ROBINSON, ROBERTS & BROWN LTD.
GROUND WATER GEOLOGISTS
4421 PATTERDALE DRIVE
NORTH VANCOUVER, BRITISH COLUMBIA
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AFFILIATED OFFICES
TACOMA, WASHINGTON
PORTLAND, OREGON

GROUNDWATER TEST DRILLING

THE CORPORATION of the DISTRICT of NORTH COWICHAN

on the

Forestry, Patterson and Anderson Properties

by

W.L. Brown, P.Eng.
R.B. Erdman, Geol.

November, 1968

INTRODUCTION

Robinson, Roberts & Brown Ltd. was requested by the Corporation of the District of North Cowichan to evaluate the groundwater potential of the Forestry property to the north of, and the Patterson and Anderson properties to the south of the Cowichan River.

Work consisted of the drilling and testing of five test wells. One each was drilled on the Forestry and Patterson properties and three were drilled on the Anderson property. The results are described herein along with a review of earlier testing in the Beverly Street and Bradshaw areas.

PREVIOUS PROGRAMS

Previous drilling and testing programs were conducted on the Bradshaw Property, the Beverly and York Street well, the field east of the school on Beverly Street and near the Beverly Street sewerage treatment plant.

Bradshaw Property

Six test wells were drilled on the Bradshaw property located approximately 750 feet west of the Beverly Street production well. These test wells were drilled on 200-foot centers near the east side of the property. Two aquifers were encountered by this drilling program. Based upon test data it was estimated that a properly designed production well screened in the lower aquifer would be capable of maintaining a yield of only 188 U.S. gpm. The upper aquifer was also tested and the estimated productive capacity of a properly designed production well was calculated to be 975 U.S. gpm. However, the high iron content (2.6 ppm) and the high cost of a treatment plant for this type of water made the construction of a production well in this area unwarranted. A complete history of this work can be found in our report entitled "Test Drilling on Bradshaw Property, Corporation of the District of North Cowichan".

Beverly Street Well

A second production well was drilled at Beverly and York Streets. This well had 10.5 feet of water-bearing sands and gravels. The Transmissibility of the aquifer in this area is 264,000 U.S. gpd/foot with a specific capacity of 70 U.S. gpm/foot. The indicated productive capacity of this well is 630 U.S. gpm when pumped by itself and 560 U.S. gpm when the first production well is pumping.

Beverly Street at School

Two test wells were drilled in the field to the east of the school on Beverly Street. The first test hole encountered nine feet of gravel at shallow depths which did not warrant testing. However, a second test well closer to the bedrock outcrop obtained 12 feet of gravel at greater depth and was tested. This test indicated a Transmissibility of 44,000 U.S. gpd/foot. However the water level did not stabilize during eight hours of pumping and the indicated safe productive capacity was estimated to be only 112 U.S. gpm.

Beverly Street Sewage Treatment Plant

This well also encountered 12 feet of water-bearing sands and gravels at depth. While the Transmissibility of the sediments in the area is similar to those in the Beverly Street wells, known boundary conditions reduced the estimated productive capacity of a production well in this area to only 90 U.S. gpm.

PRESENT PROGRAM

The present program consisted of five wells. These wells have been drilled on the Forestry property north of the River and on the Patterson and Anderson properties south of the River. Logs of all the wells drilled during the present program are included in the back of this report.

Forestry Test Well

This well was drilled to a depth of 70 feet in silts and sandy silts with zones of water-bearing sands and gravels up to six feet in thickness. The zone between depths of 31 and 36 feet was tested. Data from this testing showed that the aquifer had a Transmissibility of 26,000 U.S. gpd/foot and a probable productive capacity of 200 U.S. gpm.

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 over-lying 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 U.S. 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 U.S. gpd/foot and a probable

productive capacity of 1800 U.S. 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 U.S. gpd/foot with a probable yield of 2000 U.S. gpm to properly designed production wells.

