GOVERNMENT OF BRITISH COLUMBIA

MEMORANDUM

TO S.B. Mould
Senior Hydraulic Engineer
Water Supply Section

FROM J.C. Foweraker, Head
Groundwater Section
Water Investigations Branch

March 21, 19 75

SUBJECT Groundwater Potential available to the Corporation of the District of North Cowichan at the South End of the District.

OUR FILE 0239013

YOUR FILE

Included under this section are:

1. Recommendations on the nature of further groundwater studies required to provide an estimate of the groundwater potential available as a water supply source for the District of North Cowichan.

2. Length of time to complete these studies.

3. Cost estimates for completing the proposed work.

Appendix 1 reviews existing data, geology and groundwater potential in more depth. Appendix 2 reviews pertinent discussions on groundwater at the appeal proceedings.

Based on a review of all available groundwater data, maps, air photos and groundwater reports on file for this area, there is apparently only one area "the Cowichan River Aquifer" located on either side of the Cowichan River south of Duncan, which appears to have the required potable groundwater potential to supply the Municipal requirements for some time into the future. It would also appear that the two York Street wells of the North Cowichan District, are located in an aquifer further north of the Cowichan River aquifer where quantity is more limited and quality is poor. Elsewhere on the south end area of the District groundwater potential is low or groundwater quality is poor.

Figure 1 of the Cowichan River south of Duncan show three coloured areas representing three areas of interest for groundwater testing and development. The availability of this sites for development has not been investigated. These areas are in order of groundwater potential:

1. Area A (Red)

2. Area B (Green)

3. Area C2 (Yellow

4. Area C1 (Yellow)

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See folio NTS 92 B/13 for maps + figures

RED AREA A

Area A in red covers the area where much of the previous drilling and testing has been done by the District. (See Figure 1)

The proximity of the sewerage lagoons to this area makes it an unpopular aquifer for groundwater development. Testing indicates that an estimated 4,000 U.S. gallons per minute could be developed within this area.

Because there has been considerable public concern about the quality of the groundwater in this area, the following testing program is recommended for this area. Time for pump testing should be at the low stage of the Cowichan River.

1. Prior to pumping tests, two observation wells should be constructed between the sewage lagoon and the Riverside No. 2 production well.

Cost estimates are as follows for one well:

(1)	Mobilization	$ 250
(2)	Cost to drill & case 8-inch hole 80 feet @ $24.00 a foot	$1,920
(3)	Hourly rate to install plastic screen and pipe, develop well, bailing, pulling back 8" casing, moving between sites, etc. 16 hrs. at $30 an hour.	$ 480
(4)	Cost of plastic 6" pipe and screen	$ 400
(5)	Well head completion, recorder and recorder housing, etc.	$ 900
	Sub Total	$3,950
(6)	Allowance for 50 feet of 8-inch casing removed @ $5.00 ft.	- 250
		$3,700
	Contingencies @ 25%	925
	Total	$4,625

Cost estimate for two wells - $9,250

Time require to complete the well construction, including preparation of contract, calling for bids, letting contract, completion of work - say six weeks.

2. A two to four week pumping test should be run in the Riverside No. 2 production well, along with frequent analyses of the bacterial and chemical content of the well water during the test period.

Estimated costs for a 2,000 USgpm centrifugal suction pump operating at a lift of less than 20 feet are as follows: four weeks rental of pumps, discharge pipes, valves, meter fitting etc., operator and field expenses - $6,000.00.

Engineering supervision and analyses of results if carried out by the Department. N/C

3. Following the completion of the pumping test in the Riverside Well No. 2, a pumping test of short duration should be run in one of the three Anderson Property wells. This test should be run for 1-7 days and frequent samples taken for analyses. The adjacent two Anderson wells should be monitored during this test.

Cost estimates using similar equipment and operating expenses, as for the Riverside well, are for one week of pumping $2,400.00.

Total cost estimate for construction of two monitor wells, four week test on the Riversede No. 2 production well and 1 seven day test in the Anderson Test well - $17,650.00.

Time estimated for work program, analyses and report preparation 3-3½ months.

GREEN AREA B

The green area of figure 1 contains two large capacity wells for the City of Duncan and one test well drilled by the District of North Cowichan on the south side of the River(Patterson) and approximately opposite the Duncan wells.

There are two questions which first should be answered about the Duncan wells:

(1) Why did the Duncan No. 2 well yield fall to half its value?

(2) Can this well be restored to its original capacity?

These questions should be answered before further expensive wells are constructed in the green area.

It is recommended that the former Consulting Groundwater Engineers for the Duncan #2 well, be retained to remove and check out the pumping equipment and to treat and redevelop this well in an attempt to return it to its former

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productive capacity

A report should be prepared by the consultants, as to the future expected capacity of this well.

Estimated costs for this work $6,000.00 including consultant fees.

Time required to complete work and finalize a report say six weeks.

It is estimated that one or two production wells with capacities in excess of 1,000 US gallons per minute could probably be constructed in the green area. Test wells must first be drilled at the sites of all proposed production wells and subsequently, the test wells can be utilized as observation wells during later pumping tests.

YELLOW AREA - C

The groundwater of the area coloured in yellow upstream from the highway bridge requires evaluation. We have no test data on this area. However, an inspection of the aerial photographs, suggests that in the yellow area designated C1, at the river bend, there is a point bar deposit which could contain coarse sand, and gravel beds in hydraulic contact with the Cowichan River. The following recommendations are made with respect to this area.

1. Field inspection by groundwater engineer to assess the feasibility of test well drilling sites and location of bedrock outcrops.

2. Drilling of two eight-inch diameter test wells-one to be completed with a well screen and pump tested.

Cost estimates are as follows:

1.	Mobilization		$ 250
2.	Cost to drill and case 2-8 - inch holes to 70 feet at $24.00-foot.		$3,360
3.	Hourly rate to install well screen develop well, bailing, pulling back casing, surging, moving between sites, etc.		$1,200
4.	Standby for well screen order etc. 16 hours @ $25.00.		$ 400
5.	Well screen, 10 feet, and fittings		$ 900
		Sub Total	$6,110
6.	Contingencies @ 25%		$1,527.5
		Total	$7,637.5

Cost estimate for supervision ($5,000.00) if done by Department N/C. Time estimate for contract preparation, letting contract completing work. Say eight weeks.

A pumping test in the successful well should be run from 1 to 7 days. If the well is in hydraulic connection with the river, then a condition of well stabilization should become apparent early in the pumping test and the need for a prolonged pumping test would not be required.

Cost estimates for a 24-hour pumping test are as follows:

Hourly rate for 24 hours at $20.00 hour	$ 480.00
Installation and pump removal etc. eight hours at $25.00.	$ 200.00
Laying discharge pipe and rental of same.	$ 250.00
Mobilization and Demobilization	$ 250.00
Supervision and analyses ($5,000.00) if done by the Department	N/C
1 to 7 days pumping test	$1180.00
25% safety factor.	$ 295,00
	$1475.00
Total cost estimate for drilling and pumping test area C1	
Supervision extra.	$9112.00

Time estimate for contract preparation well drilling and pumping test. 9 weeks.

The second yellow area C2 upstream from the highway bridge should also be test drilled if a production well sites are to be considered further upstream from the sewage lagoons.

Recommendations with repect to this area are as follows:

1. Field inspection by groundwater engineer.

2. Drilling two test holes one to be completed as a well with screen and pumping test as well.

   Costs (as for area C1) $9,112.00

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Time estimate (assuming work done as an extension of the contract in area (C1) - 4 weeks.

Cost of the combined program for area C1 and C2 in the yellow area of Figure 1. $18,224.00.

Estimated time for drilling, testing, report writing - thirteen weeks.

If the well drilling of the two monitor wells proposed for Red area A is added to the test drilling contract for areas C1 and C2, they could be completed in about an addional three weeks. This could result in all the contract preparation and test well drilling and monitor well construction suggested under this program for areas A & C being completed in about four months provided no major problems are encountered. Pumping tests in area A and the redevelopment of the Duncan well could be carried out within this general time framework.

Total cost for the full program suggested for areas, A,B, and C are $17,650 + $6,000.00 + $18,224.00 = $41,874.00.

The "Cowichan River Aquifer" appears to receive recharge from the Cowichan River, this is indicated on well tests, however, the extent that the surface flows in the Cowichan River would be affected by groundwater withdrawals may not be so easily assessed without long term production well pumping and monitoring of river flows at several cross sections.

