S. gpm. Thus during the peak day the combined flows from the Sidney storage tanks and the Central Saanich system must have been an average of 370 less 240 = 130 U.S. gpm. For the peak hour the flow must have been around 360 U.S. gpm.

c) Probable future demands

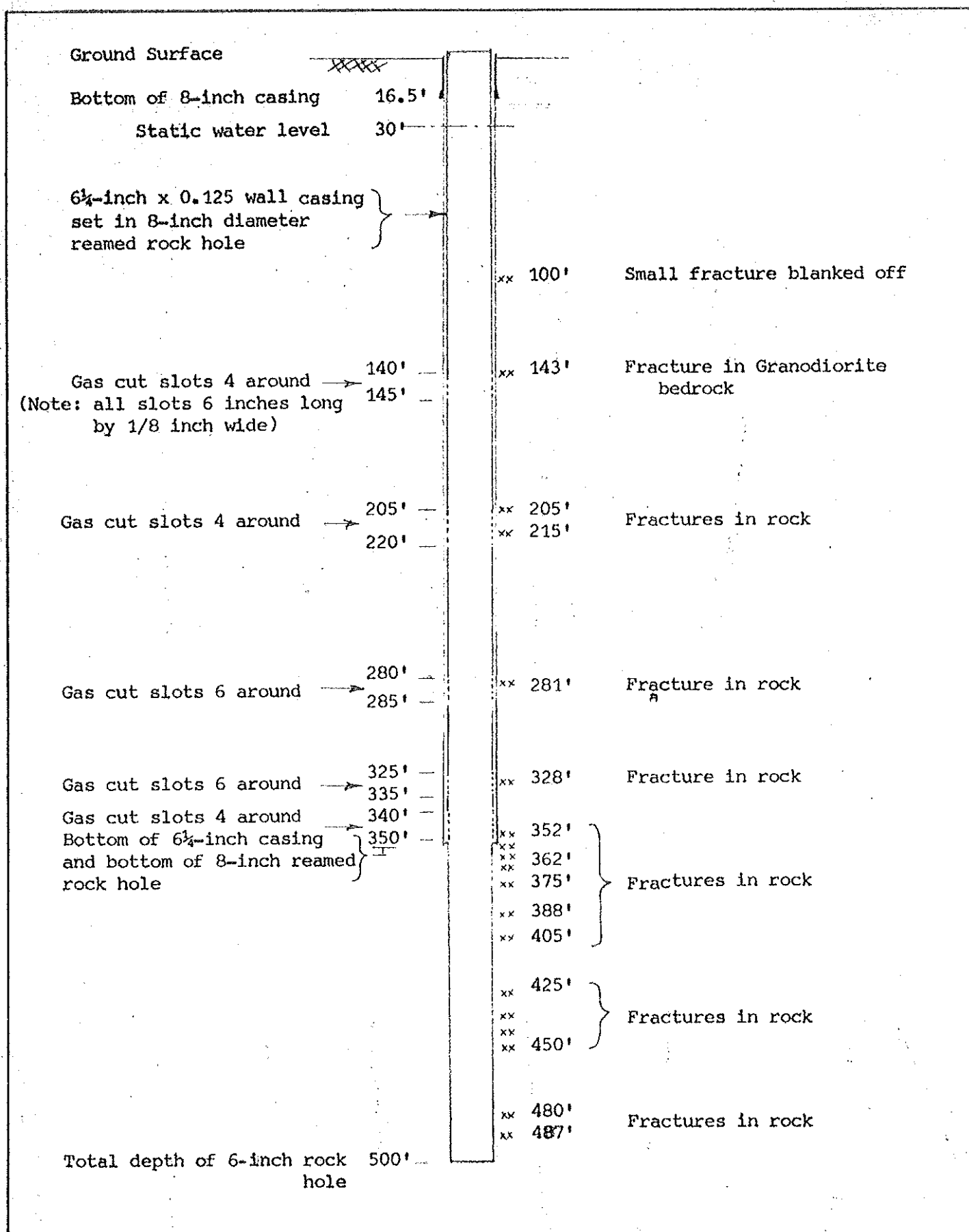
At the present time the demand for water in the District is increasing at a rate of a compounded 20% per annum. This rate of increase is likely to continue for some years until about 1975 when the rate of increase is assumed to slow down to a purely linear rate of increase. The estimated average annual water consumption has been plotted in Figure 9 for 1965 to 1985. Also on the same graph estimates for maximum month, day and hour have been predicted.