Test Well No. 2

Test Well No. 2 was drilled close to the Boys Road. This well was drilled to a depth of 79 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 U.S. gpd/foot and 58,000 U.S. 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 U.S. 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 U.S. gpd/foot. A production well in this aquifer would have an estimated capacity of 2000 U.S. 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 lower 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 U.S. gpd/foot and the transmissibility across the site to be 500,000 U.S. gpd/foot. Again a production well in this area could be expected to yield 2000 U.S. gpm.

WATER QUALITY

Water samples were collected from all wells and analysed by Coast Eldridge. The results of these analyses are included in this report. The water is potable with a low iron content. The only possible problem was indicated by the relatively high nitrate content in the water from the Anderson No. 2 Test Well. A high nitrate content suggests possible pollution. However, a Coliform test on the water pumped from Anderson No. 2 showed that the water is acceptable.

CONCLUSIONS

1. The present testing program, in conjunction with the work done earlier, shows that the only area within the District that can supply large quantities of potable water is south of the Cowichan River.

2. Wells along the south side of the river would range in depth from 44 to 70 feet with productive potential yields that would range from 1500 to 2000 U.S. gpm.

3. The only area that now warrants testing lies adjacent to the north side of the Cowichan River generally across the river from the Anderson Property.

4. The groundwater beneath the Anderson and Patterson Properties is potable and has a low iron content. The Anderson No. 2 Test Well was relatively high in nitrates. This is probably caused by a temporary sewerage sump on the opposite side of Boys Road. This sump is reportedly abandoned.

5. The lower aquifer in Anderson No. 2 appears to be an older aquifer than the upper aquifer across the area. Limited information indicates a yield of at least 800 U.S. gpm from this aquifer.

RECOMMENDATIONS

If property is obtainable adjacent to the north side of the river a test well should be drilled there. Evaluation of the Geology and Hydrology of this area will allow yields of production wells to be established. A location on the north side of the river will eliminate a costly river crossing.

The Anderson Property has the capability of supporting at least three high capacity wells (close to 2000 gpm range). Wells on the Anderson Property can meet the foreseeable demands of the District of North Cowichan. These wells when drilled should be properly supervised so that maximum supply can be obtained from each well. Proper design and construction is most important in the construction of high yield wells.

WARNOCK HERSEY INTERNATIONAL LIMITED ® COAST ELDRIDGE

PROFESSIONAL SERVICES DIVISION

125 East 4th Ave., Vancouver 10, B.C. Phone 876-4111 — Telex 04-50353

REPORT OF Chemical Analysis

AT Vancouver Laboratory

PROJECT Water Samples

REPORTED TO Robinson Roberts and Brown Ltd.,
4421 Patterdale Street
North Vancouver, B.C.

FILE No C.3-R.5-68-833

DATE August 13, 1968

REPORT No.

ORDER No.

We have tested the sample of Water submitted by you on August 1, 1968 and report as hereunder:

SAMPLE IDENTIFICATION

The submitted sample was labelled "Cowichan Forestry Test Well No. 1 July 31, 1968".

RESULTS

pH Value		-	6.90
Alkalinity:	Carbonates	-	Not detected
	Bicarbonates	-	48.6 ppm
Hardness (Soap)		-	44.2 ppm
Nitrates		-	Trace
Total Iron		-	0.10 ppm
Dissolved Iron		-	0.06 ppm

COAST ELDRIDGE

W. Wong,
CHIEF CHEMIST

/jp

WARNOCK HERSEY INTERNATIONAL LIMITED • COAST ELDRIDGE PROFESSIONAL SERVICES DIVISION

125 East 4th Ave., Vancouver 10, B.C. Phone 876-4111 — Telex 04-50353

REPORT OF Chemical Analysis — FILE NO C.3-R.2-68-1114

AT Vancouver Laboratory — DATE August 16, 1968

PROJECT Water Samples — REPORT NO

REPORTED TO Robinson Roberts & Brown
4421 Patterdale Street
North Vancouver, BC. — ORDER NO

We have analyzed the water samples submitted to us on August 13, 1968 and report as hereunder:

