GROUNDWATER SURVEY OF THE PLYMOUTH AREA
PICTOU COUNTY NOVA SCOTIA

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PROVINCE OF NOVA SCOTIA
DEPARTMENT OF THE ENVIRONMENT
WATER PLANNING AND MANAGEMENT DIVISION
PRELIMINARY REPORT

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Halifax

October 1, 1976

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ACKNOWLEDGEMENTS

We would like to express thanks to the many homeowners in the area for their interest and co-operation in the sampling program. Without their assistance this study would not have been possible.

We would also like to thank Mr.E.D.Stewart of E.D.Stewart Well Drilling and Mr. Wayne Chisolm of G.W.Reid Well Drilling for their interest and assistance in locating some of the well log information.

We also appreciate the time and effort of Mr. D.Hirtle of the N.S.Department of the Environment for the draughting of the figures.

INTRODUCTION

Due to the number of complaints of poor water quality in the Plymouth Park area, a survey was carried out in June and July 1975 to determine the extent and cause of the problem, and possible solutions to the problem. Specifically, the complaints were of salt, iron, manganese and hydrogen sulfide.

FIELD WORK

In June 1975, well logs were located, and preliminary samples analyzed in the field for alkalinity, hardness and chloride. In July 1975, 38 samples were collected for complete chemical analysis. Surficial mapping was carried out, using exposures in road cuts, ditches, and stream banks.

Due to high fluoride and chloride values in some of the first 38 samples, the following work was carried out in September 1975: 1) 29 wells were resampled for fluoride, 2) 18 additional samples were taken for complete chemical analysis, and 3) 14 samples were taken for isotope analyses. The latter analyses, for tritium and deuterium, were run by Dr.R.M.Brown of Atomic Energy of Canada Ltd., Chalk River, Ontario.

The locations of the wells and chemical analyses are shown in figures 2 and 3. The well data and field chemical data is summarized in Appendix 1. Lab chemical analyses are summarized in Appendix 2.

In October and December 1975, 31 backhoe testpits and 2 drilled testholes were logged in the area (Figure 3 and Appendices 3 and 4).

LOCATION AND PHYSIOGRAPHY

The Plymouth area is located on the east side of the East River near Stellarton (Figure 1) and lies in the Carboniferous Lowlands region of Nova

Scotia. Land elevations in the study area range from sea level to 300 feet. The study area lies within the drainage basin of the East River.

CLIMATE

Based on 20 years of record, the average total precipitation is 40.70" annually, with 32.96" as rain and 77.40" as snow. The maximum precipitation was 55.32" (1964), the minimum was 26.69" (1965). Total runoff accounts for about 2/3 of the precipitation.

The mean annual daily temperature is 43.4°F, with a mean daily maximum of 52.3°F.

The average number of frost free days is 112, with a range of 89 to 135 days. The average length of the growing season is 135 days.

GEOLOGY

Bedrock (Figure 4)

The northern part of the study area is underlain by gray, red and mottled shale, sandstone and conglomerate, and minor coal of the Stellarton Series of Pennsylvanian age.

Exposures along the East River in the Plymouth area consist of alternating hard red sandstone, gray siltstone, and shale. The bedding strikes northwest-southeast and dips northeast at 13 to 25°. Major joint sets strike parallel to the bedding and dip northeast and southwest, generally at an angle greater than 50°. There is also a prominent set striking perpendicular to the bedding and dipping from 65 to 90°.

In the southern part of the area (near Ferrona Junction), there is hard red and gray sandstone of the Windsor Group of Mississippian age. The bedding strikes almost north-south and dips about 50° west. There is a faulted contact with limestone just south of this area.

The main structural elements in the area are the Plymouth and South Faults, and a northeast striking anticline axis. Two small faults parallel the Plymouth Fault.

Elevations of the bedrock surface from well log data (Figure 5) indicate a steep dropoff in a westerly direction towards the East River. In the Park, the bedrock elevation is about 25 feet below sea level.

The following description, from the southern to northern part of Figure 4, is summarized from Bell (1940) and Fletcher (1892).

Windsor material outcrops upstream of the South Fault, consisting of reddish, flinty, slaty or prismatic sandstones and argillites with veins of quartz and ankerite. A diorite dyke cuts across the Windsor in this section. This sequence is succeeded upstream by blue-grey limestone. One outcrop of Windsor material, just east of the Plymouth-Churchville Road, consists of jointed sandstone with quartz crystals coating the faces. Conglomerate occurs on Mac Gregors Mountain and in the Churchville area.

The South Fault, trending N75E, separates Windsor and Canso strata. The Stellarton Series are downthrown several thousand feet against the older rocks in the area east of the East River.

The Canso-Pictou strata contact on the East River north of McKay Brook is marked by a thin basal gray conglomerate of the Skinner Brook Member, which lies unconformably on brownish-red sandstone of the Canso Group. The basal conglomerate is overlain by brownish red sandstone, then gray, flaggy, rippled sandstone to 420' above the contact, then 15' of blackish grey and brown mudstone and grey argillaceous shale. This sequence, representing 4800 feet downstream from McKay Brook, strikes essentially parallel to the river and dips eastward. The rocks then swing into an anticline. The higher beds consist of brownish-red sandstone and siltstone and a thin red conglomerate. The rocks are then concealed for 1600 feet, in which the Plymouth Fault occurs (downthrown on the north side).This fault accounts for the loss of several thousand feet of strata belonging to Division 1 of the Stellarton Series. There is also a minor fault 500 feet south of this, trending S76E and with a downthrow on the northern side.

Between the pumping station and Plymouth Bridge, 520 feet of the Plymouth Member is exposed - a brownish red siltstone and fine argillaceous sandstone, some gray mottled. In the coarser beds, green slate or argillite from Ordovician rocks is present. The lower part of this section to the bridge contains a few bands of blackish-gray slickensided mudstone. A small fault at the bridge strikes S65E, with a downthrow on the north side. North of the fault are exposed brownish red and mottled red and gray siltstone overlain by gray argillaceous siltstone and a thin calcareous bed.

Surficial (Figure 6)

The surficial deposits consist mainly of sandy and clayey glacial tills, and sands and gravels. The visible thicknesses in the field are indicated in Figure 6. The thicknesses from well logs are shown in Figure 7. Generally, the till thicknesses exceed 10 feet, and reach almost 100 feet in several places. Dept. of Highways boreholes (Appendix 5) and observations of outcrops in the East

River (Figure 6) indicate that the stratified sands and gravels along the river are generally less than 10 feet thick.

Thirty-one backhoe testpits were dug to determine the type and thickness of surficial materials. The locations of these holes are shown on Figure 3, and summaries of the logs in Appendix 4.

Glacial History

Work in the Northumberland Strait by Kranck (1972) has shown that pre-glacial drainage off the East River trends northeast along Cape George. After deglaciation, sea level was lowered by 300 feet. The Strait was inundated at about 11,800 B.P. Off the East River, there are two terrances, at 45-55 meters to the northeast, and 18-23 meters to the north. The terraces were formed during the last postglacial transgression of the sea. The shallowest (youngest) terrace has been dated at 5000-5500 years B.P. The present average rise in sea level in this area is more than 25 centimeters/100 years. Hence in the East River area, sea level has risen gradually from the Pleistocene to the present and there should be no residual saline groundwater due to higher sea levels from this time period.

GROUNDWATER FLOW

The water table elevation in the Park (Figure 8) indicates a northwesterly flow of groundwater in the surficial material towards the East River. The regional contours (Figure 9) also indicate a general northwesterly flow in the bedrock, following the bedrock and surface topography. The main recharge area is MacGragor Mountain, the main discharge area the East River. A local recharge area (piezometric elevation 55') occurs just east of the Park, with a discharge area to the southeast and northwest. A local discharge area also occurs along the old River Road.

The water levels in dug wells are generally higher than those in adjacent drilled wells where information is available, indicating a vertical component of flow from the surficial materials to the bedrock.

Evidence of groundwater discharge is also provided in the many seepages (Figure 6). Some of these, especially those in the Ferrona Junction area, were flowing at 1/2 to 1 gpm. The seepages marked on Figure 6 were present after about 1 1/2 months of no rain and hence should represent perennial discharge. Unfortunately the iron concentrations were high enough to cause a bright orange precipitate of iron oxide or hydroxide and hence these springs would not be suitable for a domestic water supply.

Wells with high yields, i.e. greater than 5 gpm, appear to be related to faults and to Windsor Group materials (Figure 4). Several wells in Windsor conglomerate yield 10-40 gpm.

Water level fluctuations in the two N.S.D.O.E. test holes were monitored monthly from January to July 1976 (Figure 20). If it is assumed that the two wells are analagous to piezometers, then the results suggest that the interval area of the river is a groundwater discharge area during most of the year when water levels are relatively high, but converts to a recharge area during the groundwater recession in summer. Further monitoring is required to substantiate this.

GROUNDWATER QUALITY

The field results and complete chemical analyses (Appendices 1 and 2) indicate a fairly serious problem in the area, with respect to chloride, iron, manganese and fluoride (Table 1).