Note: This memorandum formed the basis for the section on Groundwater Potential - Alternative Water Supply Sources in S.B. Moulds memo of March 13, (0242512-139) to the Associate Deputy Minister.

J.C. Foweraker

JCF/sg

April 3, 1975

APPENDIX 1

NOTES ON GROUNDWATER POTENTIAL - SOUTH END AREA CORPORATION OF THE DISTRICT OF NORTH COWICHAN

In the course of this study the following reports were reviewed and will be referred to in the text by the numbers assigned to them below.

1. Groundwater Development South End Area, North Cowichan by W. L. Brown, May 1967

2. Test Drilling on Bradshaw Property, North Cowichan by W. L. Brown, September 1967

3. Southend Water System - Groundwater Development letter report from W. L. Brown, March 20th, 1968

4. Corporation of the District of North Cowichan Feasibility Report on Alternative Future Water Supplies for the South End Water District by J. D. Sanson

5. Groundwater Test Drilling in North Cowichan by W. L. Brown November 1968

6. Infiltration Wells and Testing Production Well #2 Duncan by W. L. Brown, October 1969

7. Completion Report Riverside Test-Production Well #2 for the Corporation of the District of North Cowichan by R. A. Dakin, W. L. Brown, January 1970

8. Groundwater Geology and Hydrology of Fish Gut Alley - Rotary Park, City of Duncan, W. L. Brown, March 1973.

9. Response to the Comptroller of Water Rights on the question of Development of the Chemainus River as a Regional Water Supply, the alternatives available and the environmental impact

10. Proceedings at Appeal - Water Act, Corporation of the District of North Cowichan (Chemainus River Water Application)

11. Surficial Geology of Duncan and Shawinigan Map Areas by E. C. Halstead, Paper 65-24, 1966

Pertinent groundwater well location maps and well records for the area were reviewed in some detail.

Aerial photographs for the area were studied including BC 5057 82-84, 49-51; BC 7697 71-72, 85-87, 95-103.

Because this report had to be completed within a two week period and the writer was on sick leave for part of that period it was decided to postpone temporarily the field trip to the area.

GEOLOGY

Most of the unconsolidated deposits in the area are related to the regimen and wasting of the last major ice sheet that occupied Vancouver Island. The ice moved in a general south to south east direction as indicated by striae, flutings and stoss and lee topography (11). Deglaciation was accomplished by downmelting and wasting of the ice sheet. When downmelting had progressed so that the mountain ridges were exposed, the ice sheet split into a network of glaciers. Cowichan Valley was also occupied by a valley glacier or ice tongue. This later stagnated and on wasting left ice contact deltas as well as kettle and kame deposits west and southwest of Duncan.

On the attached surficial geology map from (11), map units 4-8 are those deposits associated with the advance and wasting of the last major ice advance and valley ice tongues.

Deglaciation was mainly by stagnation and was accompanied by transgressing seas that attained elevations of about 300 feet. Silts and clays that contain ice rafted stones and boulders (map unit 7) were deposited in the sea and are found covering the older unconsolidated deposits up to elevations of 265 feet. There stony marine clays are commonly less than 20 feet thick but in some areas drill records indicate they are more than 60 feet thick. During the lowering of sea level streams deposited gravels and sands (map unit 8) and cut terraces in older deposits while clays and silts were continually being deposited in the deeper water. Present sea level has been maintained for a considerable time during which the Cowichan and Chemainus Rivers have built sizable deltas, on which clays and silts have accumulated (11).

GROUNDWATER

The Southend water supply system was established in 1967, and consists presently of two wells at York Street on the southern edge of the Somenos Lake flood plain (9). These wells are shown on the attached well location map. These wells are capable of producing a combined total of 835,000 gallons per day, but in 1971 the maximum day's consumption was 850,000 gallons. Water supplied from the York Street wells have had to be augmented during periods of high demand by flows from the B. C. Forest Products Crofton Pulpmill supply main. This has been due to the failure of the No. 2 well to produce more than one half of its designed flow, rather than to excessive demands (9). According to J. D. Sanson the wells are capable of producing a combined total of 580 gpm. There have been numerous groundwater surveys conducted in the area of the south end, with numerous test wells having been drilled. The large producers are all located close to the Cowichan River east of the highway and they all tap aquifers hydraulically connected to the Cowichan River. The two York Street wells are drilled north of the central city area and produce less water than those mentioned above near the Cowichan River. The two York Street well logs show about twelve feet of silt and clay over 12 feet of sand and gravel over finer clays and silts. The sand and gravel components in the aquifer in which the York Street are located contains some finer matrix and this may be clogging the natural sand pack surrounding the well screen and thereby reducing the well performance.

Apart from the two York Street wells a survey of other wells located in the Duncan area and away from the Cowichan River, are generally poor producers. A review of the well location maps in the folio file 92 B/13 will make this point clear.

The areas of greatest known groundwater potential appear to be located adjacent to the Cowichan River and downstream from the raised and dissected marine deposits and glacio marine deposits which occur immediately to the west of Duncan along with ice contact and bedrock outcrops which confine the river at this point. Downstream of this point the river flows along the west side of the broad valley, the river then turns eastward and flows through what is called here the "Cowichan River Aquifer" south of Duncan. The largest producing test wells and production wells are located in this aquifer.

The enclosed Well Location Map shows the six test wells and three production wells that have been drilled in the area of interest. Two of these wells were constructed for the City of Duncan and the rest for the Municipality of North Cowichan. The logs of each well are attached.

The pertinent features of each well are described below (from 8). The comments on each well are also taken from 8.

City of Duncan Production Well No. 2 - (The City of Duncan Production Well No. 1 was constructed beside the Cowichan River near to the original river intake and thus has no bearing on the present study.)

City of Duncan Production Well No. 2 was constructed in 1963 as shown on the attached well log. It should be noted that the top twenty feet of the well has been cement-grout sealed to protect the well water from contamination by surface or near surface waters. This seal is necessary because the waters in Fish Gut Alley get quite close to the well at certain times of the year. The well was drilled through highly permeable sands and gravels to a depth of 49 feet where bedrock was encountered. Pump test data show that the transmissibility of the water-bearing zone is 300,000 US gpd/ft. and the specific capacity of the well is 125 US gpm per foot of drawdown. A barrier to downward vertical flow of water is present somewhere between depths of 20 and 36 feet. This condition was discovered during the pumping test when the water in well points drilled to a depth of 20 feet and located ten feet from the Production Well was not affected by the pumping of the Production Well at a rate of 1980 US gpm. Water standing in the annular space between the 18 and 16-inch casings also was not affected. No specific impervious zone was noted when the well was being drilled. However, these river deposited sands and gravels will have thin high silt-bearing beds and lenses deposited within them during flood periods. The very low vertical permeability evidenced by the pump test has a marked affect upon how groundwater could be developed along Fish Gut Alley. The safe productive potential of this well when it was constructed was 2000 US gpm (1666 Imp. gpm). We understand that the productivity of the well has declined during the past 10 years by a factor of one half. The reasons for this decline are unknown to this writer. However, the well can be (according to W.L. Brown) returned to its original productivity if correct redevelopment practises are used. It is quite normal to redevelop a well every 5 to 10 years at the same time that the pump bearings, impellors, etc., are inspected.

City of Duncan Production Well No. 3 - This well was drilled through water-bearing sands and gravels as shown on the attached log to a depth of 53 feet where bedrock was encountered. The "as constructed" sketch of the well is also attached. At a discharge rate of 1980 US gpm the well has a specific capacity of 244 US gpm per foot of drawdown. During the pump test the water levels in the Cowichan River, Fish Gut Alley and Production Well No. 2 were carefully measured. No water level changes were noted. It was very important to learn that there is no mutual interference between the two City of Duncan Production

Wells even though they are only 680 feet apart. The City of Duncan Production Well No. 3 has a safe perennial yield of 3000 US gpm with a safety factor of 2. Water level measurements indicate that the transmissibility of the screened zone is 2,000,000 US gpd/foot which is very high.

Riverside Test-Production Well No. 2 - This well, located at the end of Wharncliffe Road, was drilled in 1970 for the Corporation of the District of North Cowichan. The attached log of the well shows how the well was constructed and that it encountered water-bearing sands and gravels between depths of ten and eighty feet. Pump test data show that the well has a safe productive capacity of 3000 US gpm with a safety factor of 2. The pumping of this well had no effect on Riverside Test Well No. 1 or on the City of Duncan Production Well No. 2. The well was very carefully sealed against possible contamination or pollution by surface or near surface waters. The precautions taken can be observed on the attached well log. The transmissibility of the aquifer is 500,000 US gpd/ft.