SAMPLE IDENTIFICATION

Cowichan August 9, 1968 - Patterson Test Well - Temperature 50°F

TEST RESULTS

pH	-	7.10
Colour (Pt-Co Scale)	-	Trace
Colour with Charcoal	-	Trace
Turbidity (SiO_2 Scale)	-	0.5 ppm
Suspended Matter	-	9.0 ppm
Alkalinity: Carbonate	-	Not detected
Bicarbonate	-	36.0 ppm
Total Hardness (Soap Method)	-	32.5 ppm
Chlorides	-	6.5 ppm
Sulphates	-	Trace
Total Dissolved Solids	-	63.5 ppm
Volatile Solids	-	19.0 ppm
Fixed Solids	-	44.5 ppm
Calcium	-	9.0 ppm
Magnesium	-	1.5 ppm
Sodium	-	7.5 ppm
Potassium	-	Trace
Manganese	-	0.01 ppm
Total Iron	-	0.04 ppm
Dissolved Iron	-	0.04 ppm
Total Aluminum	-	0.28 ppm
Dissolved Aluminum	-	0.28 ppm
Dissolved Silicon	-	1.6 ppm

COAST ELDRIDGE

W. Wong,
CHIEF CHEMIST

/jp

WARNOCK HERSEY INTERNATIONAL LIMITED
COAST ELDRIDGE
PROFESSIONAL SERVICES DIVISION
125 East 4th Ave., Vancouver 10, B.C.

REPORT OF: Chemical Analysis — 1997

AT: Vancouver Laboratory — September 28, 1968

PROJECT: Water Samples

REPORTED TO: Robinson, Roberts & Brown,
4421 Paterdale Drive,
NORTH VANCOUVER. B.C.

We have analyzed the water samples submitted to us on September 18, 1968 and report as hereunder:

SAMPLE IDENTIFICATION

The submitted samples were labelled -

Sample 1 - "63-68' North Cowichan Anderson Test Well #1 15/9/68".

Sample 2 - "44-49' North Cowichan Anderson Test Hole #1 - Screened - Temp. 62°F".

TEST RESULTS

	Sample 1	Sample 2
pH	7.1	7.1
Colour (Pt-Co Scale)	Not Detected	Not Detected
Colour with Charcoal	Not Detected	Not Detected
Turbidity (SiO_2 Scale)	-	0.5 ppm
Suspended Matter	-	11.0 ppm
Alkalinity: Carbonate	-	Not Detected
Bicarbonate	-	43.6 ppm
Total Hardness (Soap Method)	36.6 ppm	41.5 ppm
Chlorides	1.5 ppm	1.5 ppm
Sulphates	trace	trace
Sulfides	Not Detected	Not Detected
Total Dissolved Solids	-	60.7 ppm
Volatile Solids	-	22.0 ppm
Fixed Solids	-	38.7 ppm
Calcium	-	8.5 ppm
Magnesium	-	2.6 ppm

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FORM 119-CE-80-E

TEST RESULTS (Cont'd)

	Sample 1	Sample 2
Sodium	-	trace
Potassium	-	trace
Manganese	-	Not Detected
Total Iron	0.06 ppm	0.04 ppm
Dissolved Iron	0.02 ppm	0.02 ppm
Total Aluminum	-	0.28 ppm
Dissolved Aluminum	-	0.24 ppm
Dissolved Silicon	1.8 ppm	1.6 ppm

Spectrographic Analysis attached per sample 2.

C O A S T E L D R I D G E

W. Wong
CHIEF CHEMIST

/mr

TO:

Robinson, Roberts & Brown,

4421 Paterdale Drive,

NORTH VANCOUVER, B.C.