With the present system the peak discharge rates can be met without having to purchase water from Central Saanich until 1973. If the storage was increased the present well and pump system would probably be adequate until 1974.

CONCLUSIONS and RECOMMENDATIONS

1. a) Well No. 13 is capable of delivering 100 U.S. gpm. This rate will be sustained even after 100 days of continuous drought. The maximum capacity of the well is 150 U.S. gpm for short periods.
b) The pump suction should be set at 310 feet below ground.
c) The water temperature was 49° F.
d) The water is potable. If the water is to be used for boiler purposes a treatment program should be considered.
2. Well No. 12 is capable of delivering at least 130 U.S. gpm on a continuous basis, even after 100 days of drought. The well is now safe from damage that may have been caused if rock fragments were loosened in the well. With the new 100 gpm pump the pumping level will be around 84 feet below ground.
3. Well No. 11 is capable of delivering at least 50 U.S. gpm on a continuous basis even after 100 days of drought. With the 50 U.S. gpm pump transferred from Well No. 12 the pumping level is around 190 feet below ground.
4. The excellent program of water level and flow measurements should be continued. This means that an access hole should be provided and maintained free so that a 1/4-inch probe can pass. These records should be reviewed by us at regular intervals.

5. Serious consideration should be given to doubling the storage capacity of the present system in the near future. By some design criteria a 24-hour demand should be held in storage as protection against a major power failure. At the average projected annual consumption from the well field of 230 U.S. gpm and 10 U.S. gpm from Central Saanich approximately 350,000 U.S. gallons or 280,000 Imp. gallons should be held in storage.
6. Groundwater exploration work should continue some time within the next 18 months with the aim of proving additional groundwater supplies.



SIDNEY WATERWORKS DISTRICT	Log of REAMED AND LINED WELL No: 11	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA	
Sidney, B.C.		June 1970	Fig. 5

Approx. Static Water Level
Ground Surface

+6'

Overburden of clays and sands

Bottom of 10-inch casing 43'
Bottom of 8-inch casing 47'

46'

Top of bedrock

6 1/4-inch diameter x 1/8-inch
casing placed in 8-inch
reamed rock hole

xx 73'
xx 80'
xx 88'

Fractures in Granodiorite
bedrock

Top of slotted casing

120'

xx 119'
xx 124'
xx 138'
xx 145'
xx 150'

Fractures
in rock

6 1/4-inch diameter x 1/8-inch
casing slot perforated
6 rows around 6-inch slots
spaced 6 inches staggered
Total openings 720

xx 184'
xx 190'
xx 207'
xx 215'
xx 235'
xx 242'

Fractures
in rock

Total depth of 8-inch reamed well 249'
Bottom of 6 1/4-inch casing 250'

Bottom of 6 1/4-inch hole

300'