TABLE 1

Field data:

Cl > 50mg/l	37/118	31.4%
Cl > 250mg/l	12/118	10.2%
Reported sulphide odor	5/118	4.2%
Hardness > 120 mg/l	40/118	34.0%

Complete Analyses:	DUG WELLS		DRILLED WELLS		TOTAL	
	No.	%	No.	%	No.	%
Cl > 250 mg/l	3/17	17.6	11/40	27.5	14/57	24.6
Fe > 0.3 mg/l	5/17	29.4	13/40	32.5	18/57	31.6
Mn > 0.05 mg/l	11/17	64.7	25/40	62.5	36/57	63.2
F > 1.2 mg/l	0	0	16/40	40.0	16/57	28.1

Salt

The values of chloride are shown in Figures 12 and 13. There is essentially no relationship between Cl and well depth (Figure 10); however, it is noteworthy that all drilled wells (except the two circled) with greater than 100 mg/l Cl are from the localized area of the Park. The well waters have also undergone a considerable amount of ion exchange and natural water softening, as indicated by Figure 11. A trilinear plot (Figure 18) indicates that most drilled well waters in the study area are of the Na-HCO_3 or Na-Cl type. Most drilled wells in the Park area contain Na-Cl type waters.

The natural softening of water usually occurs in shales and other sediments originally laid down under marine conditions or affected by marine incursion after deposition. At this time, a large number of Na ions are adsorbed on ion exchange sites. When fresh water recharge occurs, generally with Ca-rich waters, the Ca is preferentially adsorbed and the Na is released, resulting in high Na/Cl and Na/Ca ratios. The drilled wells outside the park show this relationship (Figure 11). The drilled wells in the Park show high Na/Ca ratios, but low Na/Cl ratios due to the Na and Cl, respectively, contributed from salt (NaCl). Some possible reasons for this are: 1) regional groundwater discharge; 2) the bedrock surface here forms a depression and may contain residual or incompletely flushed saline brines; 3) the Plymouth Fault to the south and the small fault to the north of the Park may have acted as barriers to groundwater flow and caused entrapment of meteoric waters in a stagnant condition; 4) incomplete flushing of original saline pore water. The latter is unlikely in view of the isotope results to be discussed later. The most reasonable explanation is slow flushing due to the large number of shale beds, some of which are reported as sticky and clay-like; such beds may act as barriers and also as membranes.

One well high in sulphate (index no. 65) is likely affected by gypsum of the Windsor Group.

Most dug wells are of the $Ca-HCO_3$ or Ca-Cl type. High values of chloride in these wells appear to be related to road salt.

Fluoride

Fluoride values were found to exceed the suggested limit of 1.2 mg/l in sixteen wells.

Origin

The main possible sources of Fluoride are: 1) from sea water during the original deposition of a marine bed which has not been completely flushed out, 2) volcanic emanations, 3) weathering or solution of fluoride-bearing minerals such as fluorite, apatite, tourmaline, topaz, vesuvianite, lepidolite, phlogopite, and glauconite (LaMoreaux, 1948).

Fluoride levels up to 3.4 mg/l have been found in Alabama (LaMoreaux, 1948 and Carlston, 1942) to have the following relationships: 1) fluoride more than 1 mg/l found exclusively in deep wells, 2) high fluoride is found in soft groundwaters (less than 60 mg/l total hardness) high in HCO_3. A direct correlation exists between fluoride and HCO_3, 3) high fluoride is correlated with phosphatic material, pyrite, lignite and abundant glauconite. Pyrite in association with organic material could be expected to decompose and produce H_2SO_4, which in turn could attack the more insoluble fluoride-bearing minerals (LaMoreaux, 1948). Glauconite alone was not found to produce high fluoride levels, but was the chief base exchange agent causing natural water softening; 4) high fluoride was found in deeper wells in discharge areas, hence the fluoride concentration may be related to depth of formation and distance to outcrop, and hence to the extent of groundwater circulation and length of contact time.

In Florida, Toler (1967) found apatite group minerals in phosphatic sediments to produce groundwaters high in fluoride.

Handa (1975) found that well waters high in fluoride were: 1) associated with low Ca, which he attributed to the low solubility of fluorite, 2) associated with high HCO_3 and sometimes NO_3, 3) often saturated with respect to calcite and fluorite.

In the Plymouth study area, high fluoride values were found to be associated with: 1) deeper wells (Figure 14), 2) high chloride (Figure 15), 3) high HCO_3 (Figure 16) and soft waters, 4) often higher values of NO_3 and PO_4 than wells with lower fluoride values (Appendix 2), and 5) a groundwater discharge area, possibly regional. Three wells were found to be saturated with respect to fluorite (Figure 17), and most were also found to be saturated with calcite and fluorapatite (as computed by program WATEQF). This supports a primary mineral source for the fluoride. Also, the strong positive correlation between fluoride and hydroxyl concentrations and pH indicates that fluoride is not simply exchanging for hydroxyl on clay mineral sites.

Most dug wells in the study area contained less than 0.5 mg/l fluoride, as found by Handa (1975), due either to absence of fluoride-bearing minerals in the overburden or rapid groundwater circulation.

The fluoride source in the Plymouth area could possibly be correlated with pyrite and lignite, since coal seams and coal shale are common. Unfortunately no cores were available to check for phosphatic or tuffaceous layers in the bedrock. The latter occurrence is a possibility, since high fluoride values in the Moncton area are thought to be associated with a volcanic ash unit in the Pictou Group which has been identified in a few deep wells (Dyck et al, 1976). The natural water softening could be a result of natural base exchange, as explained earlier, or a shale membrane mechanism. The latter works on a reverse osmosis principle, whereby shales or clay layers act as sieves or membranes, with a driving force provided by hydrodynamic or permeability gradients. According to White (1965) and vanEverdingen (1968), the low pressure side of the membrane generally has a higher Na/Ca ratio, higher fluoride, pH > 7, and low Cl as compared to the high pressure or input side. This hypothesis fits the chemistry of the high fluoride waters in the study area with the exception of the high Cl values (Figure 15), which may be the result of such factors as stagnation in bedrock depressions, proximity to Windsor bedrock and proximity to fault zones. As shown by Figure 19, the driving force could be a combination of regional hydroynamic pressure and permeability gradients produced by alternating shales and sandstone. Figure 19 also suggests the presence of an old channel deposit of the East River in the vicinity of well 45 - this may contain materials of high permeability and hence create a low fluid pressure area.

To ensure that entrapped sea water from pre-Pleistocene times or recent salt water intrusion was not causing the salt, Dr. R.M.Brown kindly carried out tritium and deuterium analyses on selected samples. The results (Appendix 7) indicate that all wells deeper than 75 feet contain water more than 20 years old. This supports the idea of stagnant groundwater associated with a regional flow system, or incomplete flushing of saline water associated with nearby Windsor rocks or faults. The possibility of a bedrock knoll (Figure 19) as suggested from water well logs could account for the stagnation and membrane filtration effects; however, depth to bedrock from the well log data is not conclusive because of the soft shales present, which make it difficult in some cases to ascertain the bedrock-overburden contact.

Health Implications

Fluoride values in municipal water supplies in Nova Scotia are maintained at about 1.2 mg/l, the amount theoretically required for strong teeth in children. Excessive amounts of fluoride may cause mottling of tooth enamel and may have toxic effects on the bone structure of the body. The use of such water generally affects children less than 8 years old whose permanent teeth have not yet formed. The mottling is a permanent effect.

As a followup to our sampling, N.S. Dept. of Public Health resampled wells with more than 1.2 mg/l fluoride. The values agreed with the previous sampling to within 0.2 mg/l. A dental survey was then carried out, but fortunately no serious fluorosis problems were found as a result of fluoride in the well water (Appendix 8).

Economic Implications

Dyck et al (1976) found that a band of high values of fluoride, uranium, helium, radon, alkalinity and conductivity exists along the Northumberland Strait from the New Glasgow area, N.S. to Cape Tormentine, N.B. in the Pictou Group bedrock. They suggest that this may be analagous to a "roll front", of the type that has produced economic uranium ore deposits in the United States. Circulating groundwaters are presently leaching the deposits. A uranium anomaly has been found in the Plymouth area (G.S.C. Open File 340), possibly due to stagnation of groundwater in this area.

TESTHOLE RESULTS

Surficial

Backhoe testpits were dug to determine the type of surficial materials, and if there were any sand and gravel deposits suitable for a screened well or infiltration gallery along the East River. Appendix 4 summarizes the logs.

The pits indicated a fairly consistent pattern from top to bottom of silt or till, stratified sand, gravel and boulders, and clay or bedrock. The top sands and silts in many cases represent recent alluvium deposited on the flood plain of the East River. The stratified materials are generally only 2 to 5 feet thick except at P12, which is at a higher elevation. The sands and gravels on the interval area are likely a central bar deposit, built up due to change in river slope just upstream and to rising sea level. Above the 20 foot contour, the slope is about 15°, but increases to 20° between 20 and 10 feet due to bedrock control. From 10 to 5 feet, the slope decreases to 12°, resulting in a critical slope on the border between meandering and braiding. The meander length-channel width relationship indicates a disequilibrium, with increase in channel width or decrease in meander length being desirable. The small gravel terrace in the vicinity of P12 is likely an outwash remnant.

The lower clay layer is of two types: 1) a hard compact clay containing angular gravel and a few rounded pebbles, and 2) a soft plastic clay with minor thin laminae of silt and fine sand, and containing minor organic material. The former is likely a glacial till, while the latter likely represents a quiet depositional environment that might exist in an old cutoff channel or swale on the flood plain.

