GROUND WATER DIVISION
WATER INVESTIGATIONS BRANCH
B.C. WATER RESOURCES SERVICE
DEPT. OF LANDS, FORESTS & WATER RESOURCES
VICTORIA, B.C.

March 3rd, 1967
File No. 0239016

Notes on a Test Well Drilled in North Surrey

General

Work was completed last month on a test well situated north of Fry's Corner in North Surrey, B.C. The site location was based on information obtained from a rotary drilling program carried out in the Spring of 1966, in the Nicomekl-Serpentine Basin area, as part of an A.R.D.A. investigation program No. 10032 . There were numberous well construction problems associated with this test well, but every effort was made to test the water bearing deposit and also to make a production well in the aquifer.

During preliminary pumping trials it was evident that the filter pack around the well screen became plugged off with silt during continuous pumping - this caused the capacity of the well to fall off rapidly under heavy pumping. Although the well overflows at approximately 35 gallons per minute, the capacity of the test well is very limited because of the silt problem, probably not over 60 gallons per minute. The information we obtained during the construction and development of this well together with the behaviour of the well under test showed that with present methods at least, a large capacity well cannot be constructed in an aquifer with these characteristics. Methods of well construction will undoubtedly be developed in the future which will be able to handle this problem effectively.

The test well is being retained at the present time as a groundwater observation well within the network of observation wells already established in the Lower Fraser Valley.

Location of Test Well Site

The test well is located within the Nicomekl-Serpentine Basin which drains into Boundary Bay, south of Vancouver, B.C. (See Index Map #1, Lat.49° 09', Long. 122° 45'). The site is located on the north bank of the Serpentine Canal, immediately east of 176 St. (Figure 2). The site is included in a portion of an 80 foot easement containing the Serpentine Canal and located within the N.W. 1/4 of Section 29, Twp 8, N.W.D. The Surrey Dyking District formerly held title to this land. (See Title No.45719E). Arrangements were made by Mr. P. Livingstone, Municipal Manager District of Surrey (see letter dated June 15, 1966, file No. 0239016/0242512-24) to purchase this easement. Mr. Livingstone also gave the Water Resources Service permission to drill a test well on this easement. (see same letter), and later to maintain an observation well at this site (letter dated February, 1967, File No. 0239016).

Drilling Notes and Drillers Log of Test Hole

Western Water Wells and Hamelin Drilling Ltd., of Vancouver, were selected on the basis of a low bid to drill the test well by cable tool method. The contractor first drove 12 inch casing to 154 feet, and 10 inch casing to 353 feet. A further reduction was then made to 8 inch casing which was driven to 410 feet. The driller drilled 'open hole' an additional 20 feet to 430 feet when drilling was terminated.

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Daily report sheets of driller
and copy of these notes filed under completed projects

Procedures for logging and sampling required for this test well were outlined to the driller. (For logging, sampling and screening procedures for cable tool drilling of water wells, see notes on file No. 0242686, May 3rd, 1966). Drill hole samples from the test well have been stored in this office, and additional samples have been sent to the Department of Highways for sieve and hydrometer size analysis. Size analysis curves for these samples are on file in this office. A sample of wood collected at a depth of 270-273 feet has been sent to the Geological Survey of Canada in Ottawa, for a radio carbon age determination.

The following is the driller's log for the test hole, although some additional information is added in the aquifer zone. A detailed composite log with geological interpretation will be discussed with reference to the rotary test holes drilled in the Nicomekl-Serpentine Valleys, in a later report.

LOG OF TEST WELL #1

Feet	Description	
0 - 18	Soft brown sand	
18 - 200	Clay - blue	
200 - 205	Clay, silt, some gravel	
205 - 210	Silt, sand	
210 - 212	Silt, sand, gravel, a little water	
212 - 230	Silt, clay with some coarser zones, a little water	
230 - 238	Silty coarse to medium gravel)	
238 - 242	Coarse to medium gravel)	
242 - 245	Fine silty gravel)	Main aquifer zone
245 - 250	Sand and gravel)	
250 - 260	Medium sand and some gravel)	
260 - 273	Very fine sand	
273 - 300	Sand with silt, a little clay, water shut off.	
300 - 309	Silty sand	
309 - 330	Sand with some clay	
330 - 335	Sand with clay	
335 - 350	Sandy clay with some pebbles	
350 - 354	Some gravel with silt and sand	
354 - 360	Sand with some gravel - tight - till?	
360	Reduced from 10-inch to 8-inch casing	
360 - 370	Sand with silt	
370 - 379	Sand and clay	
379 - 385	Hard blue clay	
385 - 425	Clay, sand, silt, some small pebbles	
	End of hole	

Well Construction, development procedures, difficulties encountered.