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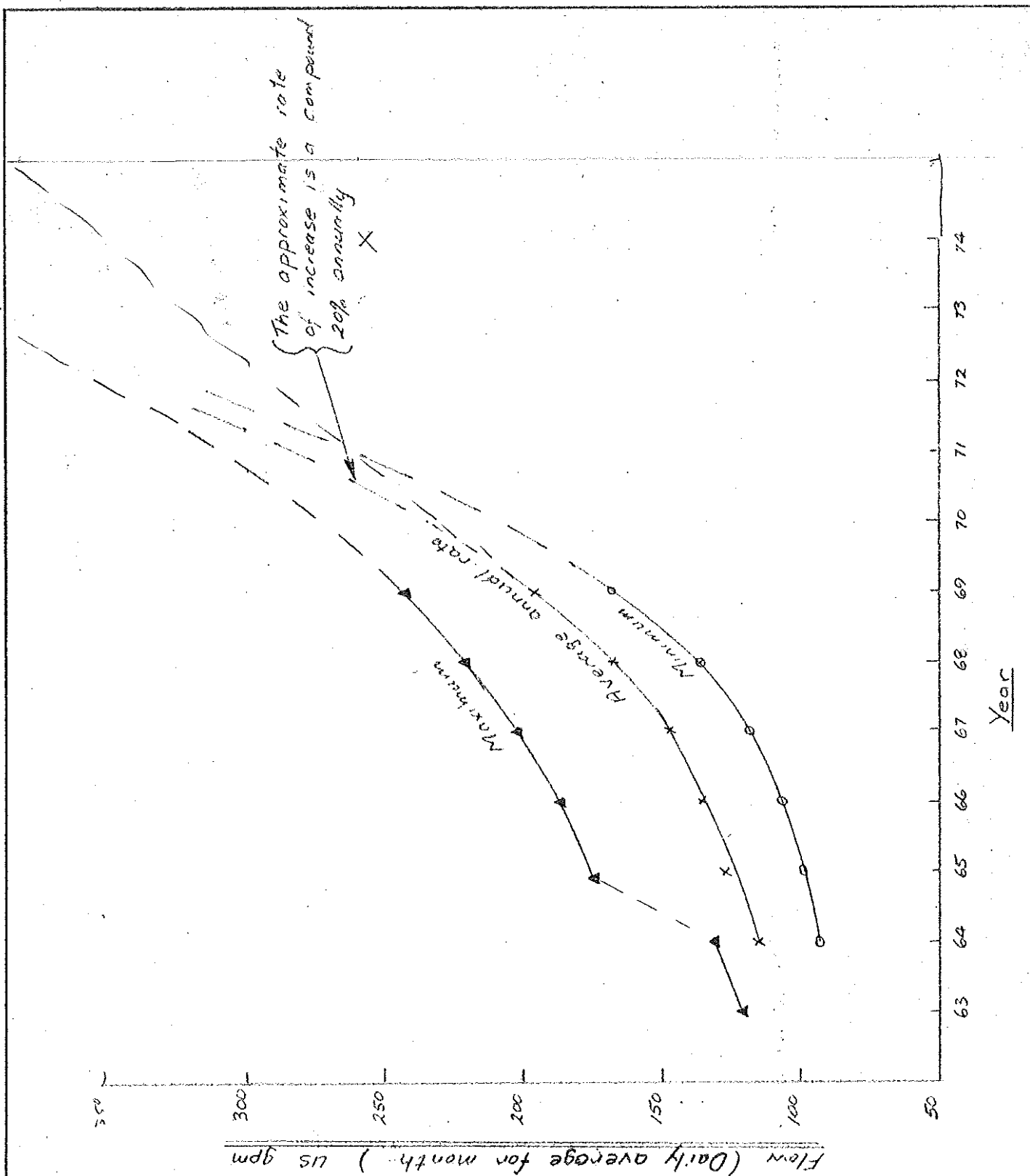
Sidney, B.C.