COAST ELDRIDGE
PROFESSIONAL SERVICES DIVISION
WARNOCK HERSEY INTERNATIONAL LIMITED

1997

September 28, 1968

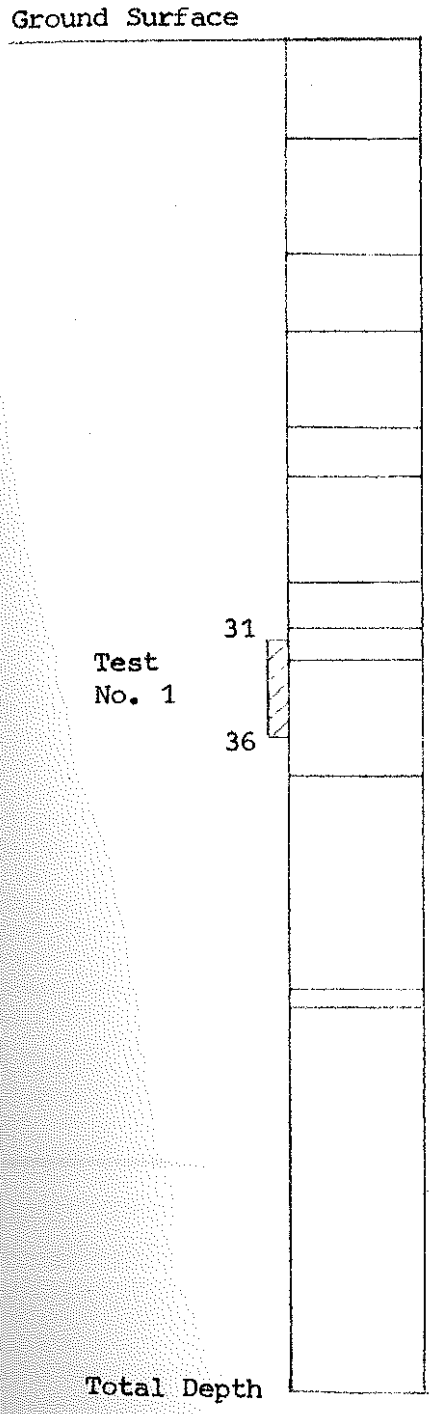
SEMI-QUANTITATIVE SPECTROGRAPHIC ANALYSIS

Water

SAMPLE IDENTIFICATION															
Sample 2 (44-49)	1.0	ND	ND	0.02	ND	ND	ND	ND	8.5	0.001	ND	0.005	ND	ND	0.08
	0.005	3.0	ND	ND	ND	ND	3.0	ND	ND	ND	0.002	ND	ND	0.001	0.005

All results are expressed as parts per million in the water.
ND - Not Detected

/mr



FORESTRY Test Well No. 1	Log of Sediments Encountered	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
Corporation of North Cowichan		July, 1968

WARNOCK HERSEY INTERNATIONAL LIMITED

PROFESSIONAL SERVICES DIVISION

[illegible] Ave [illegible]

2450

REPORT OF: Chemical Analysis

AT: Vancouver Laboratory

[illegible] 13, 1966

PROJECT: Water Samples

REPORTED TO: Robinson Roberts & Brown Ltd.
2421 Letterdale Street
NORTH VANCOUVER, B. C.

We have tested the samples of water submitted [illegible] October 7, 1966, and report as hereunder:

SAMPLE IDENTIFICATION:

Sample 1 - North [illegible]
Anderson No. 2 depth 42-47.

Sample 2 - Anderson TH 2 54-59.

RESULTS:

	Sample 1	Sample 2
pH Value	7.0	7.6
Colour Pt-Co Scale	3.0 ppm	Trace
Turbidity SiO_2 Scale	22.1 ppm	Trace
Alkalinity - Carbonates	Not Detected	Not Detected
Bicarbonates	41.5 ppm	46.0 ppm
Hardness, Soap Method	38.4 ppm	46.7 ppm
Chlorides	2.0 ppm	1.5 ppm
Sulphates	Trace	Trace
Nitrates	[illegible] ppm	0.2 ppm
Total Iron	0.12 ppm	0.06 ppm

COAST ELDRIDGE

U. Kong
Chief Chemist

/bg

FORM [illegible]

WARNOCK HERSEY INTERNATIONAL LIMITED

COAST ELDRIDGE
PROFESSIONAL SERVICES DIVISION

Telex 04-50353

Chemical Analysis — C.3-R.2-68-2955-B

Vancouver Laboratory — November 18, 1968

Water Samples

Robinson Roberts & Brown
4421 Patterdale Street
North Vancouver, B.C.