A screen was selected for the test well based on visual inspection of the samples and size analyses from representative bailer samples taken every two feet in the aquifer zone. A stainless steel 10 inch nominal size 'Cook' screen was ordered by the contractor, made up of the following specified slot sizes:

231 - 241 feet	-------- 60 slot
241 - 246 "	-------- 30 slot
246 - 256 "	-------- 40 slot

The overall length of the screen was 27.5 feet. Silty sand heaving into the hole during the setting of the screen caused the driller some trouble, but the screen was finally set between 229.5 and 257 feet. The ten inch casing was pulled back to 234 feet, leaving 3½ feet of packer and screen unexposed.

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During the early stages of development it became apparent that silt and very fine sand might be a problem in development. From the beginning we limited the amount of surging with surge blocks in order to avoid any bridging or blocking of the screen by fine silts. The well was first bailed for a few days then after that, lightly surged. After a week of this development, no more fine sand came into the screen. A small pump was then installed and the well pumped for an hour at about 70 U.S. gallons per minute for about 15 feet of drawdown. A considerable amount of silt and very fine sand was also pumped out of the well.

The well was then developed for over a week using Calgon each day. Calgon a dispersing agent for clays and silts, was introduced into the well in solution form. Between 10-20 lbs. of Calgon were used for every 100 gallons of water in the well casing. The well head was then sealed and backwashing carried out with compressed air using pressures of about 40-50 lbs. per square inch, applied and then released suddenly through an escape valve. This backwashing was repeated at four intervals during the day, and the following morning, and the sand that had collected in the screen was bailed out. The whole process was then repeated again each day. After the first day, the driller obtained seven feet of fine sand in the screen, but on subsequent days of development with Calgon, this amount was reduced to zero. The casing slipped one foot during this development operation, but it was able to be pulled back very easily, and the driller pulled the casing an extra foot to reduce the overlap with the screen to 2½ feet. The distance from the ground datum to the top of the lead packer on the screen was found to be the same during all these movements of the casing.

A shaft pump was then installed with 190 feet of pump column, and a pump test commenced. The well was pumped at 250 U.S. gallons per minute for about one hour, and the static level fell from 0 - 92 feet below ground level. Although the static level was still falling, the pump engine overheated at this point and it was necessary to reduce the engine speed, and the pumping rate to 190 U.S. gallons per minute. This rate was held for a further hour, and the water level continued to fall more slowly. When the static level reached 97 feet the engine overheated once more, and a further reduction in pumping rate was made to 115 U.S. gallons per minute. The static level then commenced to rise slowly over a half hour period to 89 feet. At this point the engine failed. Throughout the pumping period, large amounts of silt and very fine sand were pumped out of the well.

Before proceeding with further development work, the driller removed the pump column from the well and checked the screen which he found to be empty and free of sand. He then replaced the pump column, this time to 210 feet, and installed a larger engine in preparation for a 24 hour pumping period. However, on a preliminary trial by the driller to test the equipment, the pump bowls seized up due to the presence of gravel and coarse sand.

Wax impressions were made of the packer and the top of the screen in an attempt to assess damage to the screen. The driller also found he was unable to penetrate more than 2 feet inside the screen with a four inch bailer. Deep scratches on the bailer bottom were thought to have been caused by the broken screen. An underwater television camera, owned by Videospection Engineering Ltd., was then brought in, and it appeared from the pictures obtained that the screen had become broken immediately below the top screen collar and therefore, in part within the 10-inch casing which overlaps the screen for 2½ feet. The picture on the T.V. screen showed coarse sand flowing through a tear in the screen. Photos showing this are on file in this office.

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Attempts were then made to place an eight inch diameter 6 foot long sleeve inside the screen, over the broken portion, and to try and seat this sleeve collar inside the top screen collar. A removable $7\frac{3}{4}$ inch diameter swedge, fitted inside the sleeve, and protruded through the lower end, to prevent broken parts of the screen from snagging on the bottom edge of the sleeve. The sleeve could not be pushed down all the way however, and it was not possible to get the bailer beyond the sleeve, so the sleeve was removed from the hole. Attempts were then made to salvage part of the screen, however these attempts proved to be unsuccessful and the driller finally had to drill out the screen.