Using the aquifer coefficients obtained during the pumping test and assuming the worst conditions of 100 days of drought, the cone of influence around the pumping well can be calculated. The 100 days of drought is a very stringent assumption in this case because it would mean that the Cowichan River would be dry for this period. The average gradient of the drawdown water level at the pumping rate of 3000 gpm from 100 to 1000 feet away from the well is calculated to be one foot in 300 feet or at an angle with the horizontal of 10 minutes. The natural gradient on the water table slopes to the northeast at one foot in 250 feet or at an angle with the horizontal of 14 minutes. It therefore follows that the gradient on the water table when the well is pumped at a rate of 3000 gpm will still be towards the northeast or from the well to the sewerage treatment ponds. The gradient around the well when pumping at 3000 US gpm equals the natural gradient of the water table a distance of only 250 to 300 feet from the well.

The chances of the well water becoming polluted by sewerage effluent is therefore extremely remote.

This well has been left idle since it was constructed in the fall of 1969 because of the totally unsubstantiated fear that it could become contaminated by seepage from the sewerage treatment ponds that lie approximately 500 feet to the north of the well.

Riverside Test Well No. 1 - This well is located on the dyke beside the Cowichan River and was drilled to a total depth of 125 feet without encountering bedrock. Three water-bearing sand and gravel zones were encountered above a depth of 96 feet. These are shown on the attached log of the well. The two lower zones were test pumped with good results indicating that a high capacity (2000 gpm) well could be constructed in this area.

Patterson Test Well - This was the first well drilled south of the river. The well encountered shale bedrock at a depth of 63 feet. The overlying material was mostly coarse sands and gravel. The main aquifer was encountered between depths of 20.5 and 59.5 feet. The transmissibility of this aquifer is estimated to be 500,000 US gpd/foot with a probable productive capacity for large production wells of 1000 gpm.

Anderson Test Wells

Test well No. 1 - This well was located near the river and was drilled to bedrock at a depth of 82 feet. The main aquifer lies between depths of 29 and 70 feet. Two zones within the aquifer were tested. The lower zone between depths of 63 and 68 feet has an indicated transmissibility of 100,000 US gpd/foot and a probable productive capacity of 1800 US gpm. The upper zone in the same aquifer was tested between depths of 44 and 49 feet. The indicated transmissibility in this zone is 500,000 US gpd/foot with a probable yield of 2000 US gpm to properly designed production wells.

Test well No. 2 - Test Well No. 2 was drilled close to Boys Road. This well was drilled to a depth of 75 feet and penetrated five feet of gray silts at its bottom. This is the same silt that is found immediately overlying the shale bedrock throughout most of the area. The main aquifers were encountered from 15 to 48 feet and from 54.5 to 74 feet. The aquifers are separated by 2.5 feet of till-like material and 4 feet of silty sand.

The lower aquifer was tested twice from 54 to 59 feet and from 68 to 73 feet. Testing results in this aquifer indicated transmissibilities between 15,000 US gpd/foot and 58,000 US gpd/foot. The low transmissibilities in this aquifer suggest that it lies in an older river channel that was not encountered in the other test wells on the Anderson property. However, because of the depth of the aquifer the indicated capacity of a production well would be close to 800 US gpm. This figure is somewhat lower than the data would seem to indicate but information from other wells in the area indicates that negative boundary conditions could exist that would adversely affect the well yield.

The upper aquifer was tested between depths of 42 and 48 feet and showed a transmissibility that was calculated to be 500,000 US gpd/ft. A production well in this aquifer would have an estimated capacity of 2000 US gpm.

Test well No. 3 - This well was drilled midway between Test Hole No. 1 and Test Hole No. 2. The total depth of the well was 70 feet. Only one aquifer was encountered in this well. The lowest aquifer found in Test Hole No. 2 was not present in this hole. The aquifer lies between depths of 17 and 44 feet and was tested between depths of 38 to 43 feet.

A long term high-rate pumping test was performed in this well. The test was conducted to establish the transmissibility of the sediments at the well and also the areal transmissibility across the site. The transmissibility at the well was indicated to be 600,000 US gpd/foot and the transmissibility across the site to be 500,000 US gpd/foot. Again a production well in this area could be expected to yield 2000 US gpm.

In summary then the City of Duncan has constructed on the north side of the Cowichan River two production wells in the area of interest. Production Well No. 2 producing only 1000 gpm (½ initial rate) and Production Well No. 3 producing 2000 USGPM (8). The Municipality of North Cowichan completed two test wells; Riverside No. 1 indicated that wells with a capacity of 2000 USGPM could be constructed at this site, Riverside No. 2 has a safe productive capacity of 3000 USGPM.

On the south side of the Cowichan River the Patterson test well indicated that a production well at this site could produce up to 1000 USGPM. Three test wells were constructed on the Anderson property and all three indicate that properly designed production wells could produce up to 2000 USGPM (8).

Future development in this test area will have be be planned so that each production well causes minimum well interference with existing wells. For example there is no interference between City of Duncan Production Wells 2 and 3 spaced 680 feet apart. Similarly for Riverside No. 1 and 2 spaced 625 feet apart there is also negligible interference.

WATER QUALITY

The temperature of the groundwater beneath the test area is expected to be close to the mean annual daily air temperature of 51°F (8). In those production wells where there is a relatively direct connection between the Cowichan River and the aquifer the temperatures in the summer will be higher.

Chemical tests of the York Street Well supply indicated that the water is extremely corrosive (Ph 5.6). To combat this undesirable condition the water was treated with sodium carbonate at the well head.

In the test area at the Cowichan River a number of analyses have been made on samples collected from test wells during pumping tests. Some analyses results are attached. In summary the water is potable with low iron content. There is a problem in the Anderson No. 2 well - relatively high nitrate values were obtained from this well. A high nitrate content can indicate possible pollution. A coleform test on this well however, showed the water to be acceptable (5).

The chances of well water becoming polluted by sewerage effluent from the sewerage treatment ponds is extremely remote. Riverside Well No. 2 which is located approximately 500 feet south of the treatment ponds has been left idle because of the unsubstantiated fears it could become contaminated by seepage from the treatment ponds.

Monitor wells located between this well and the lagoon could help establish more accurately the groundwater gradients and the groundwater quality at points closer to the ponds.

J. C. Foweraker

April 4, 1975

APPENDIX 2

NOTES FROM:
PROCEEDINGS AT APPEAL - WATER ACT
CORPORATION OF THE DISTRICT OF NORTH COWICHAN
(CHEMAINUS RIVER WATER APPLICATION)
January 14, 1974, Victoria, B. C.

Chairman: D. G. Cocke
Member: L. T. Nimsick
Member: C. R. Lea
Member: P. F. Young

D. R. Williams, Esq. Q.C. - for the Corporation of the District of North Cowichan
E. R. A. Edwards - for the Attorney General

Mr. Williams: North Cowichan's production wells are located on the North side of the River.

Suggestion to drill two wells directly across river from the city of Duncan's well on the North bank of the Cowichan. P. 17

The City of Duncan's well is beginning to dry up a bit - they are not getting the supply out of it they thought and this seems to be characteristic of wells. P. 17

This is the same problem that North Cowichan had with its present wells as I said - they just don't seem to produce the rated design capacity in the long haul, something seems to go haywire, there is an interference, perhaps underground, miles away which effects the supply of water. It is not really known it is an uncertain thing.

What would be the interference affects of the two new wells located opposite the Duncan well?

You are also still going to be taking river water because that is the source of the water. What effect is all this going to have on river levels and on the fisheries resource.

If the water level fell because of large scale pumping from wells, the environmental impact of this is going to be far greater than the environmental impact of the proposed scheme on the Chemainus River. P. 19

So we don't know by taking water out of those wells whether we are going to get enough water to supply our needs. We don't know what affect it is going to have on the river level and what affect it may have on fisheries.

We just know how long you can go on pumping from a well as close to the river as these are at high rates. P. 19

Now it is true that the engineers have tested these wells (5 days) but can you go on pumping out of a well or wells 40,000,000 gallons a day without having some effect on the level in the river. Well I suggest it is doubtful, it is an uncertain thing and it is unreliable. P. 20

Existing municipal wells are heavily laden with iron and they have a lot of it and the water has to be treated. There is so much iron in fact that out of the existing wells the water literally rots the pipes and they have to be treated with special chemicals.