The sand and gravel in several of the pits contained appreciable quantities of groundwater; however, this only occurred just near the gravel-clay contact and represents perched water. The saturated thickness was less than 1 foot, and the sand and gravel would likely not be saturated on a perennial basis.

Bedrock

Logs of the two N.S.D.O.E. and the N.S.D.M. holes on the interval are contained in Appendix 3. The location of the N.S.D.M. hole is not certain but it is thought to be from 200-400 feet north of INT-1-75. The depths to bedrock in the three holes are 70, 39 and 24 feet. The sand and gravel may be saturated in the lower 5 feet for most of the year, however the groundwater is perched on clay and gravelly clay, hence there is no apparent extensive buried channel network. The yields of the two N.S.D.O.E. holes were 5-8 gpm and 1-2 gpm from the section of the hole below 20 feet. The quality of this water is poor (Appendix 2), with high values of salt, iron and manganese. It is possible that a shallow drilled well screened from 15-25 feet could supply more than one home; however, the yield would likely not be sufficient to serve the needs of the Park area.

CONCLUSIONS

The results of the study indicate a fairly serious problem of water quality in drilled wells in the Park area and the area east of the Park to the Churchville Road. Many dug wells in the Park either have problems of surface water contamination, as indicated by salt, or experience water shortages in summer.

The main problems of salt and fluoride in the drilled wells are likely due to slow flushing or stagnation of meteoric water. The iron, manganese, and hydrogen sulphide problems are likely related to coal and other organic matter in the subsurface.

Test hole results indicate that the sands and gravels in the area are generally too thin or the saturated thickness insufficient to provide an alternate water supply for the area. The groundwater is perched somewhat by the underlying clay, and hence drains rapidly, i.e. storage is small. The potential for high capacity bedrock wells could exist southeast of the Park area in association with faults and Windsor conglomerate. The water quality from these wells is generally good also, although slightly excessive iron and manganese values may occur.

RECOMMENDATIONS

We would recommend that an alternate water supply be obtained for the area of the Park and east of it to the Churchville Road. About 50-60 homes are involved. We would suggest the following options:

1) serve the area from either the New Glasgow or Stellarton systems

2) consider a well field in the bedrock in the MacGregor Mountain area. This

option would involve a test drilling and pump testing program. If groundwater of sufficient quantity and acceptable quality were obtained, then a pipeline of at least a mile would be involved.

In both cases, water and sewer lines would have to be installed.

From an academic viewpoint, there are interesting projects which could stem from this work, such as:

1) a detailed analysis of some of the well waters in the Park area for uranium. The Geological Survey of Canada sampling for uranium suggests an anomaly in the Plymouth area.

2) diamond drilling to obtain cores for petrologic study, to determine the overall mineral composition, and the minerals providing the fluoride source and base exchange mechanism.

3) coring might help to establish if any fault zones are present at depth through which mineralized groundwaters from the Windsor Group could enter the Pictou Group rocks in the area.

4) installation of piezometer nests to determine accurately the regional groundwater flow pattern.

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FIGURES

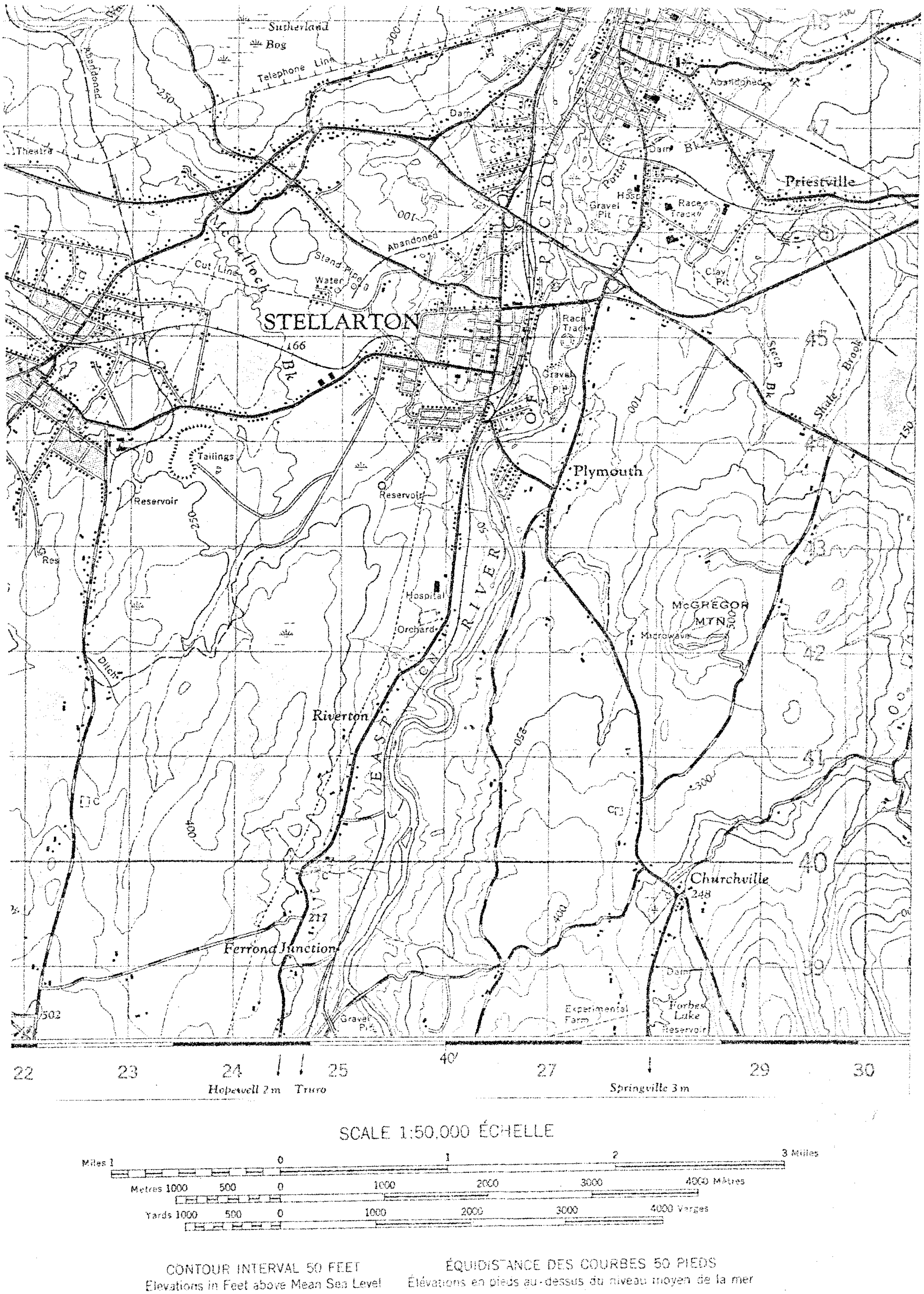


Figure 1. Location map.