From correspondence with R.L. Schreurs, Chief Geologist for the Johnson Division in Minnesota (see file No. 0239016, November 28, 1966) and from discussions between Mr. Livingston and myself, it was concluded that the screen had collapsed during the final pump trial, the day before the scheduled pump test. Mr. Schreurs pointed out the screen might have been damaged when the casing settled. He also suggested that the waterbearing formation may have been slightly consolidated because of the silt content, and over excavation occurred, hence material would not uniformly cave against the screen and a sudden slump of material, when the well was pumped at a higher rate, collapsed the screen. However he calculated that the collapse resistance of the screen would be something like 25-30 P.S.I. Mr. Schreurs thought possibly the screen slot size selected may have been a little large, but not excessively so.

Mr. Schreurs suggested two methods of recompleting the well. Firstly by developing a natural pack around a 10 inch screen, and secondly by gravel packing a 20 foot long, four inch "pipe size" screen. Subsequently Mr. Fryberger, also from the Johnson Division, suggested in a telephone conversation with me that it would be advisable, in view of the danger of collapse from overlying silts, to eliminate the upper 5 feet of the gravel packed screen, and thus reduce the total length of screen and pack to 15 feet. We adopted the suggestion to use a 4 inch pipe size screen with a 15 foot screen, using 20 slot between 240-243 feet and 50 slot between 243-255 feet. The filter pack sand was graded between 1/16 inch to 1/8 inch as suggested.

Difficulty was experienced by the driller in pulling back the 10 inch casing to expose the filter pack and screen. The screen became sand locked and moved up with the casing. Finally the filter pack sand had to be sucked out through a 1 1/4 inch pipe with a 4 inch diaphragm suction pump in order to free the screen. A 20 foot scaffolding was then erected around a 20 foot extension on the 10 inch casing and the additional head of water obtained cut down the artesian flow to practically zero during construction of the gravel pack. This additional head also minimized the risk of heave in the filter pack while filling. A four inch pipe extended from the top of the screen to 20 feet above ground. Working atop the scaffolding, sand was added, a bag at a time, to the space between the two casings. The ten inch casing was pulled back and cut off in three foot sections. The addition of small quantities of filter pack sand at a time prevented further sand locking between the screen and the 10 inch casing. In all, 48 bags of filter pack sand were used during construction and subsequent well development.

The well was developed by bailing and surging with the bailer. The overflow remained fairly constant at 35 gallons per minute approximately, which is in the same order as that obtained during development on the first screen. A centrifugal pump was installed and the well pumped at about 60 gallons per minute for 12 hours. After this period the overflow remained constant at 25 gallons per minute, but a few minutes surging with the bailer brought the flow right back to 35 gallons per minute again. At this stage we suspected that silt was plugging the filter pack and reducing the efficiency of the well under steady pumping. However, a sudden agitation with the bailer loosened up this material and caused the well to return to its normal efficiency.

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Further development with an air-line set at 155 feet was found to be less effective than using the bailer for development. Although greater drawdowns could be obtained by this method the overflow did not return to the 35 gallon per minute obtained with surging with the bailer. Backwashing with air therefore was found to be an unsatisfactory means of well development here. Also the sand filter pack remained fairly stable during development with air.

The 4 inch casing was finally withdrawn when it became apparent that the level of sand in the filter pack was no longer being affected by bailer development. Some bailing and surging was then done with an eight inch bailer fitted with a 9½ inch flange. This bailer could not reach inside the screen and it was not very effective. The lead slip packer was finally installed between the top of the seventeen foot, 4 inch "riser" pipe and the 10 inch casing. Twelve feet of filter sand were packed around the riser pipe as a "reservoir" for the pack.

Trial Pump Test

(Due to the behaviour of this well under trial pumping no detailed analysis of pumping test results has been attempted.)

A shaft pump was finally installed in the well with 200 feet of pump column and a trial pump test commenced. The well delivered 70 Imperial gallons per minute (average) for 1 hour and 20 minutes for a drawdown below well head of 22 feet. The well took five minutes to recover to overflow and was overflowing at 30 gallons per minute within half an hour. At the end of the pumping period the well water was moderately milky.

The next day the pump was started at 80 Imperial gallons per minute, and the drawdown increased rapidly over a one hour period to 67 feet below well head. At this point the well water was very milky and a little very fine sand was obtained in a sample bottle.