Log of
Reamed and Lined
WELL No. 12

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CONSULTING GROUNDWATER GEOLOGISTS
NORTH VANCOUVER, CANADA

May 1970

Fig:6

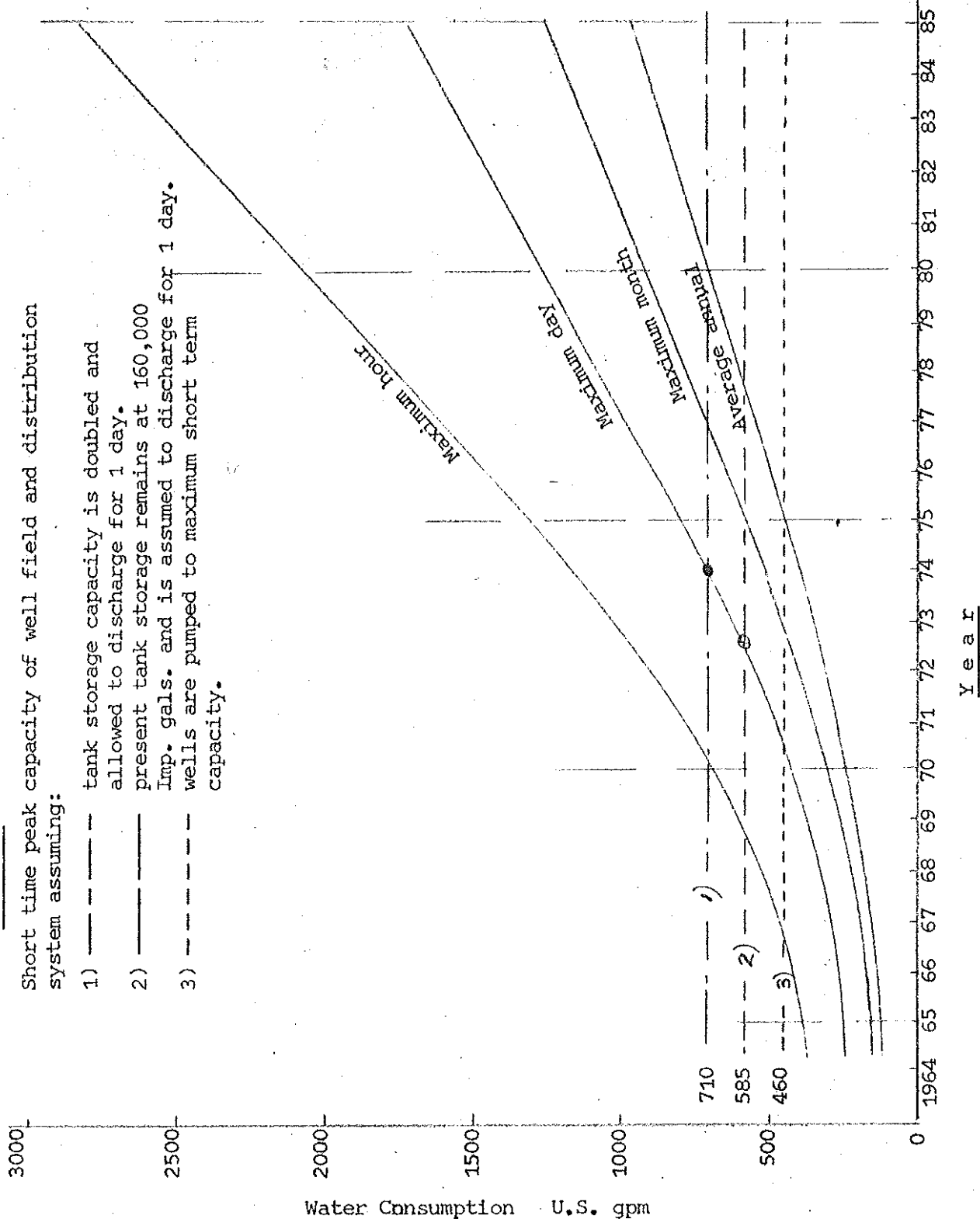


SIDNEY WATERWORKS DISTRICT	Trends in Water Consumption for Main Well System	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA	
Sidney, B.C.		June 1970	Fig:8

Notation

Short time peak capacity of well field and distribution system assuming:

- 1) ——— tank storage capacity is doubled and allowed to discharge for 1 day.
- 2) ——— present tank storage remains at 160,000 Imp. gals. and is assumed to discharge for 1 day.
- 3) - - - - - wells are pumped to maximum short term capacity.



SIDNEY WATERWORKS DISTRICT

Sidney, B.C.