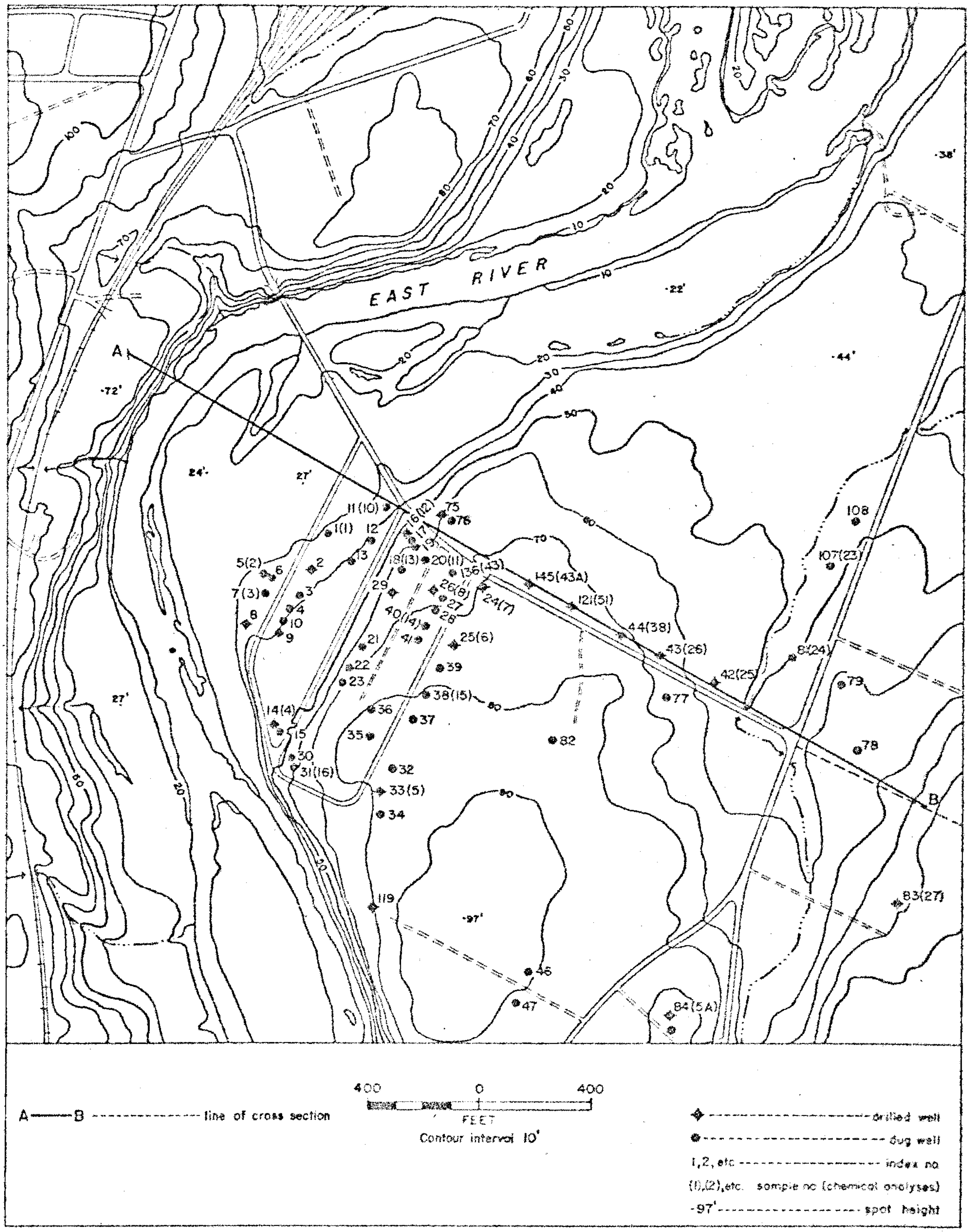


Figure 2. Sample locations, Park area.

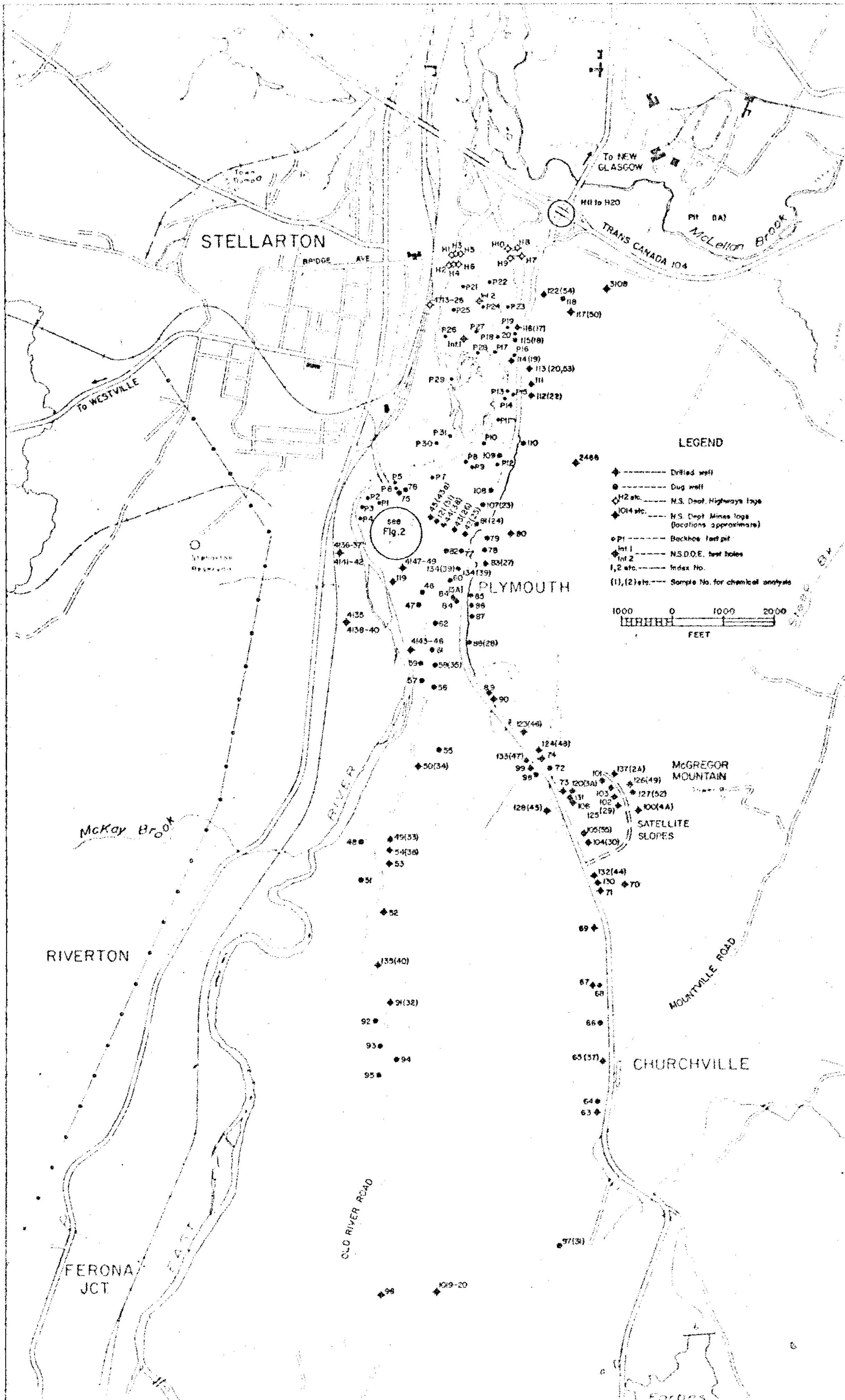


Figure 3. Sample locations, general area.

TABLE OF FORMATIONS TO ACCOMPANY FIGURE 4

CARBONIFEROUS

PENNSYLVANIAN

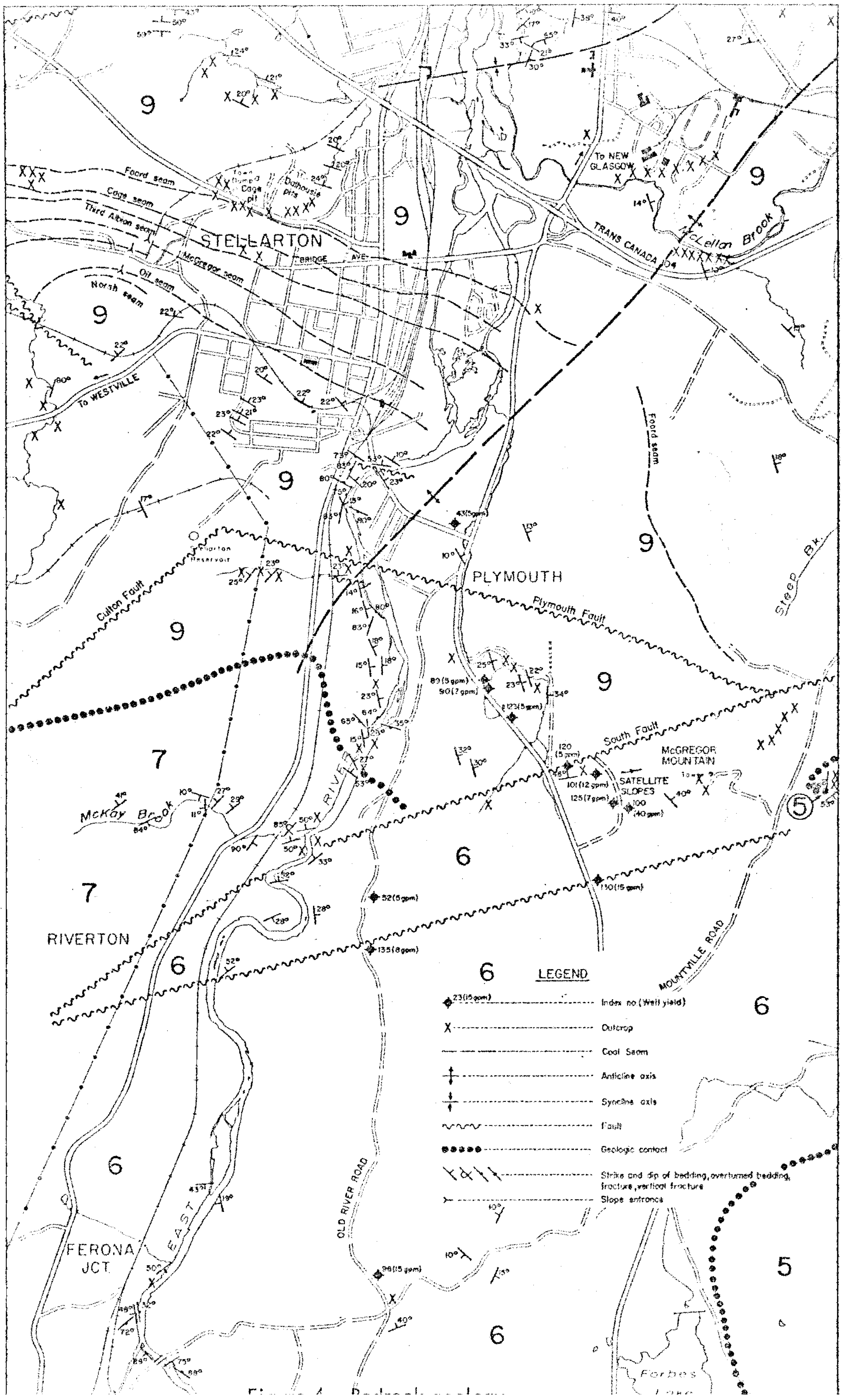
9	STELLARTON SERIES Grey, red and mottled shale and sandstone, conglomerate, coal seams
8	CUMBERLAND SERIES Brownish-red sandstone and shale, grey sandstone, red and grey conglomerate, 8a, New Glasgow Formation: conglomerate
7	CANSO SERIES Brownish-red sandstone and shale, grey sandstone and shale, limestone conglomerate