The same type of water is notwithstanding that it comes at a point closer to the Cowichan River than the existing wells, notwithstanding that the water still has a very high iron content. P. 20. City of Duncan well is ½ mile from sewer lagoon there is just something about the proximity of wells to sewer lagoons that turn people off! P. 21

The wells are at best a short term solution. The water is not good in them - it is uncertain the investment to bring them into production so to speak would be reasonably substantial. The Municipality does not want to invest a reasonably substantial amount of money into a particular form of water supply that is unreliable. P. 22

It may be expensive to treat and it is a short term solution. P. 22

Mr. Nimsick: Are the wells serving the Duncan area liable to run out? P. 58

Mr. Williams: There is one well serving the City of Duncan and our information is that this is running short.

The North Cowichan has 2 existing wells. One of them is only supplying half of what it was designed to produce. P. 58

Mr. Nimsick: Is (the supply) gradually diminishing?

Mr. Williams: Yes it is. And it is apparently the same experience that the City of Duncan is having with its wells which is somewhat further south of the present municipal wells and this adds up to council that you just can't rely on groundwater wells in that area... P. 59

Mr. Williams: In answer to a question by Chairman, you can send a team of engineers to test a well.... but what happens when you pump at high water for a long period of time?

Mr. Chairman: We are sitting here really talking about an unknown.

Discussion on river coleform counts. P. 60

The Chairman: You are talking about the iron content of the wells. The iron content of that river is extremely high.

Mr. Williams: It is sometimes - certain times of the year...

Mr. Lea: Has there been a cost comparison (between the dam) and wells including operating expenses, etc. P. 61-62

Mr. Williams: Municipality has opted for dam - they think it is cheaper. They are very much concerned that if they sink money into a well it may be down the drain and they will later have to go to a dam.

Mr. Lea: Studies were asked of the municipality that were not done: (costs using wells, etc.)

Mr. Williams: The municipality did not want to spend substantial sums of money knowing full well what it was going to demonstrate. i.e. the Chemainus scheme was the most expensive. They were prepared to except this for political reasons. P. 63

Mr. Chairman: It seems to me that we have been restricting this thing around 2 wells across the river from the present wells. It strikes me this is not the only place that wells could be drilled. Nobody knows because nobody has been doing the work. P. 68

Mr. McMaster: Municipality hired Robinson, Roberts and Brown to look at the groundwater potential of the area. They believed the Cowichan Valley was the one that had the potential water source and where the drilling should be done. P. 65

Well when they did the test drilling and the pump testing as I recall there were two wells near the sewage lagoons and the public feeling was this water was getting into the well system so they did tests and they were able to show that the ground water gradient dropped from the lagoons towards the well which indicates positively you are getting a flow in this direction. So you know right there it is enough evidence to not to use these wells.

- this situation is much more precarious where you have got lagoons in the straight hydraulic gradient from them towards the wells. P. 67

In these river beds and if you look at the well logs you will see this overburden and its high concentration of iron and it is not showing up on the well test and it didn't show up in the 5 day pump tests but over long periods of sustained pumping, you can eventually drag these heavy iron deposits in and once you start drawing on that iron laden water there is nothing you can do about it except put in a very expensive treatment plant that makes this 2.7 million look like peanuts. P. 68

Now we had that experience where we did drill in a similar instance for municipal supply and we got good tests on the pump tests and we went ahead and we got the final well constructed to supply the town and suddenly it started to draw a large amount of iron and the whole thing had to be abandoned and the town go back to its gravity supply.

Mr. Edwards: P. 89. There was an indication for material before the Comptroller that alternative sources which were economically feasible existed and I would refer you to material before you - item 7.1 of the initial study by Mr. Sanson regarding the feasibility report on alternative water supply for the south end district dated September 15, 1970.

"Wells drilled away from the river produce water with a higher iron content or low pH both of which require extensive treatment at estimated cost for treatment to remove the iron from the wells well west of the Canada Highway as $120,000 -- the development of production wells on the Anderson properties would satisfy the demand for years. The water is of good quality and quantity varies from 2500 to 3500 gallons per minute. There is no doubt that these wells could produce 10,000 g.p.d. - additional wells could cost $30,000 easily.

In response to the Comptroller of Water Rights question of the development of the Chemainus River as a regional water supply and alternatives dated April 2nd, 1973 section 3.2.2 Page 8.

North of the Cowichan River there are two wells known as Riverside No. 1 and 2 have estimated yields of 2,280 gpm and 3000 gpm respectively. In 1970 J. D. Sanson.... facilities to incorporate the two wells into the southend water system. A five year program was proposed at a cost of $120,000 which would yield approximately 4,500 US gpm.

No action was taken on these recommendations because of adverse public opinions regarding the proximity of the downtown North Cowichan sewage lagoons.

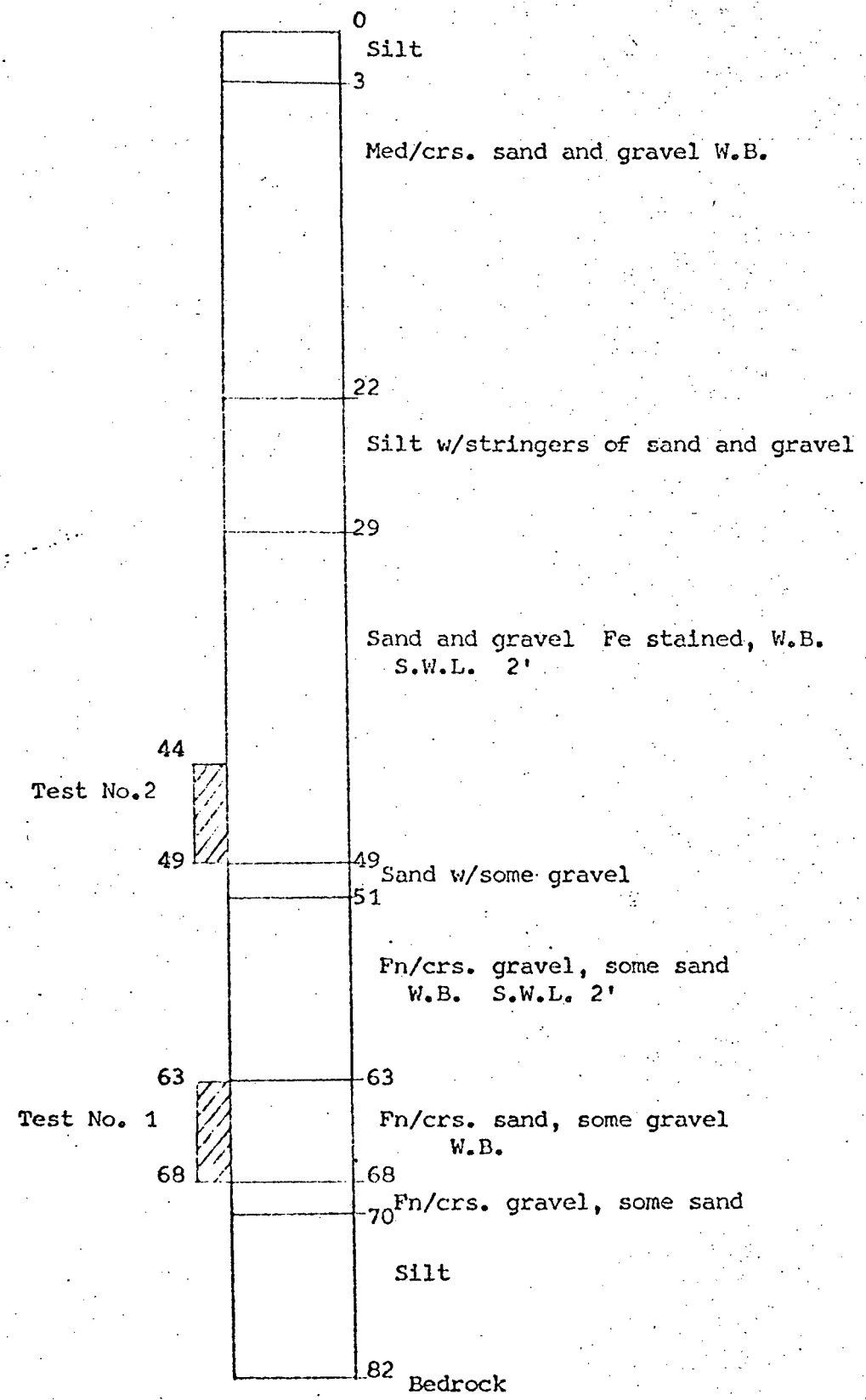
Mr. Edwards: I suggest to you that the decision to abandon those potential sources of water was largely a political decision and not based on the albeit limited information from those who had studied those alternatives. P. 91

I would also point out that the applicant has apparently conceded that these other sources were economically feasible and declined to provide further information... Now without that further information which he requested the comptroller refused to disregard the environmental concern and had no alternative but to disregard the application for licence.