Projected Trends in
Peak Flows for
Main Well System

ROBINSON, ROBERTS & BROWN LTD.
CONSULTING GROUNDWATER GEOLOGISTS
NORTH VANCOUVER, CANADA

June 1970

Fig: 9

TABLE 1 SUMMARY OF DATA ON EXISTING WELLS

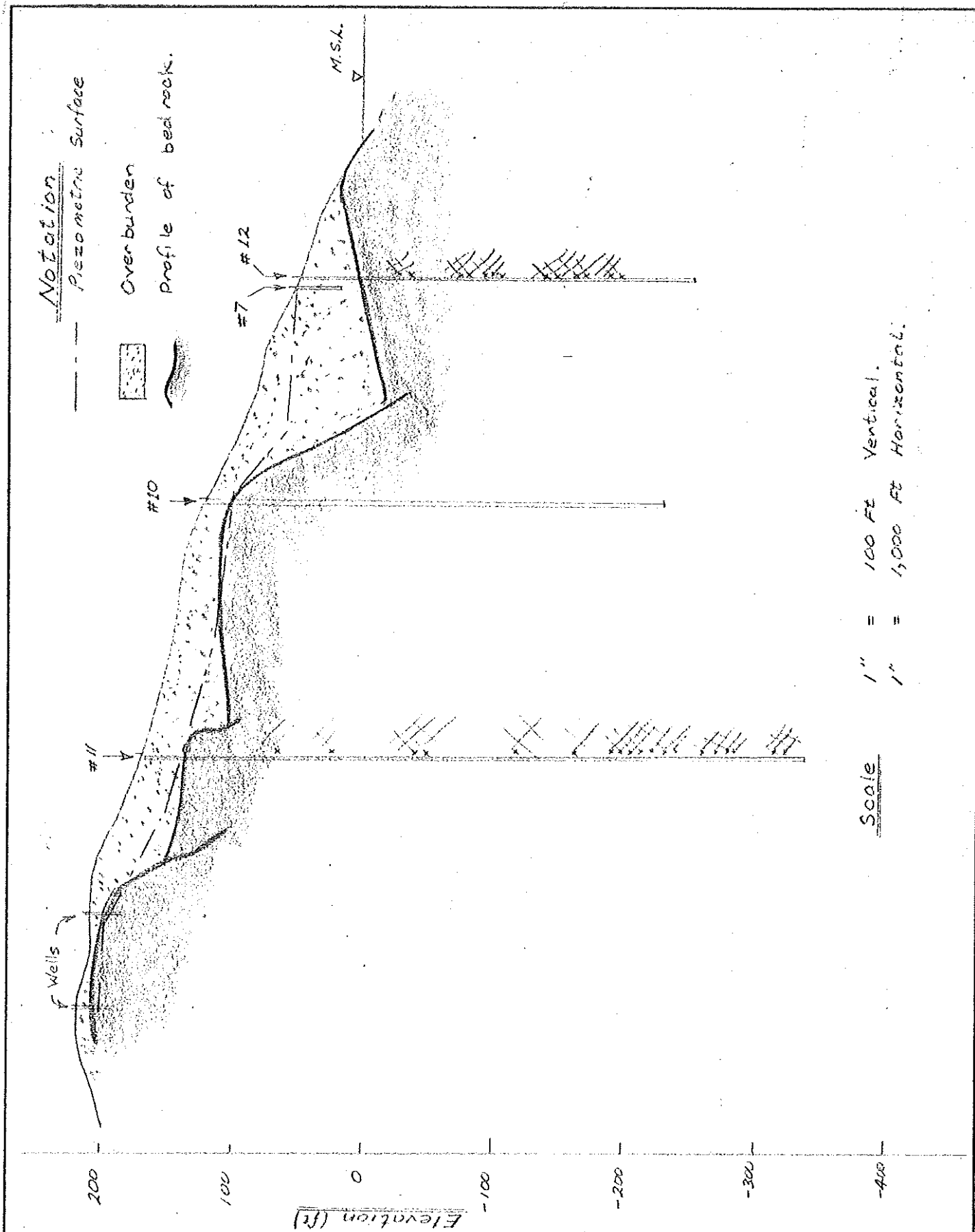
Well No.	Date of Origin	Depth of well (ft.)	Nominal Diameter (ft.)	Well log	Screened portion of well	Nature of well	Static Water Level (ft.)	Ground Elevation (ft.)	Specific Capacity (US) gpm/ft.	Present well Capacity (US) gpm
1	1912*	21	10	0-8' stony clay 8-11 till 11-21 sand, W.B.		Dug				15
2	1920*	26	3			Dug		50	2.5 *	37
3	1912*	23	7	0-8' clay 8-12 till 12-23 sand, W.B.	100'	Dug		45		
4	1916*	187	0.5 (6")			Drilled		45		55
5	1912*	20	17			Dug		45		
6	1963	39	1	0-2' top soil 2-26 dry sand 26-39 sand, W.B.	35'-39'	Drilled	25			12
7	1963	31	0.66 (8")	0-9' clay 9-31 sand	13'-31' (60 slot)	Drilled	0	50	3.5 * when well No. 12 is pumped	0
8	1966	54	2			Drilled				24
9	1966	36	1			Drilled				9
10	1967	350	0.5 (6")			Drilled		120		Not in use
11	1968	500	0.52 (6 1/2")	See Fig: 5 (this report) 140-350 (intermittent)		Drilled	30	150	0.33	50
12	1968	306	0.52 (6 1/2")	See Fig: 6 (this report)	120-250	Drilled (above ground)	6	45	1.2	100
13	1970	317	0.52 (6 1/2")	See Fig: 7 (this report)	110-317 (intermittent)	Drilled	11	50	1.1 (150')	100
Spring	1912*	6	7 *			Flowing				5 *
TOTAL										410 US gpm 340 Imp. gpm

NOTES: * = estimated

W.B. = water bearing material

* = the spring will maintain this rate during late summer and early fall.

+ = short time maximum capacity.



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Sidney, B.C.