MISSISSIPPIAN

6	WINDSOR SERIES Red shale, sandstone, conglomerate, limestone, gypsum; 6a, basic lava

SILURIAN

5	ARISAIG SERIES Grey shale and sandstone, calcareous shale and sandstone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PLYMOUTH
RIVERTON
FERONA JCT.
To NEW GLASGOW
To WESTVILLE
TRANS CANADA 104
BRIDGE AVE
McLellan Brook
Foord seam
Cage seam
Third Albion seam
McGregor seam
Oil seam
North seam
Dalhousie pits
Culton Fault
Plymouth Fault
South Fault
McGREGOR MOUNTAIN
SATELLITE SLOPES
McKay Brook
EAST RIVER
OLD RIVER ROAD
MOUNTVILLE ROAD
Steep Bk.
Forbes
LEGEND
Index no.(Well yield)
Outcrop
Coal Seam
Anticline axis
Syncline axis
Fault
Geologic contact
Strike and dip of bedding, overturned bedding, fracture, vertical fracture
Slope entrance

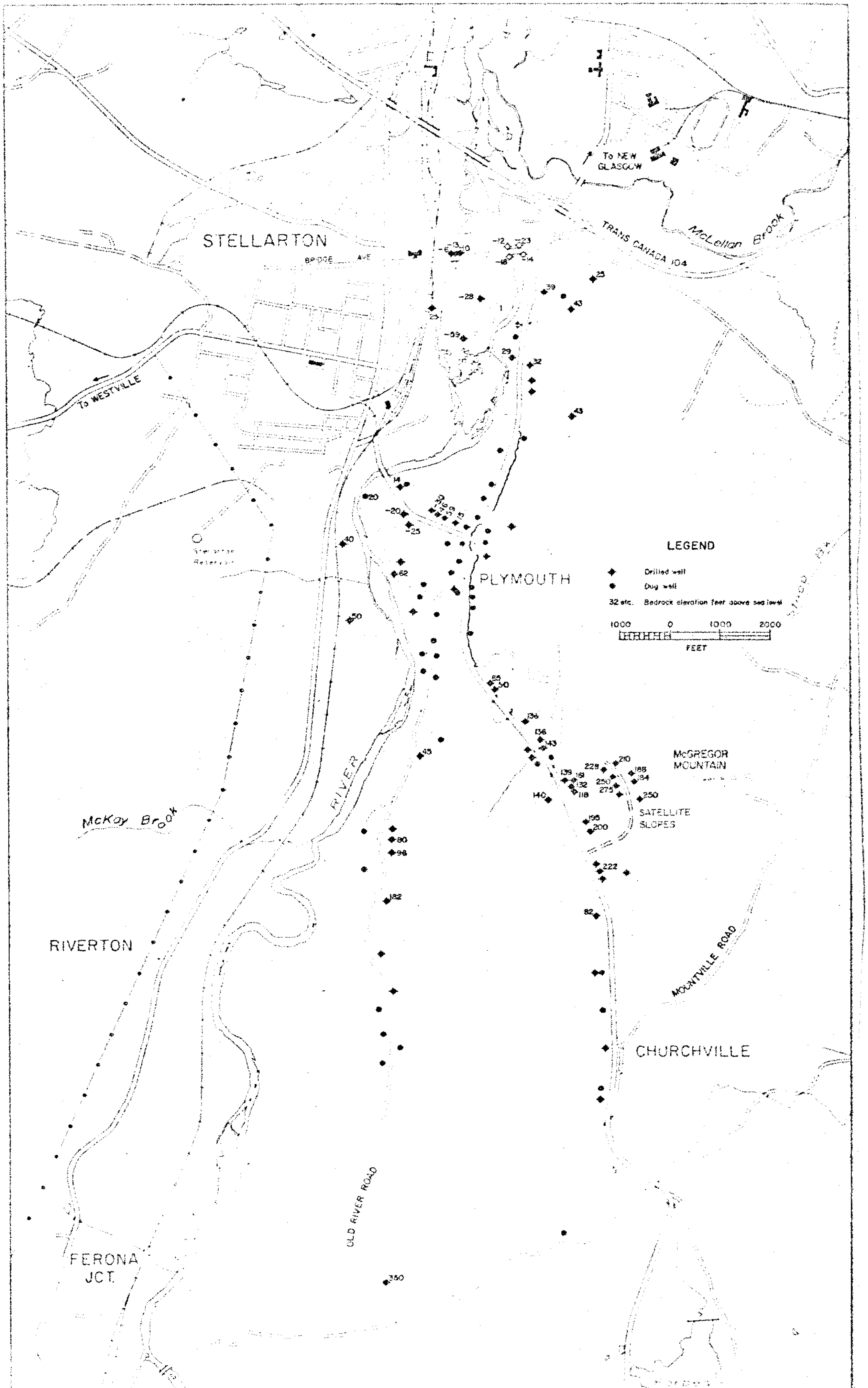


Figure 5. Bedrock surface elevations.