We have analyzed the water samples submitted to us on November 4, 1968 and report as hereunder:

SAMPLE IDENTIFICATION

Sample No. 2 - "North Cowichan Anderson No. 3 - October 29, 1968

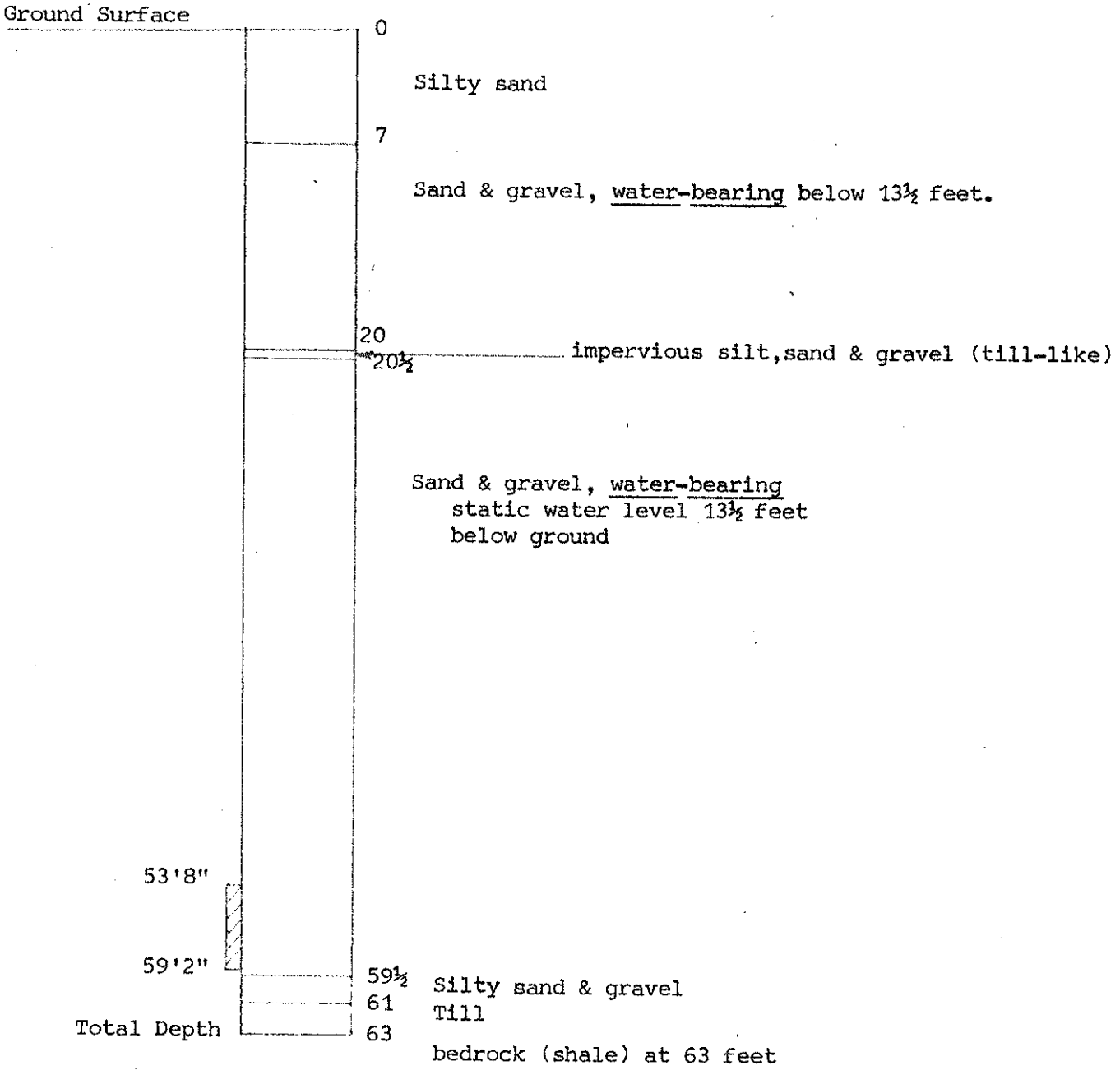
TEST RESULTS

pH	-	6.90
Colour (Pt-Co Scale)	-	Trace
Colour with Charcoal	-	Trace
Turbidity (SiO_2 Scale)	-	Trace
Alkalinity: Carbonate	-	Not detected
Bicarbonate	-	38.2 ppm
Chlorides	-	Trace
Nitrates	-	2.5 ppm
Calcium	-	7.5 ppm
Magnesium	-	5.4 ppm
Total Iron	-	0.04 ppm
Dissolved Iron	-	0.04 ppm
Dissolved Silicon	-	2.6 ppm