Geological Section BB

along McTavish Road
(refer to Fig: 1)

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NORTH VANCOUVER, CANADA

May 1970

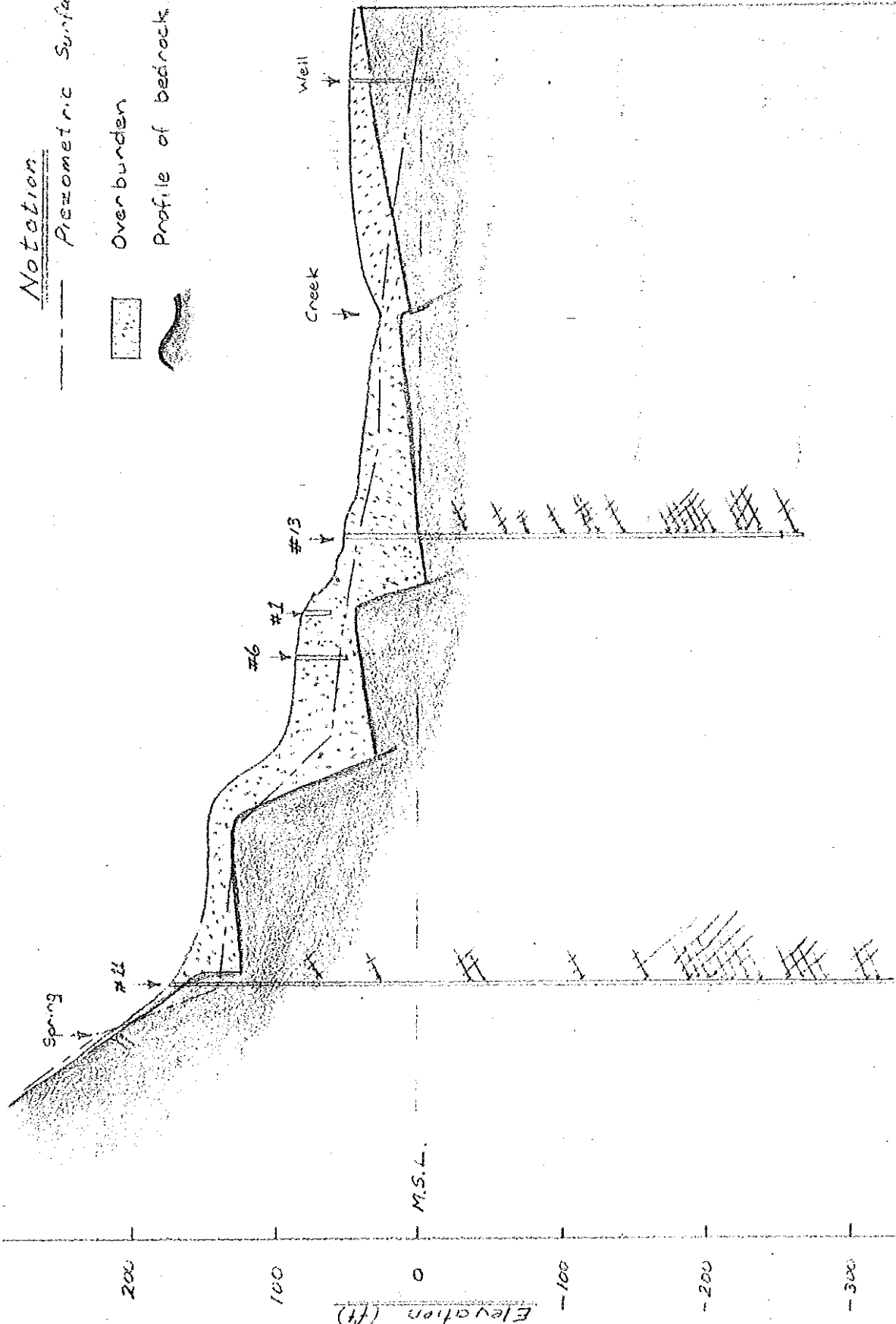
Fig: 2

Notation

--- Piezometric Surface

Overburden

Profile of bedrock



Scale 1" = 100 Ft Vertical
1" = 1,000 Ft Horizontal

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Sidney, B.C.