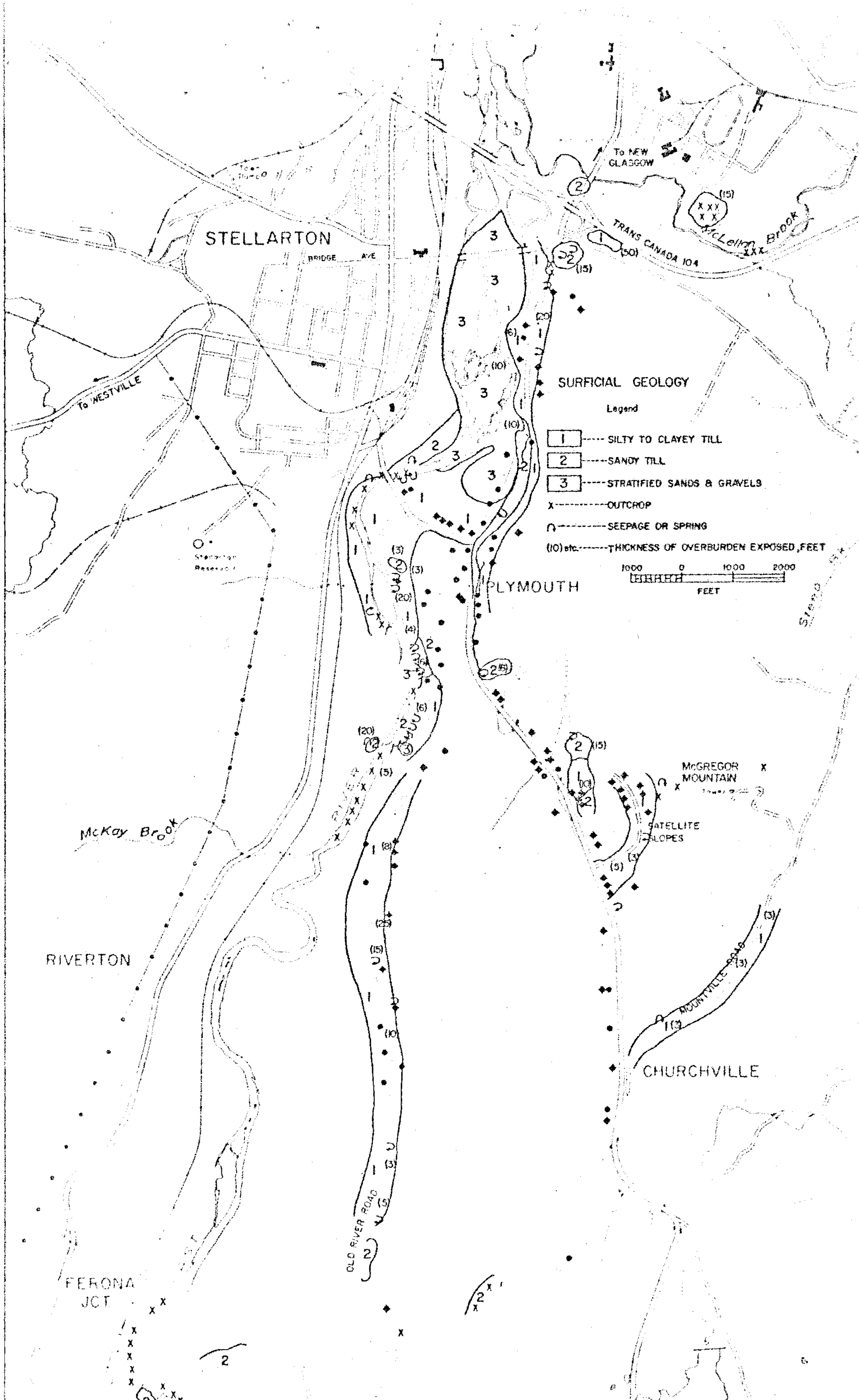


Figure 6. Surficial geology

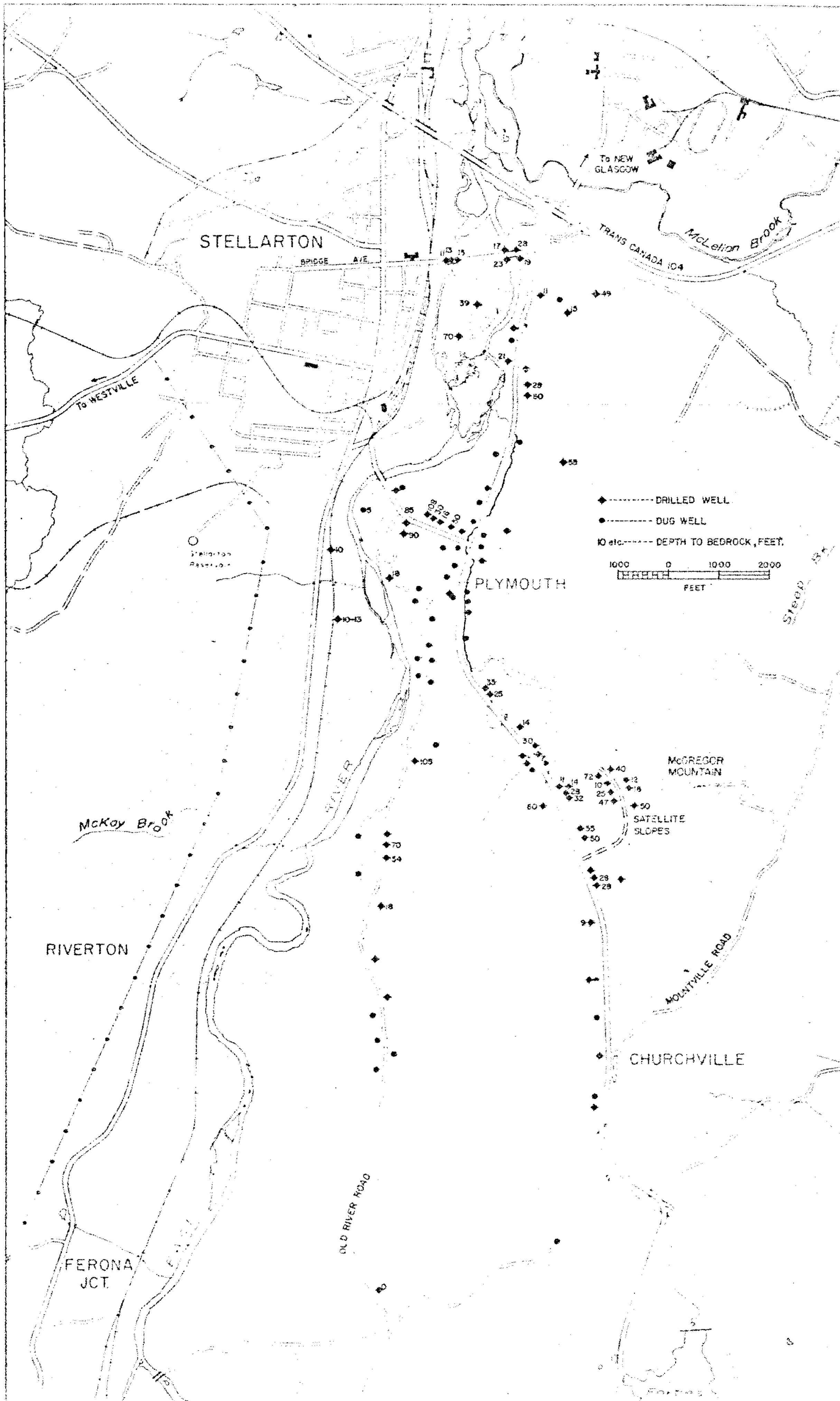


Figure 7. Depth to bedrock

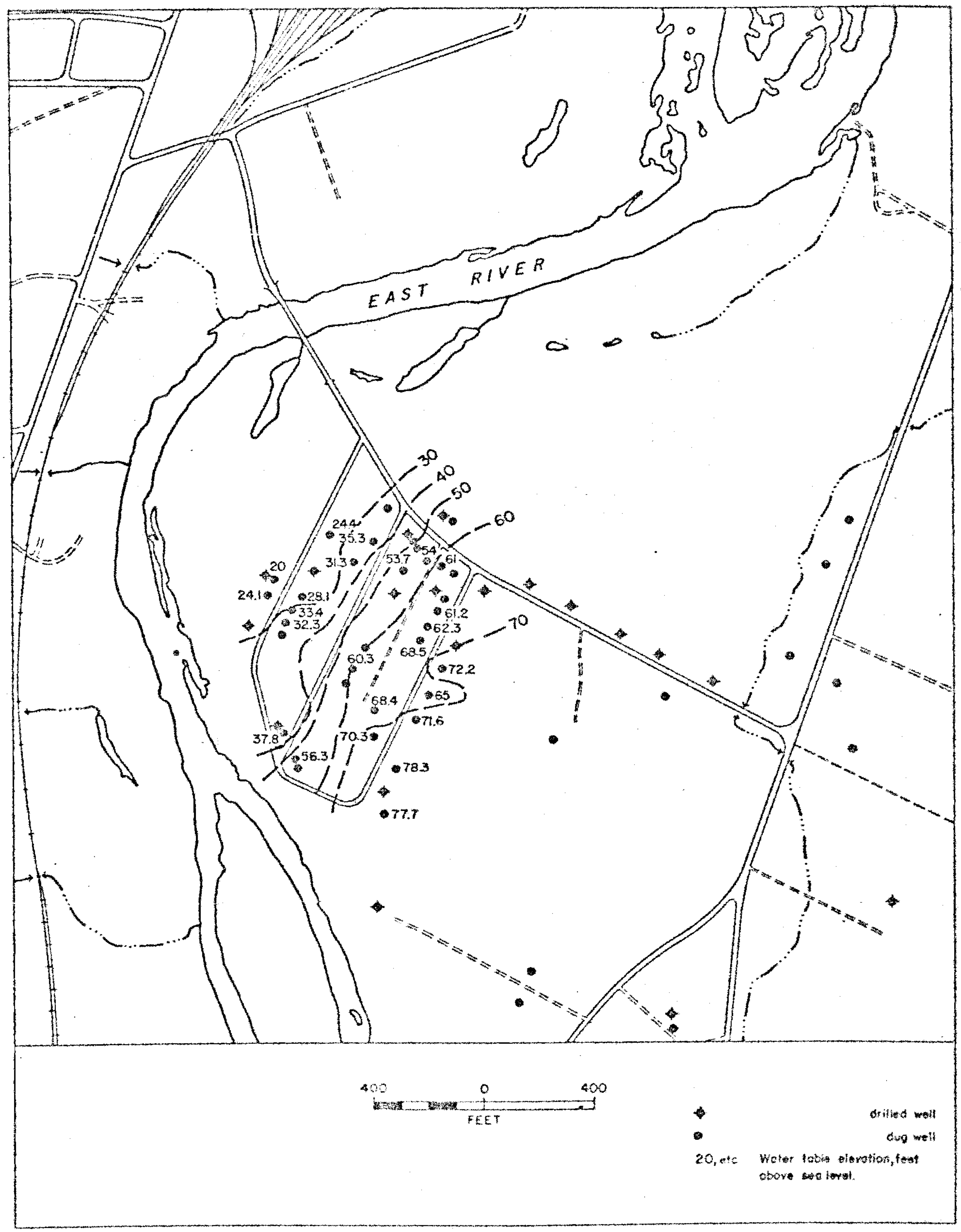


Figure 8. Water table elevations, Park area.