The pumping rate was then increased to 100 Imperial gallons per minute and the drawdown increased very rapidly over a period of 36 minutes to the pump shaft limit at 200 feet. The pump rate was then reduced to between 63-68 Imperial gallons per minute and the drawdown slowly increased from 179 to 192 feet below well head. At this stage the well water was only slightly milky. The pump rate was finally dropped to 50 Imperial gallons per minute for one hour, the drawdown reaching 165 feet below well head. Recovery to overflow took 25 minutes and after one hour the overflow was 7½ gallons per minute compared with 35 gallons per minute at the beginning of the pump test. The well was allowed to freeflow all weekend, however the overflow did not increase past 10 Imperial gallons per minute. The driller removed the pump and surged the well with the bailer for a day until the overflow returned to 35 Imperial gallons per minute. The well was then capped and connected up to a pressure recorder to make observations on the static variations.

Summary of Costs

A breakdown of costs incurred on the test well are as follows:-

Drill & case 12 inch well from 0-43 feet at $16.50 per foot	$ 709.50	
Drill & case 12 inch well from 43-154 feet at $16.50 per foot	1831.50	$ 2541.00
Drill & case 10 inch well from 154-350 feet at $15.00 per foot	2940.00	
Drill & case 10 inch well from 350-353 feet at $15.00 per foot	45.00	2985.00
Drill & case 8 inch well from 353-430 feet at $11.50 per foot		885.00
		$ 6411.50

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Forward		$ 6411.50
Allowance for 10 inch casing recovered 120 feet at $5.25 per foot	$ 630.00	
Allowance for 8 inch casing recoverd 83 feet at $3.00 per foot	249.00	879.00
		$ 5532.50
Mobilization and demobilization		250.00
Hourly rate for running in overlap casing, setting screen, pulling casing, developing well, additional sampling etc. - 727 hours @ $16.00 per hr.		11632.00
Hourly rate for standby waiting for screen etc. 40 hrs. @ $10.00 per hour		400.00
Cost #1 Screen		1571.59
Cost #2 Screen		637.54
Materials, rentals, TV pictures, etc.		2229.76
Night shift to run pump		60.00
Total Cost of Test Well		$ 22,313.39

Cost of materials in the well:-		
12 inch casing 154 feet at $6.50 per ft.	$ 1001.00	
10 inch casing 240 feet at $5.25 per ft.	1260.00	
Screen, fittings, etc.	637.54	
Filter pack sand, incl. freight etc. ...	184.67	
Well head fittings needed for observation well	33.54	
Total		$ 3,116.75

Break down of costs under hourly rate for running in overlap casing, setting screen, pulling casing, developing well, sampling etc.

		Hours	
1.	Running overlap casing, sampling etc.	64	
2.	Pulling 10, 8, 4 inch casings	81	
3.	Setting two screens	21	
4.	Running in pump, pump trials, removing pump	30	
5.	Developing well screen #1	151	
6.	" " " #2	199	
7.	Working on collapsed well screen #1..	117	
8.	Placing gravel pack and freeing locked casings	61	
9.	Capping well	3	
	727 hours @ $16.00 per hour	727	$ 11,632.00

Discussion on reduction in yield in the Test Well on pumping.

In our correspondence with the Johnson Division, Mr. Schreurs pointed out (Nov. 28/66, Feb. 15/67, File No. 0239016) that some of the sampled intervals showed bimodal sorting, that is, two predominant size fractions, and even though a great deal of development work was done on the well, and the pack is probably quite large, the velocity would still be high enough to cause migration of the finer size fraction into the pack with pumping. However the large amount of filter pack (48 bags) accepted by the well during development suggested to Mr. Schreurs an additional factor may be responsible for the reduction in yield. - The removal of coarse aquifer materials to create a large void, then partial filling of this void by filter pack sand, and finally collapse of overlying silts onto the top of the filter pack.

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This would result in interrupting the flow of groundwater into the gravel pack and hence would reduce the well yield. We favour the former explanation as a contributing factor to the well behaviour, as the creation of a large void implied in the second explantion would mean removal of a large amount of aquifer material and this does not appear to have taken place during development. It is also not clear how a silt barrier from above would prevent lateral movement of water into the pack.