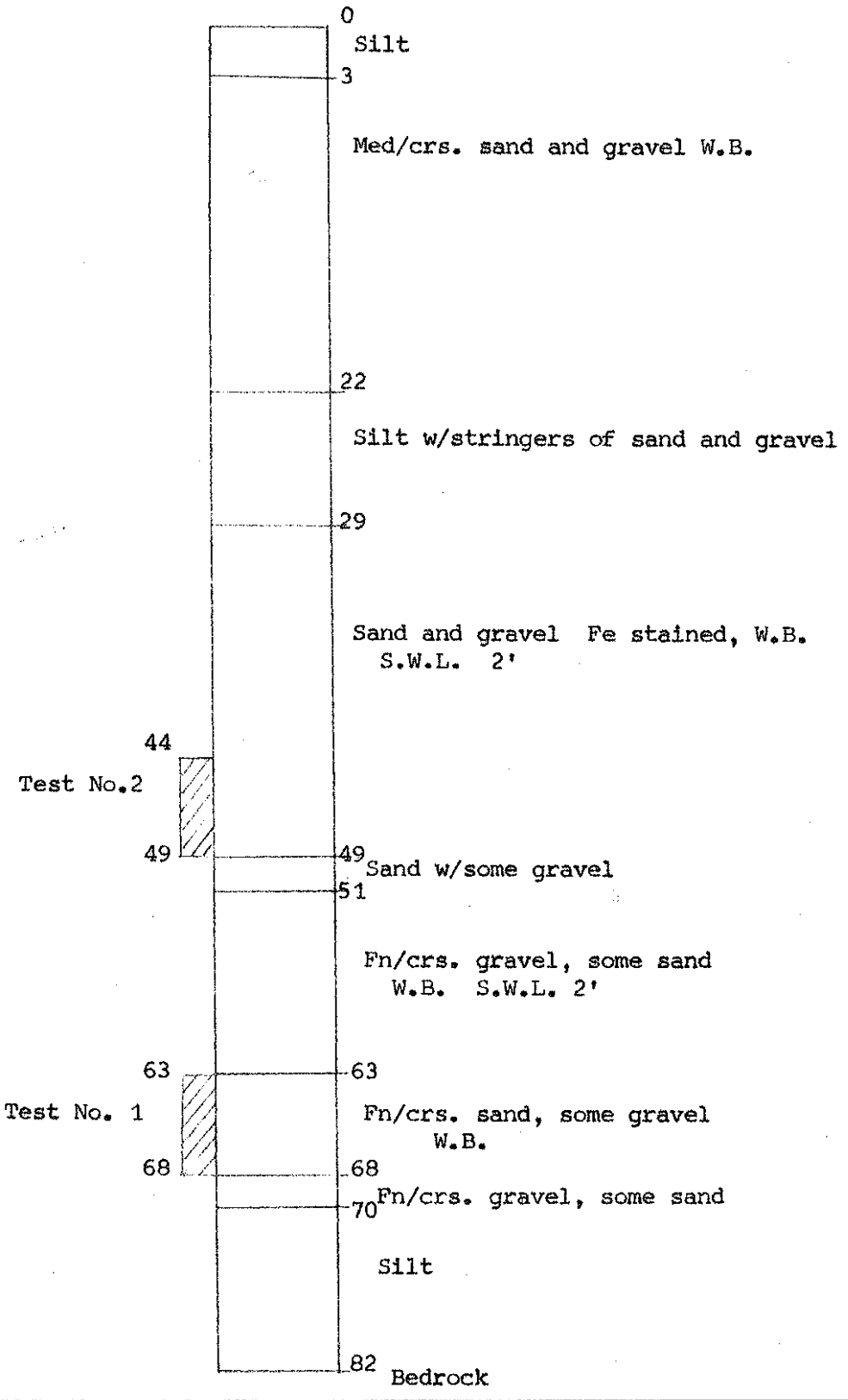
COAST ELDRIDGE

W. Wong,
CHIEF CHEMIST

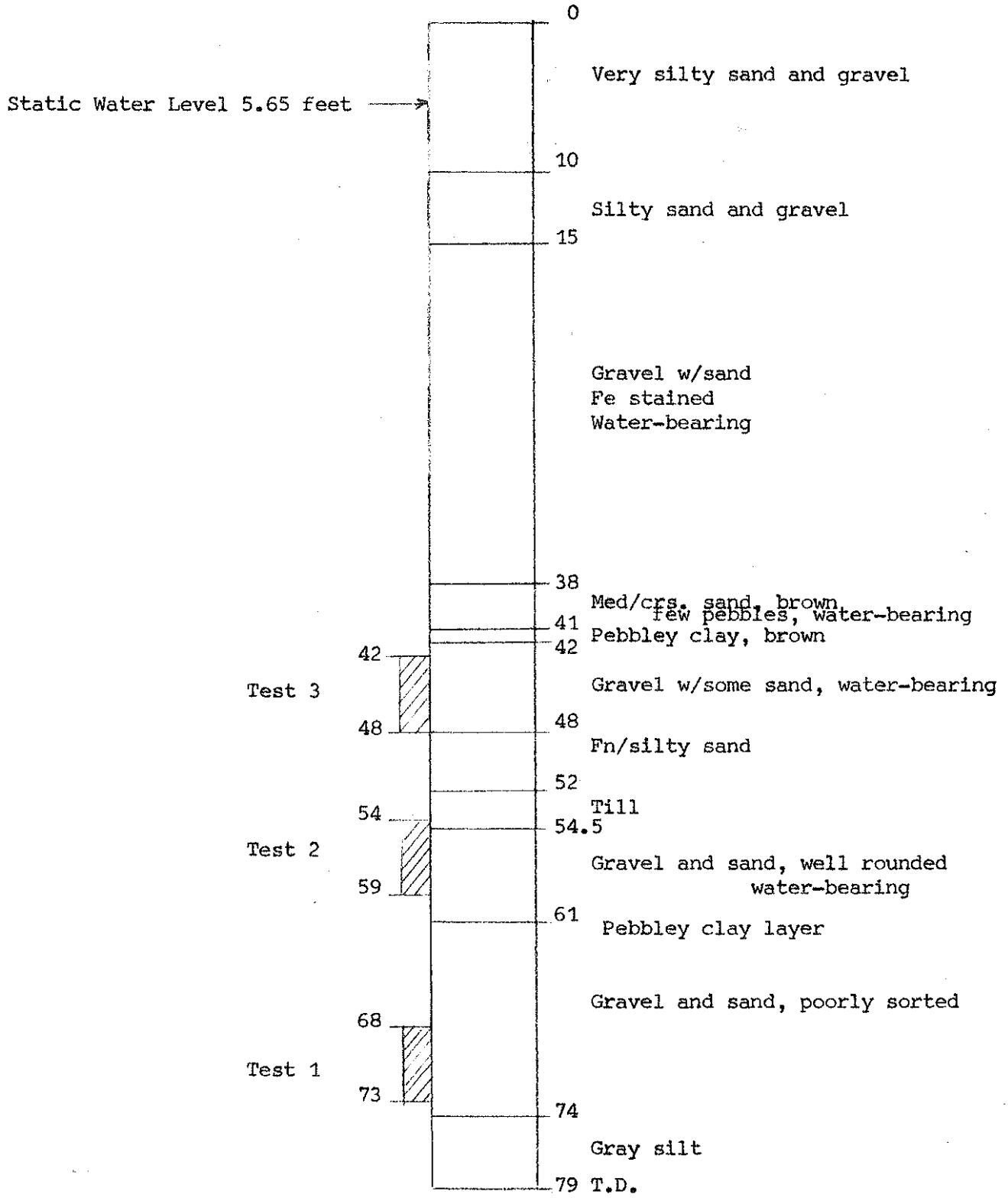
/jp