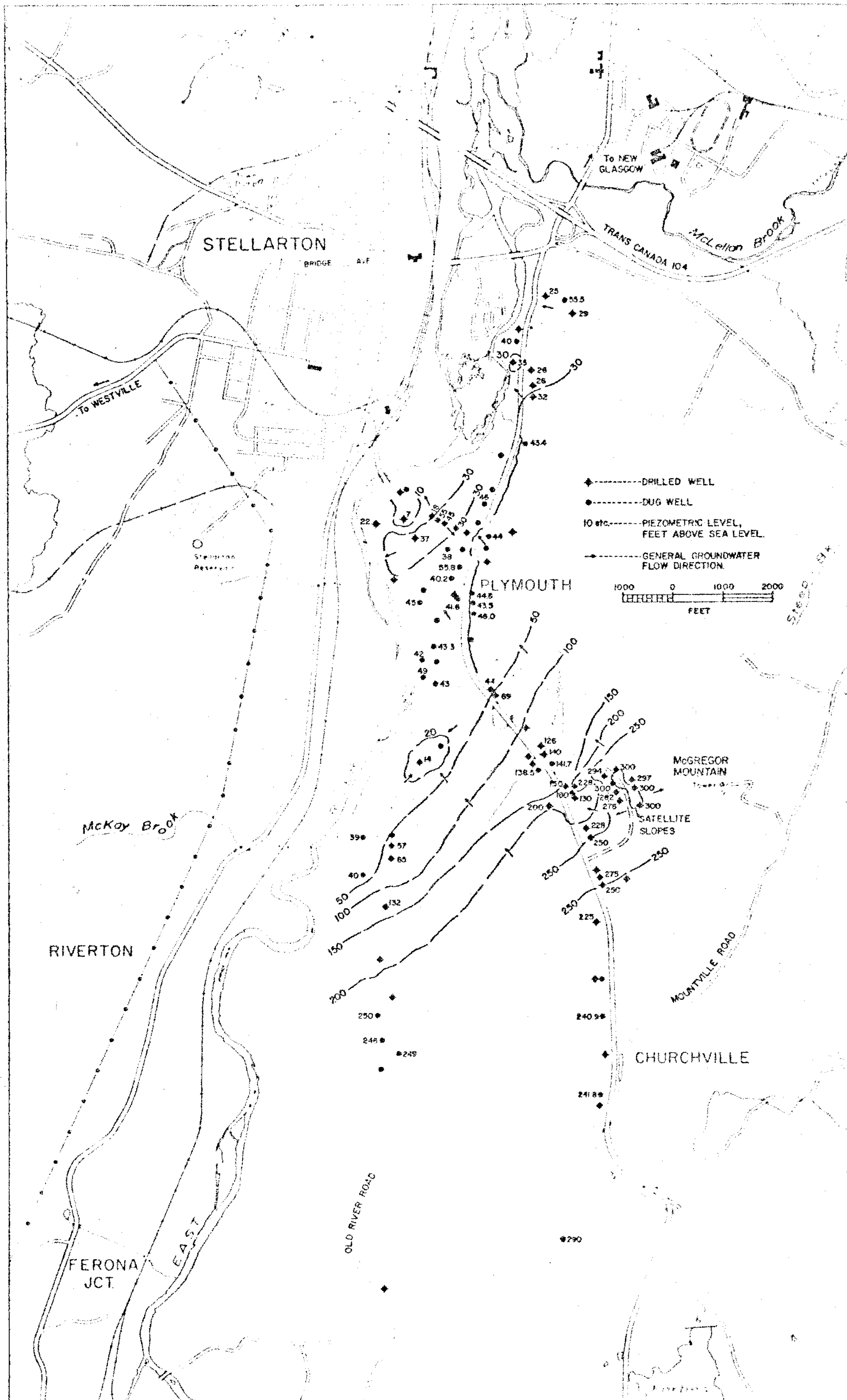


Figure 9. Piezometric levels - general area

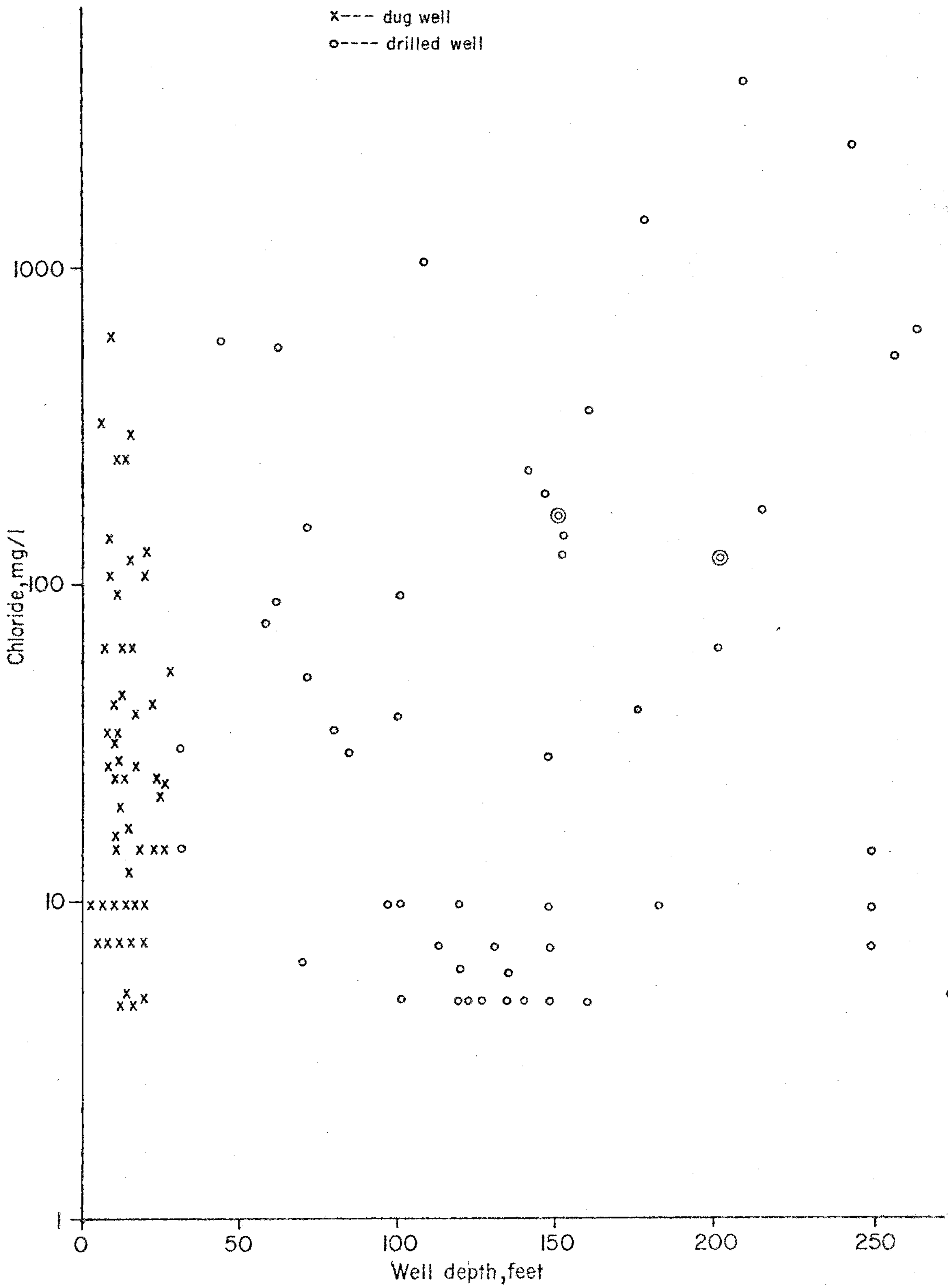


Figure 10. Chloride as related to well depth.

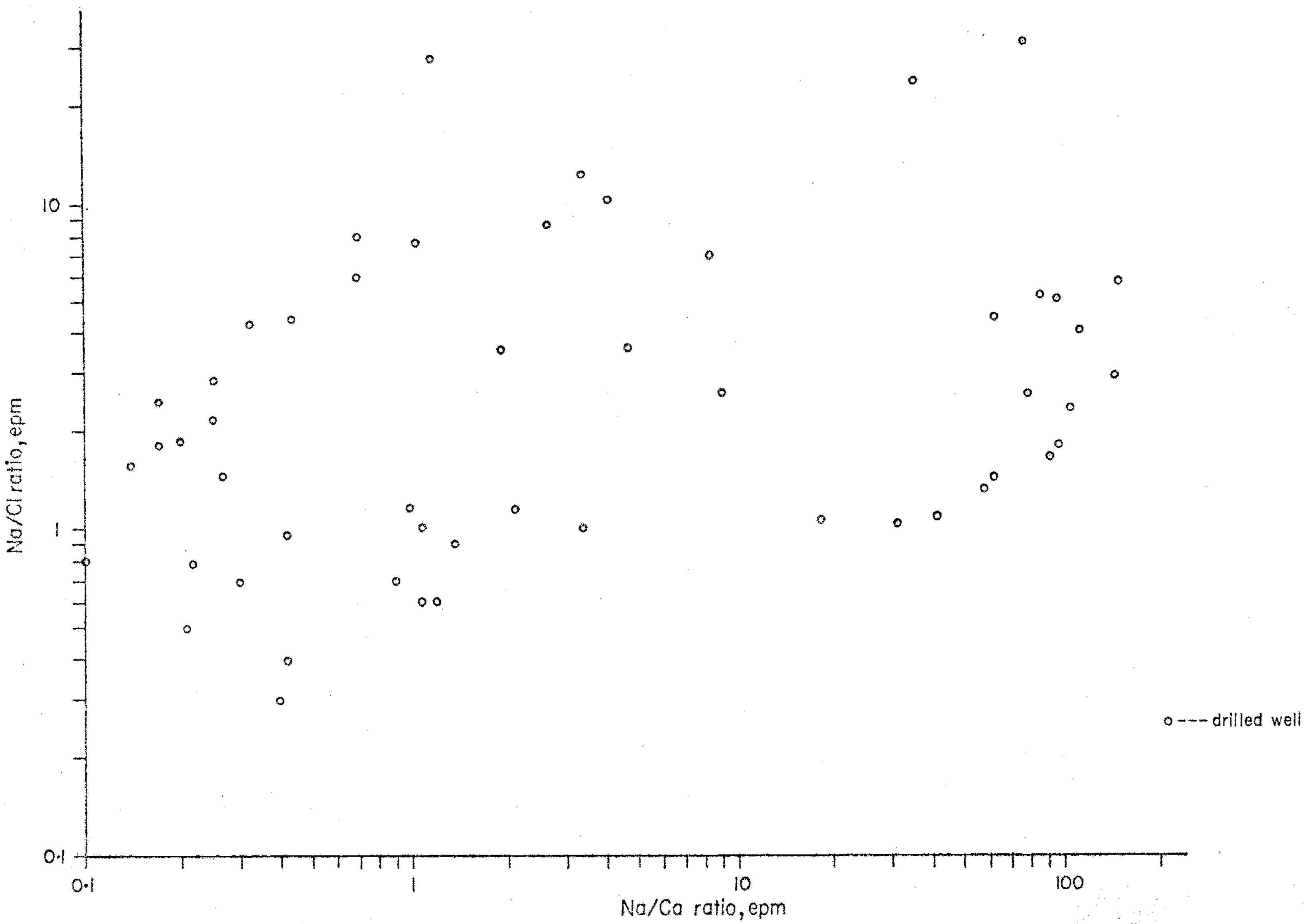


Figure 11. Na/Cl ratio as related to Na/Ca ratio.