If the aquifer had been much thicker, it might have been possible to have constructed a much longer filter pack that would have lowered the entrance velocity at the outer edge of the pack sufficiently to prevent large scale migration of fine material into the pack. However the drop off in well yield with steady pumping and the remarkably rapid increase in well yield with relatively little bailing and surging could suggest that the chief water bearing formations may be restricted to a few thin beds within more impermeable materials. The sudden bailing and surgingmight cause a fairly rapid response at a few key horizons with a corresponding rapid increase in well yield. If this is the case then a long gravel pack would not necessarily be the answer. Methods of well construction will undoubtedly be developed in the future which will be able to handle these conditions effectively.

J Foweraker

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FIGURE I.
LOCATION MAP
Scale : 1:250,000

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DATE Jan 6th 1967

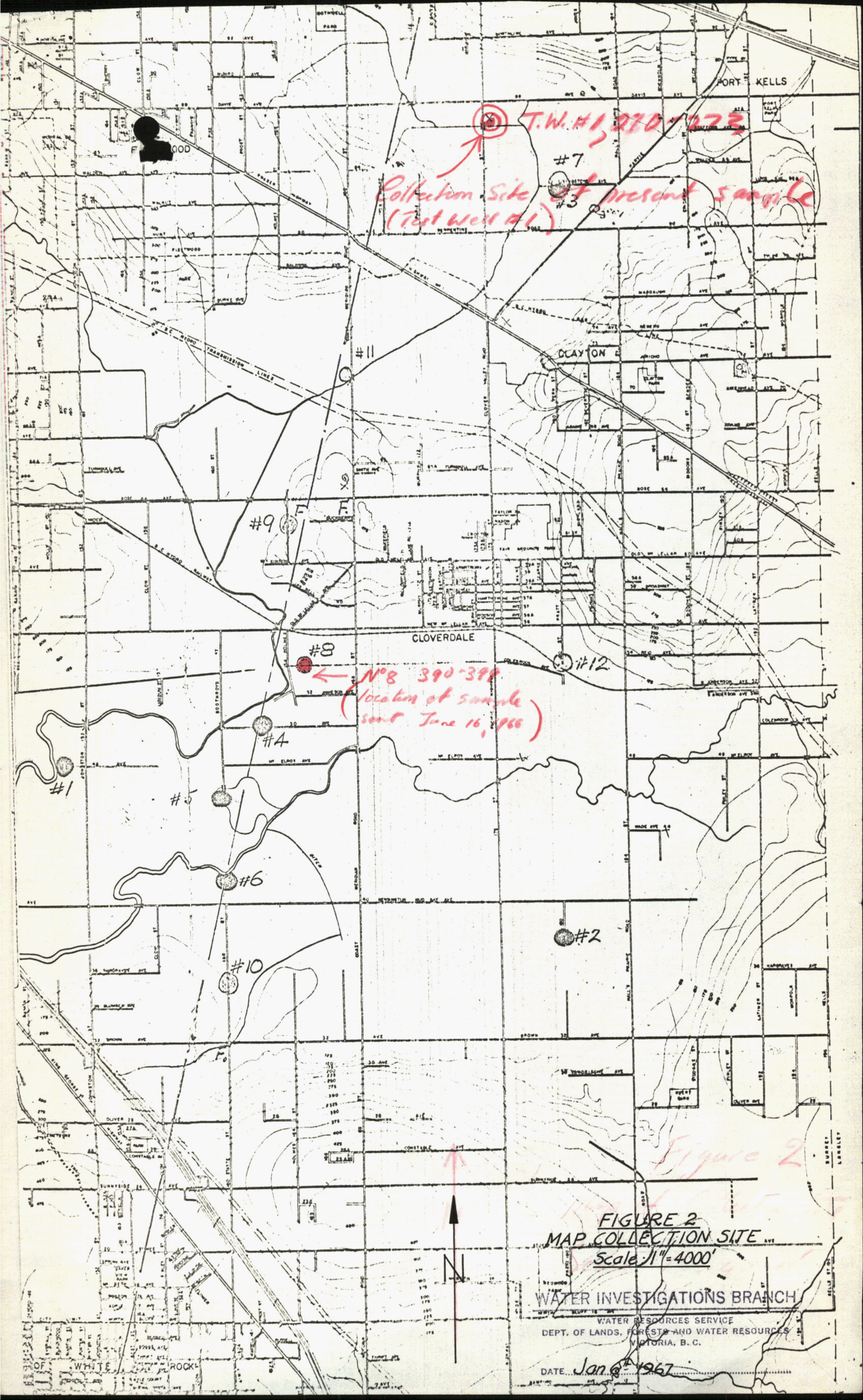

FIGURE 2
MAP COLLECTION SITE
Scale: 1" = 4000'

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