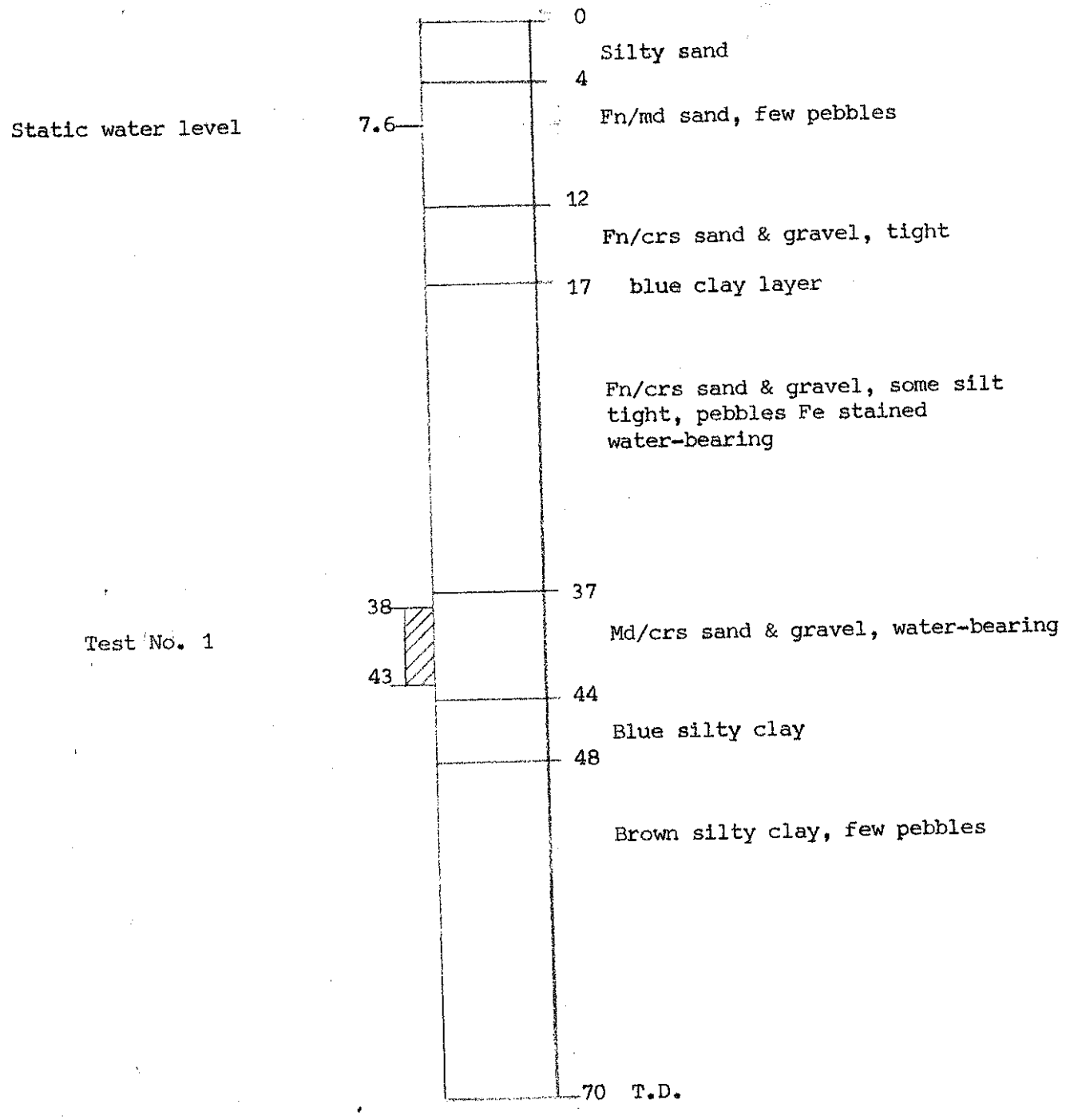
PATTERSON TEST WELL No. 1	Log of Sediments Encountered	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
Corporation of North Cowichan		August, 1968



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, 1968



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