Section AA

(refer to Fig: 1)

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May 1970

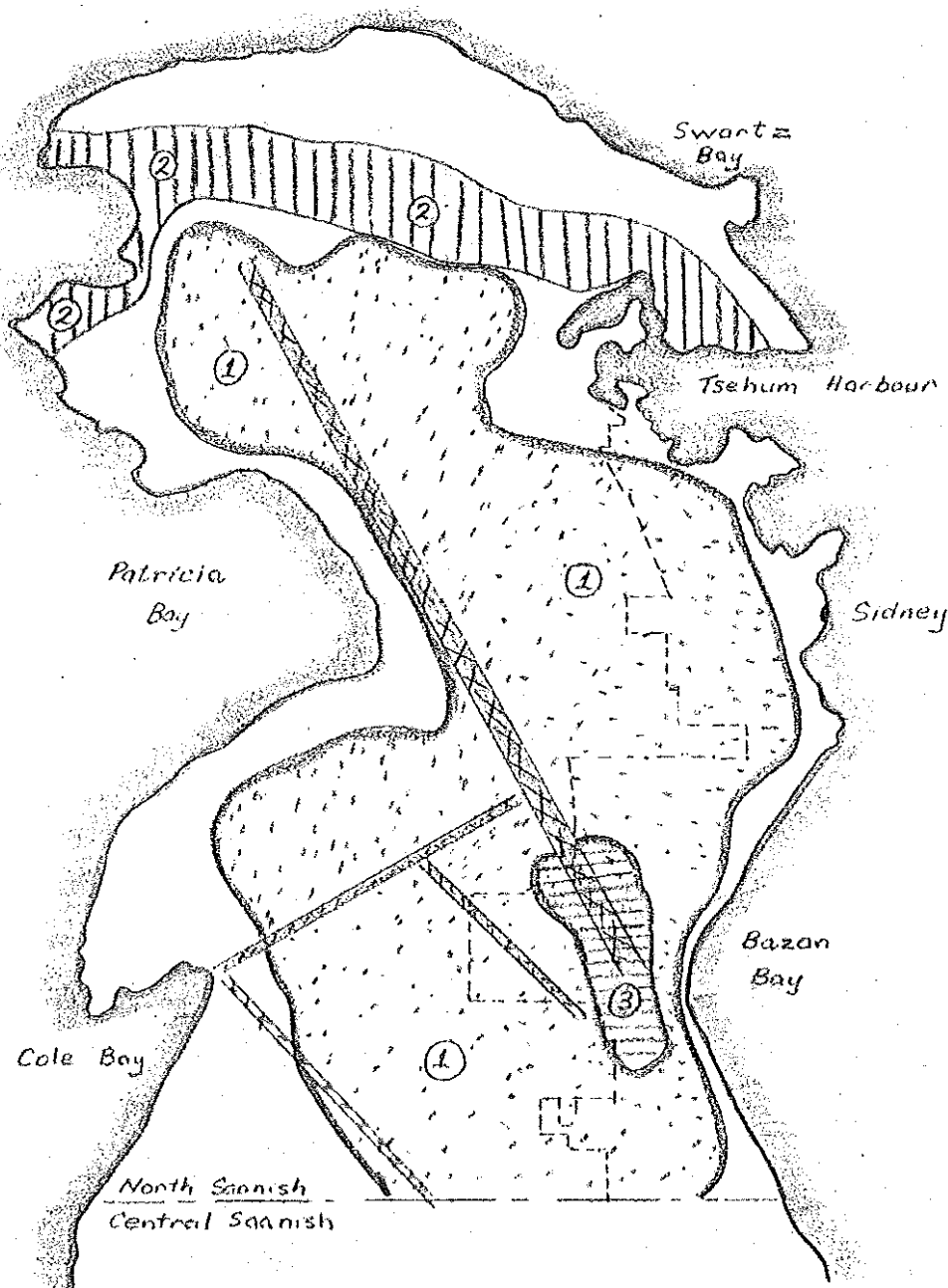
Fig: 3

NOTATION

- ① { Potential Catchement area for ground water recharge to fractured Granodiorite bedrock beneath.
- ② Potential recharge area to sedimentary formation.
- ③ Non-recharge area, because of clay layer.
- Area of little recharge potential, because of high surface runoff.
- XXX Major Fracture zone
- Sidney Water works district boundary



Scale 1" = 1 mile



SIDNEY WATERWORKS DISTRICT

Sidney, B.C.

Sketch Map of
Potential Groundwater
Recharge Areas

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June 1970

Fig: 4