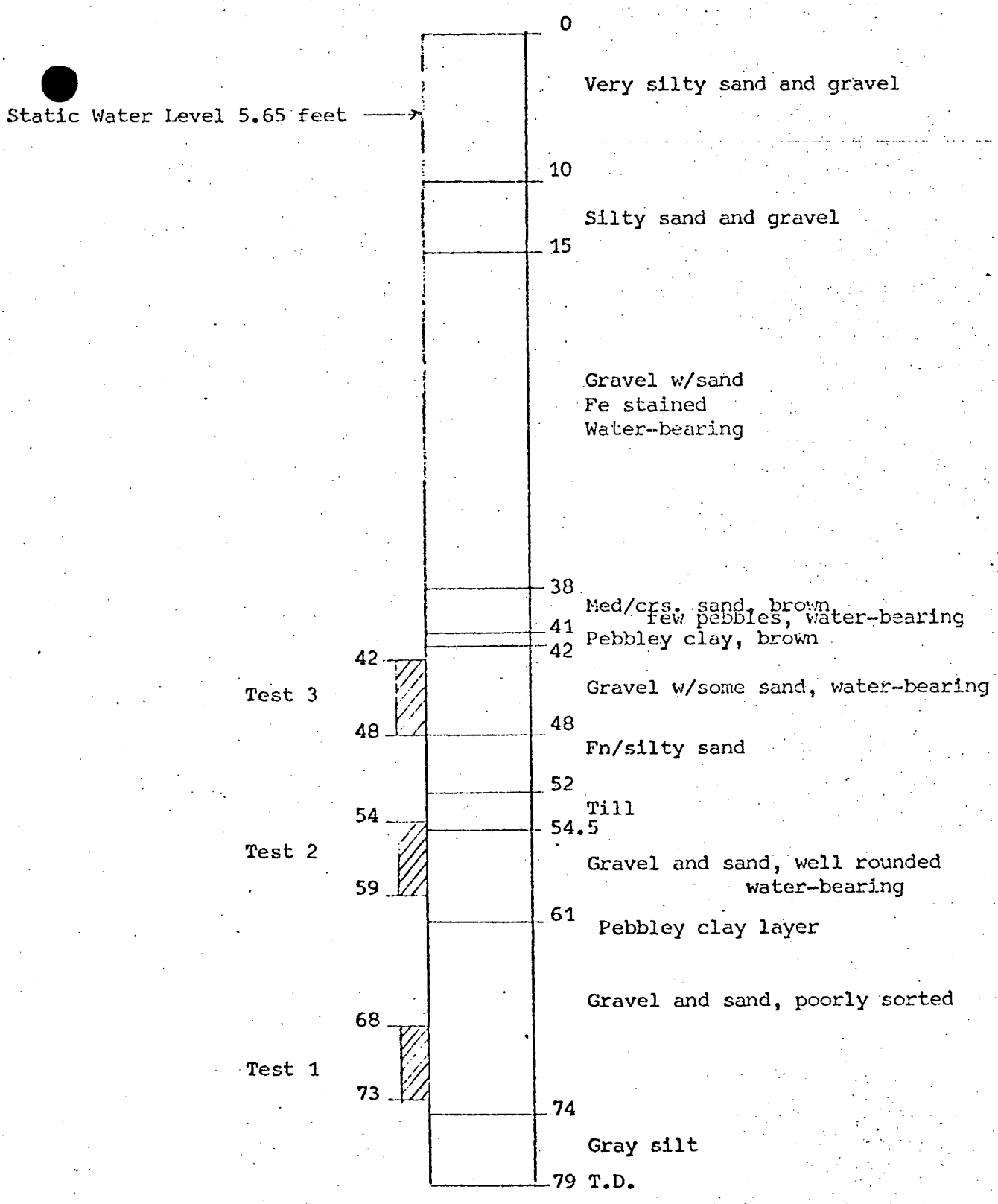
Mr. Nimsick: Mr. Chairman you stated that these wells that were abandoned were near the sewage lagoons and according to a previous speaker before these sewage lagoons showed no signs that they were running into wells. Now you (Mr. Edwards) say there is no danger.

Mr. Edwards: I didn't say that.. I say that there has been no study in effect to really establish this point and to establish the feasibility of these wells.

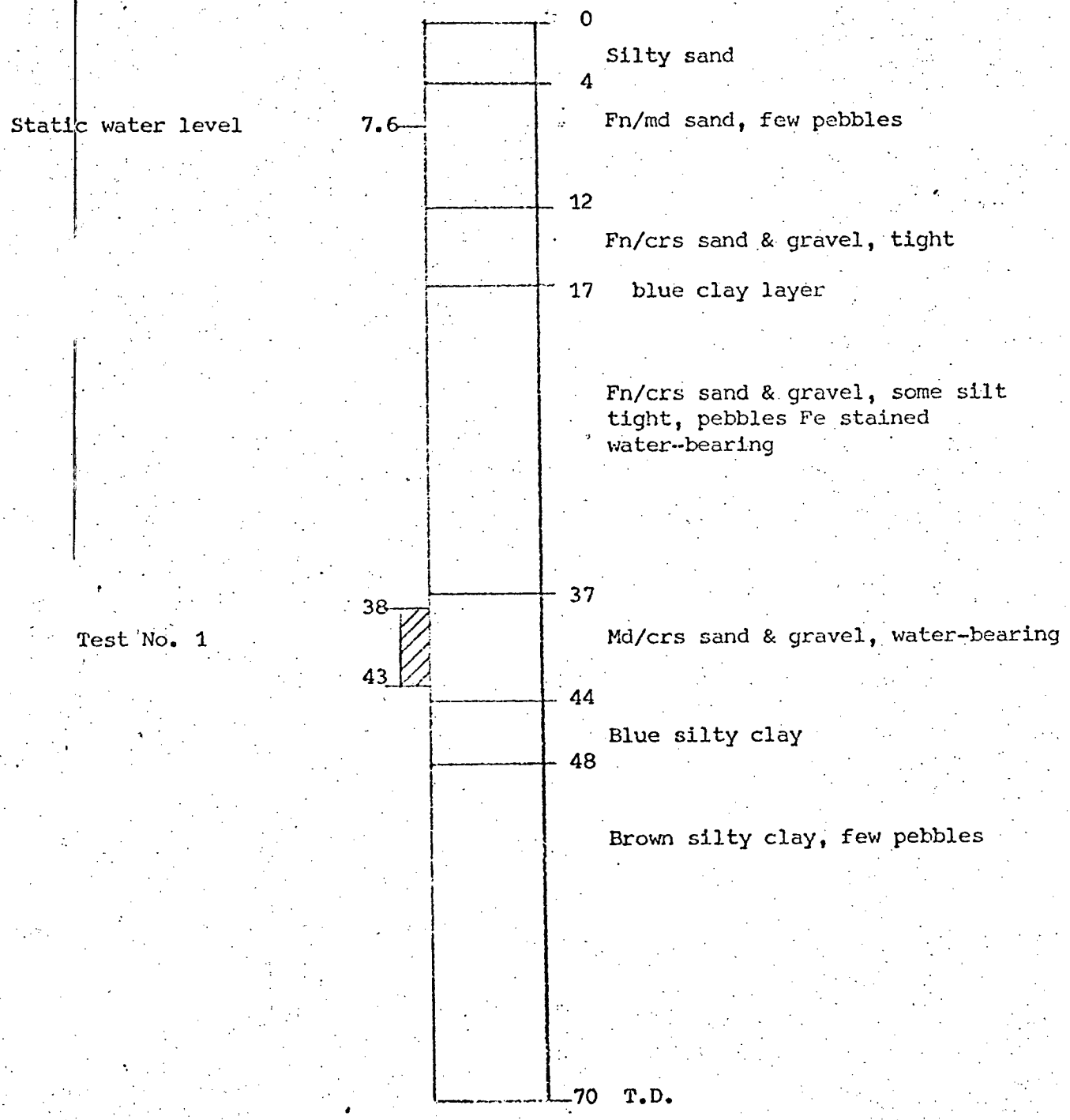
J. C. Foweraker



ANDERSON TEST WELL No. 1	Log of Sediments encountered	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
Corporation of North Cowichan		September 17, 1968



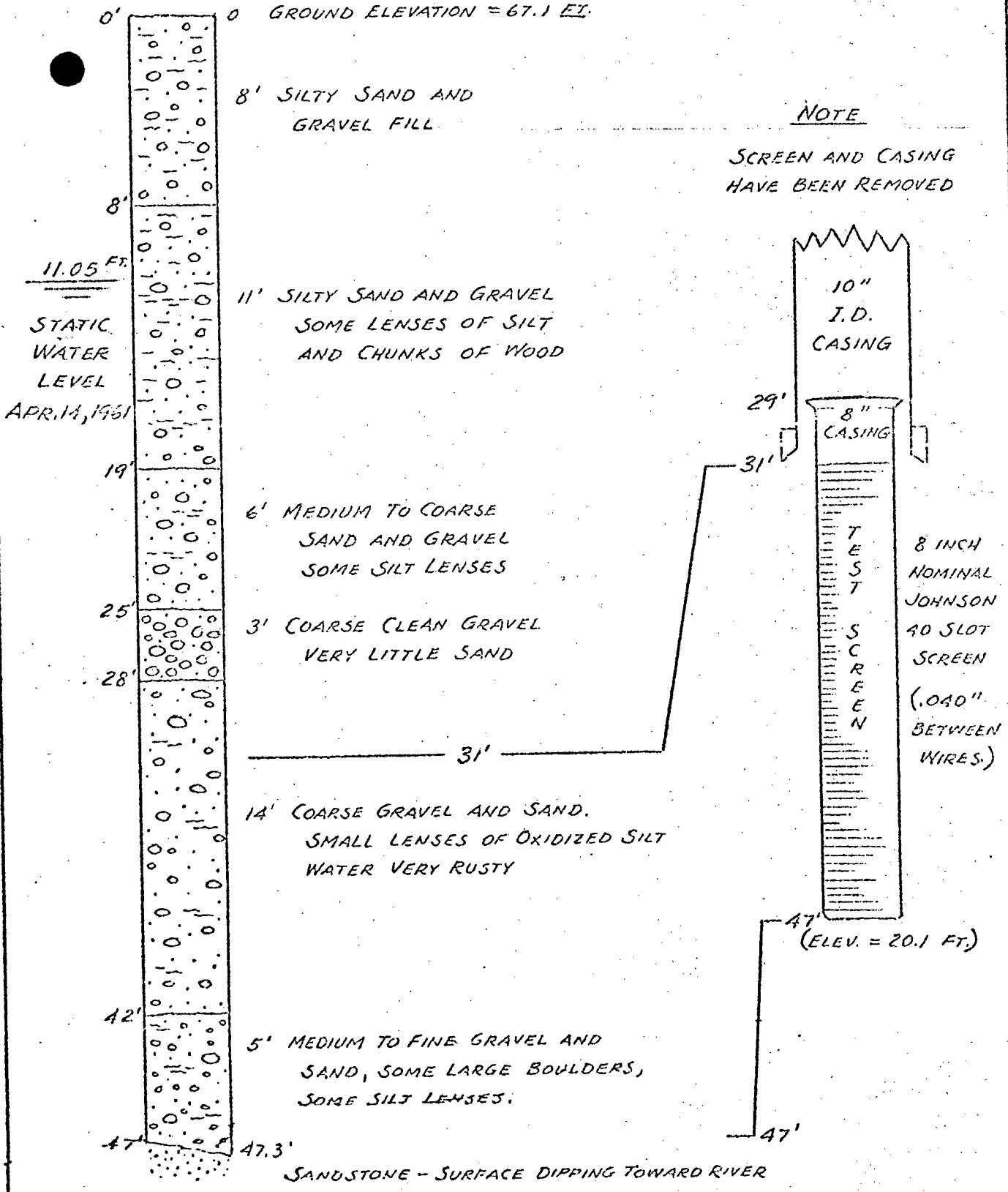
ANDERSON TEST WELL NO. 2	LOG of Sediments Encountered	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
CORPORATION OF NORTH COWICHAN		September, 1960



ANDERSON TEST WELL No. 3	LOG of Sediments Encountered	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
CORPORATION OF NORTH COWICHAN		October, 1968

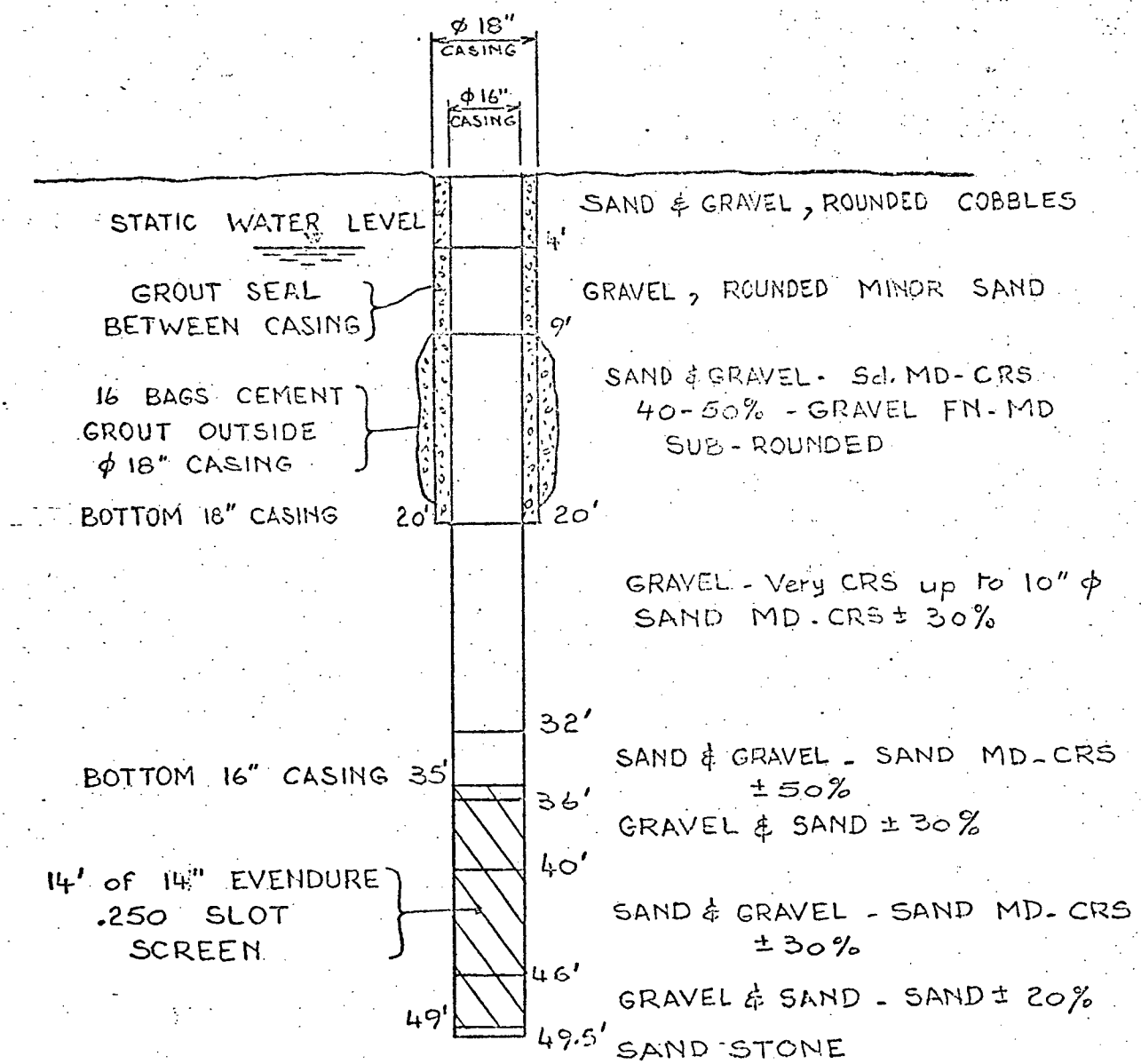
TEST WELL NO. 6

DRILLER'S LOG

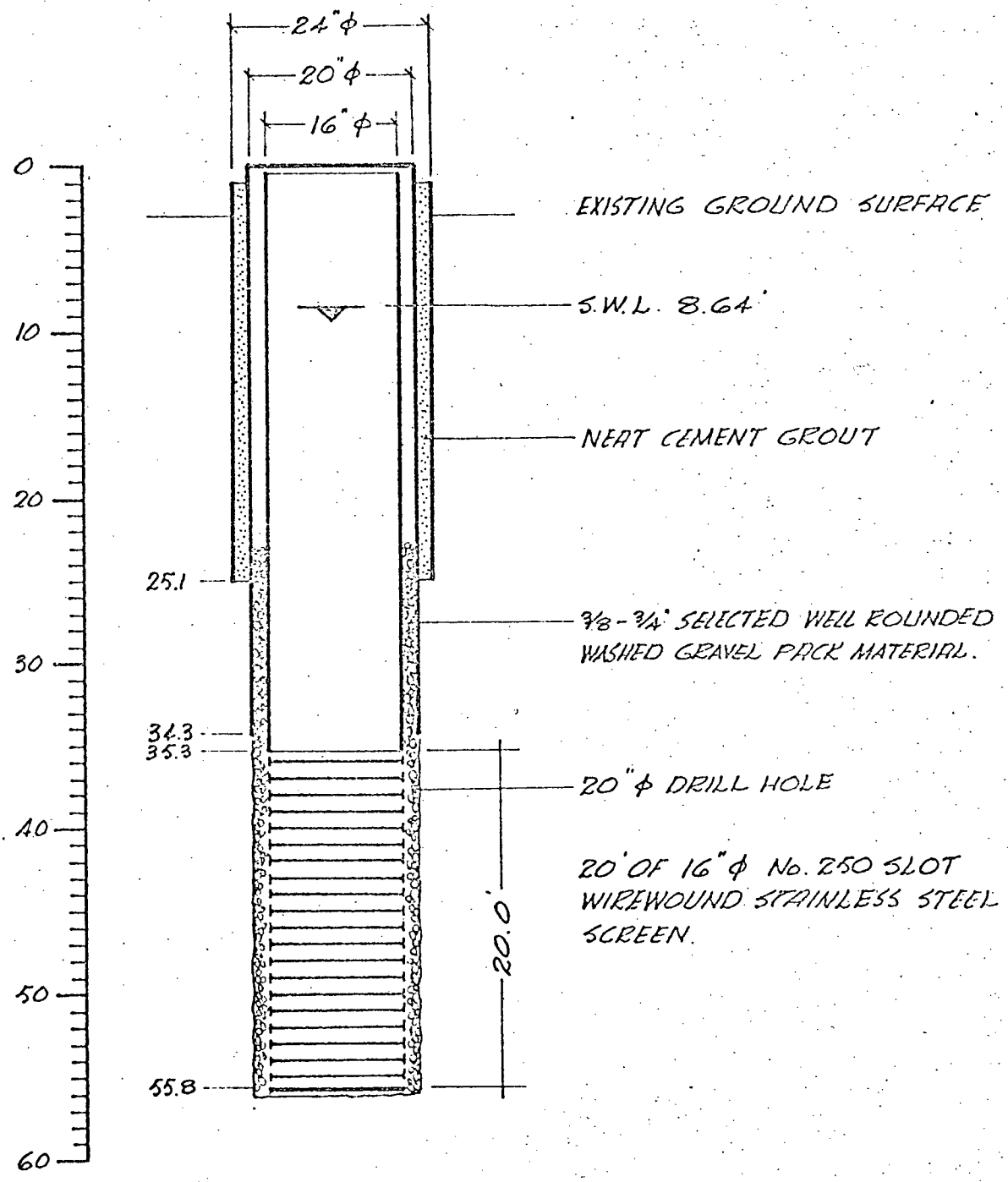


CITY OF DUNCAN, B.C. DRILLED BY PACIFIC WATER WELLS, LTD. NANAIMO, B.C.	ROBINSON, ROBERTS, AND BROWN, LTD. GROUND WATER GEOLOGISTS TACOMA, WASHINGTON JB Roberts	MAY 24, 1961 A-576 H.N.

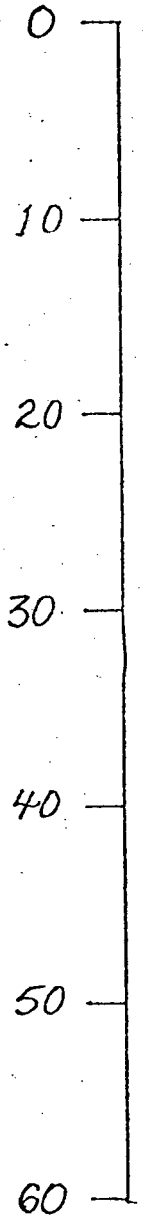
FORM D1-59-1



RUSSELL E. POTTER & Associates Ltd.			
PRODUCTION WELL n° 2 CITY of DUNCAN	ROBINSON, ROBERTS & BROWN Ltd. GROUNDWATER GEOLOGISTS NORTH VANCOUVER, B.C.	By: W.L.B	Date: Sept. 63
		Job: 342	Dwg:

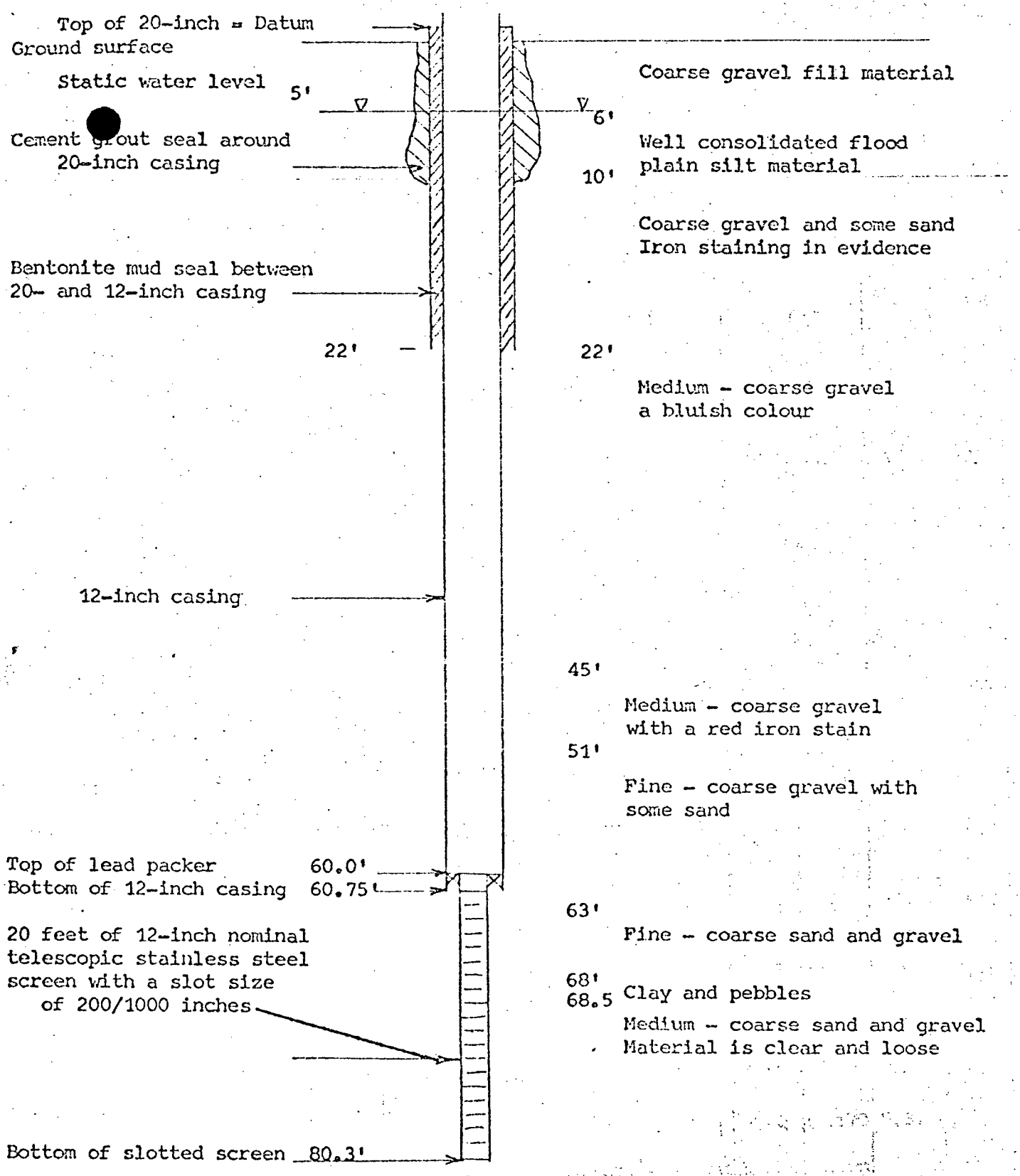


Underwood, McLellan & Associates Ltd.	Construction Diagram PRODUCTION WELL NO.3	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
City of Duncan		October, 1969

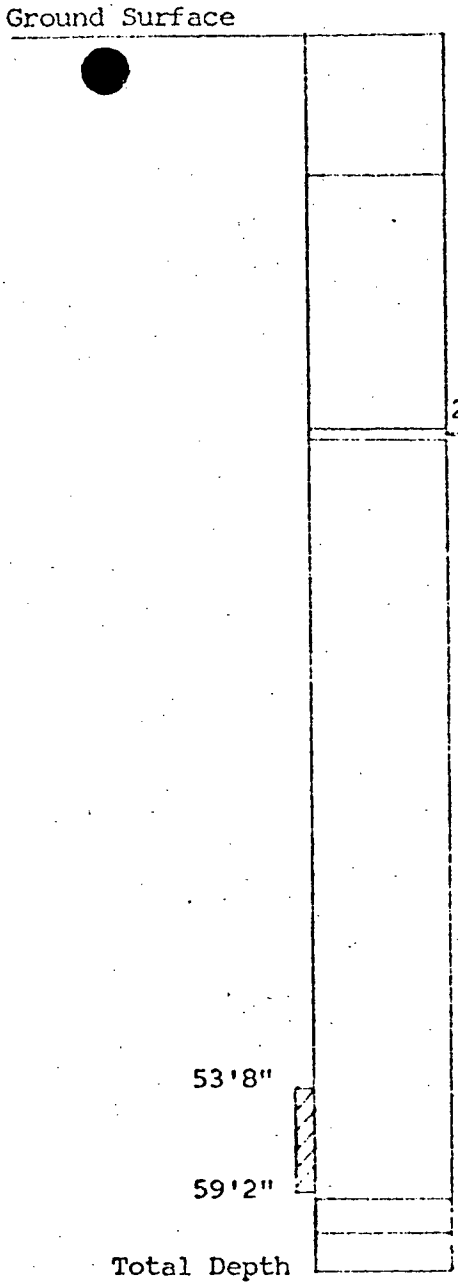


0	TOPSOIL
2	
	GRAVEL, COBBLES TO 10" WELL ROUNDED - WATER BEARING FROM 5 ft.
18	
	SAND & GRAVEL - SAND COARSE TO VERY COARSE ± 50%
30	
	SAND & GRAVEL - SAND COARSE TO VERY COARSE ± 30%
43	
	SAND & GRAVEL - SAND ± 50%
47	
	SAND & GRAVEL - SAND ± 30%
53	

Underwood, McLellan & Associates Ltd.	Sediments Encountered PRODUCTION WELL No. 3	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
City of Duncan		October, 1969



Corporation of the District of North Cowichan	Log of Riverside #2 Test-Production Well at end of Warncliffe Road.	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
Duncan, B.C.		January 1970 DWG. 3



Silty sand

Sand & gravel, water-bearing below 13½ feet.

impervious silt, sand & gravel (till-like)

Sand & gravel, water-bearing
static water level 13½ feet
below ground

Silty sand & gravel

Till

bedrock (shale) at 63 feet

PATTERSON TEST WELL No. 1	Log of Sediments Encountered	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
Corporation of North Cowichan		August, 1968

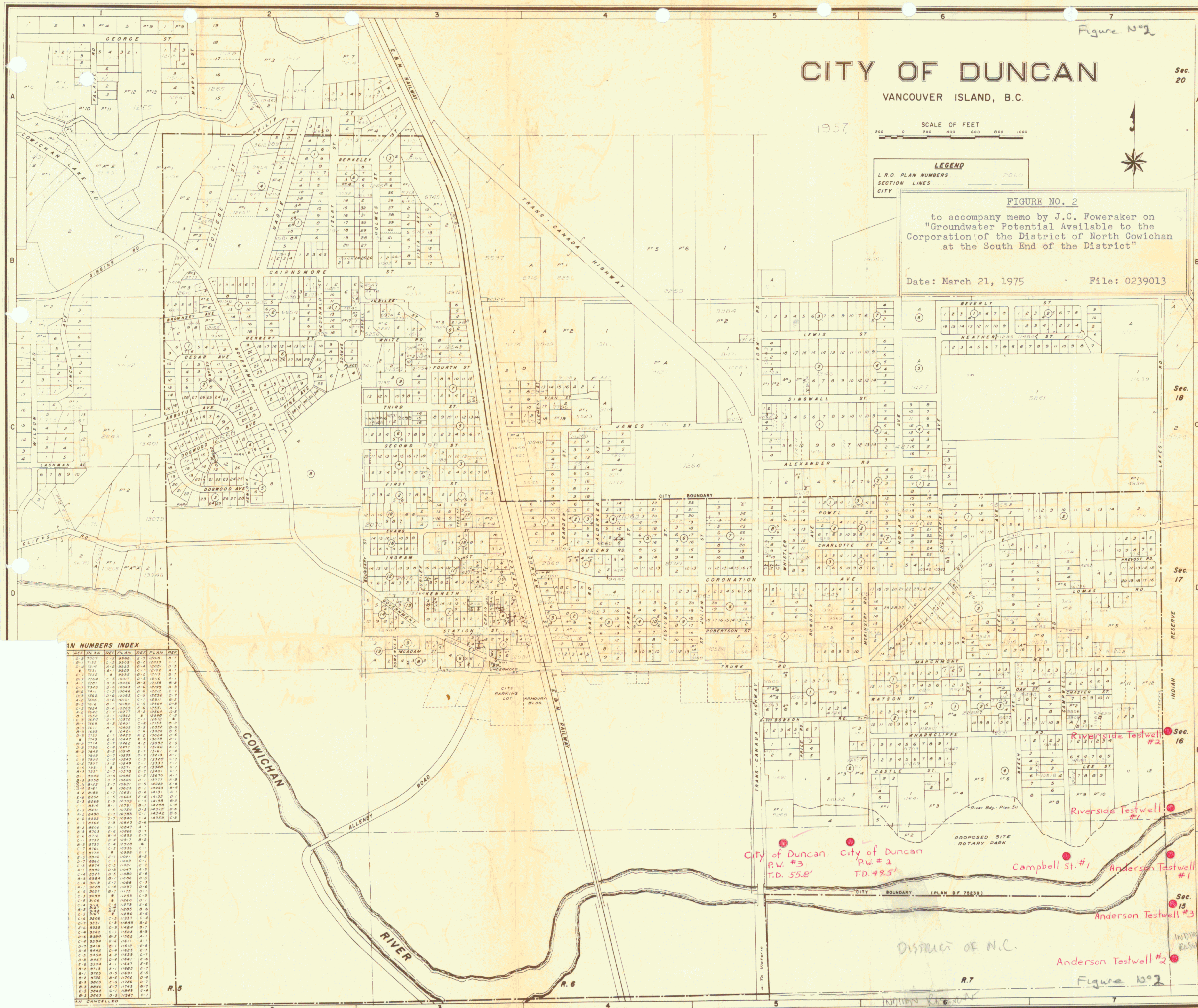


Figure No 2
CITY OF DUNCAN
VANCOUVER ISLAND, B.C.
1957
SCALE OF FEET
LEGEND
L.R.O. PLAN NUMBERS
SECTION LINES
CITY
FIGURE NO. 2
to accompany memo by J.C. Foweraker on
"Groundwater Potential Available to the
Corporation of the District of North Cowichan
at the South End of the District"
Date: March 21, 1975
File: 0239013
COWICHAN RIVER
TRANS-CANADA HIGHWAY
E & N RAILWAY
CITY BOUNDARY
Riverside Testwell #2
Riverside Testwell #1
City of Duncan P.W. #3 T.D. 55.8'
City of Duncan P.W. #2 T.D. 49.5'
Campbell St. #1
Anderson Testwell #1
Anderson Testwell #3
Anderson Testwell #2
District of N.C.
Indian Reserve
PROPOSED SITE ROTARY PARK
Figure No 2

FIGURE NO. 1

to accompany memo by J. C. Foweraker on "Groundwater Potential Available to the Corporation of the District of North Cowichan at the South End of the District"

Date: March 21, 1975 File: 0239013