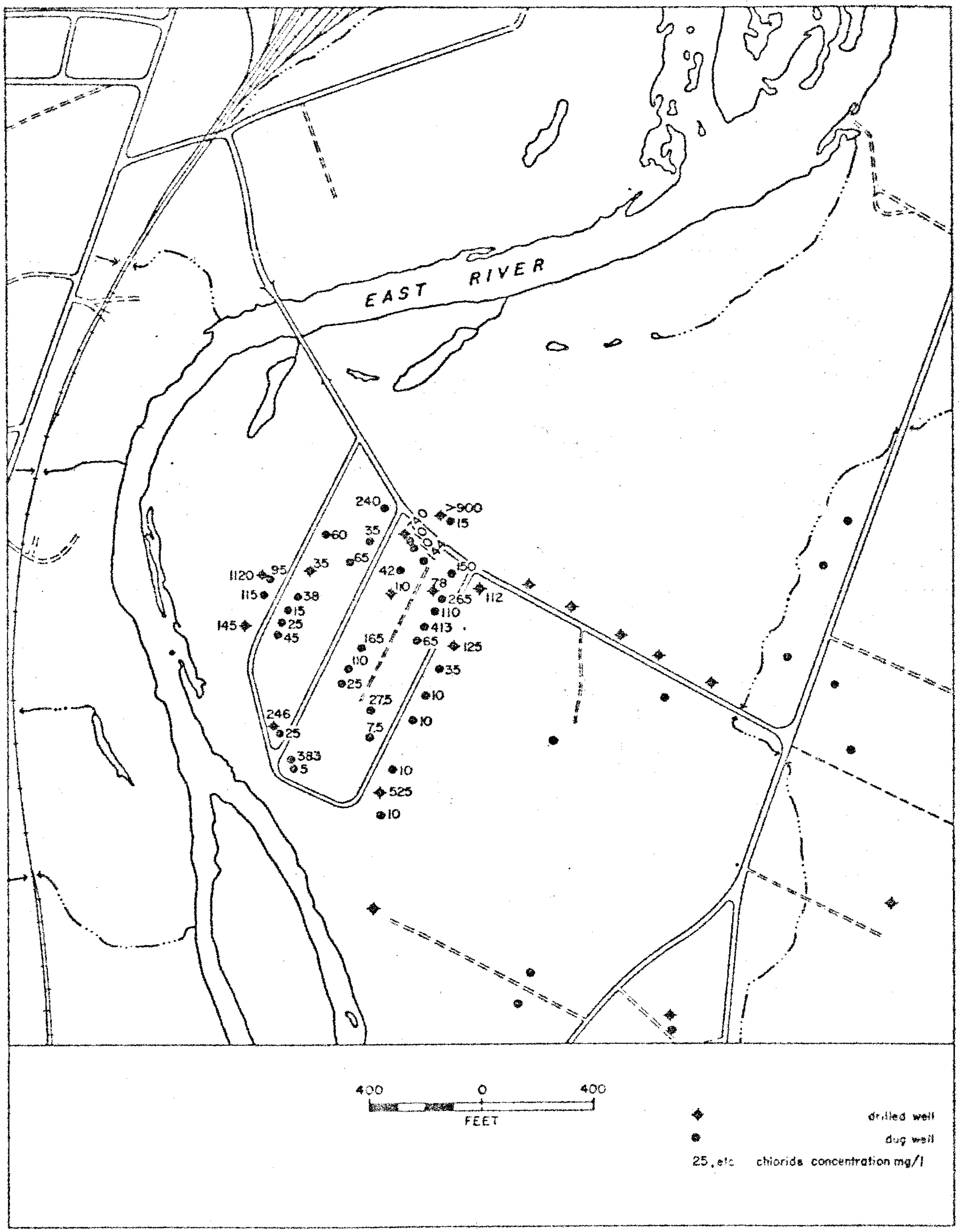
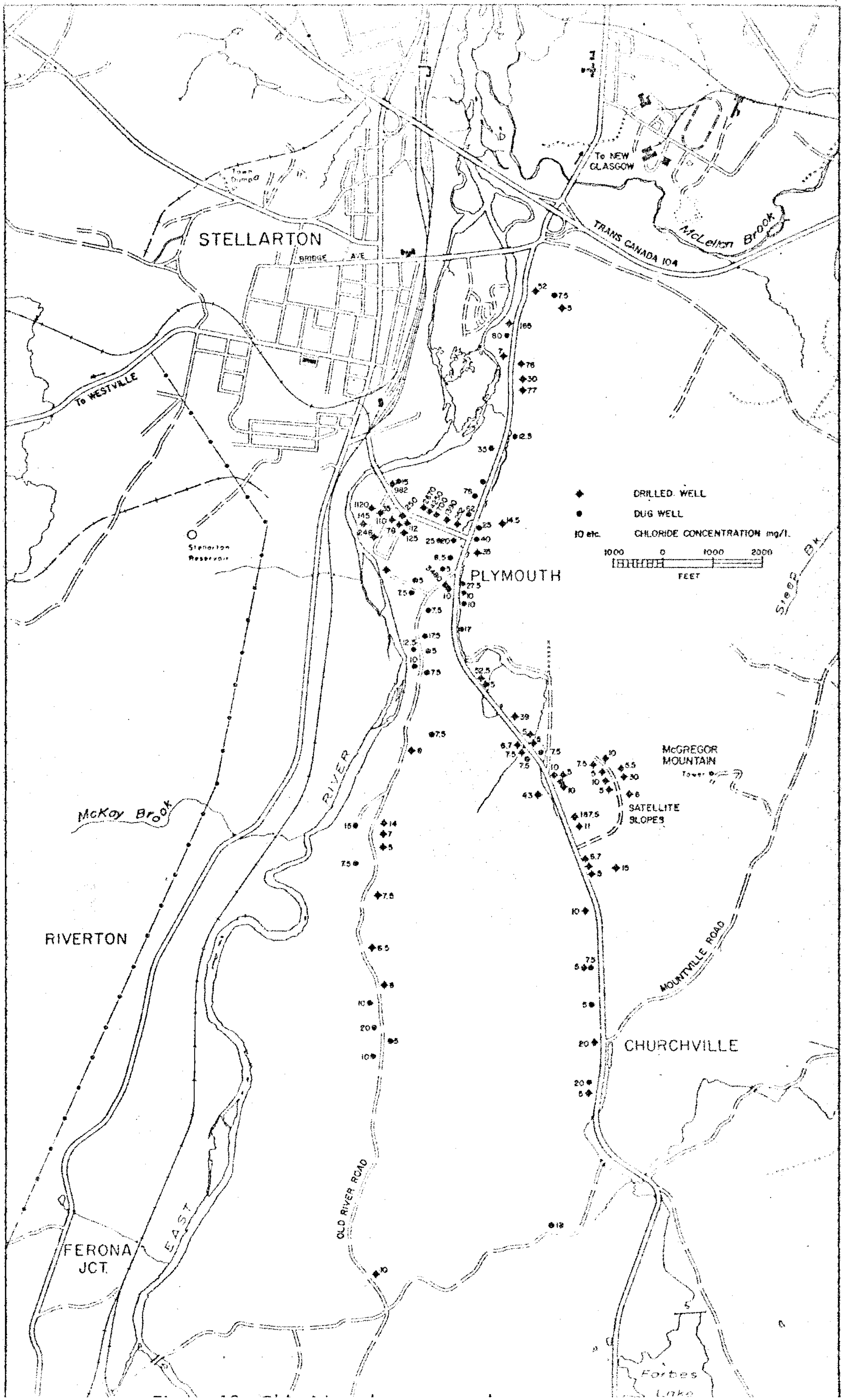


Figure 12. Chloride values, Park area.



STELLARTON
BRIDGE AVE
To WESTVILLE
Stellarton Reservoir
To NEW GLASGOW
TRANS CANADA 104
McLellan Brook
PLYMOUTH
DRILLED WELL
DUG WELL
10 etc. CHLORIDE CONCENTRATION mg/l.
1000 0 1000 2000
FEET
McGREGOR MOUNTAIN
SATELLITE SLOPES
McKay Brook
RIVER
RIVERTON
MOUNTVILLE ROAD
CHURCHVILLE
OLD RIVER ROAD
EAST
FERONA JCT.
Forbes Lake

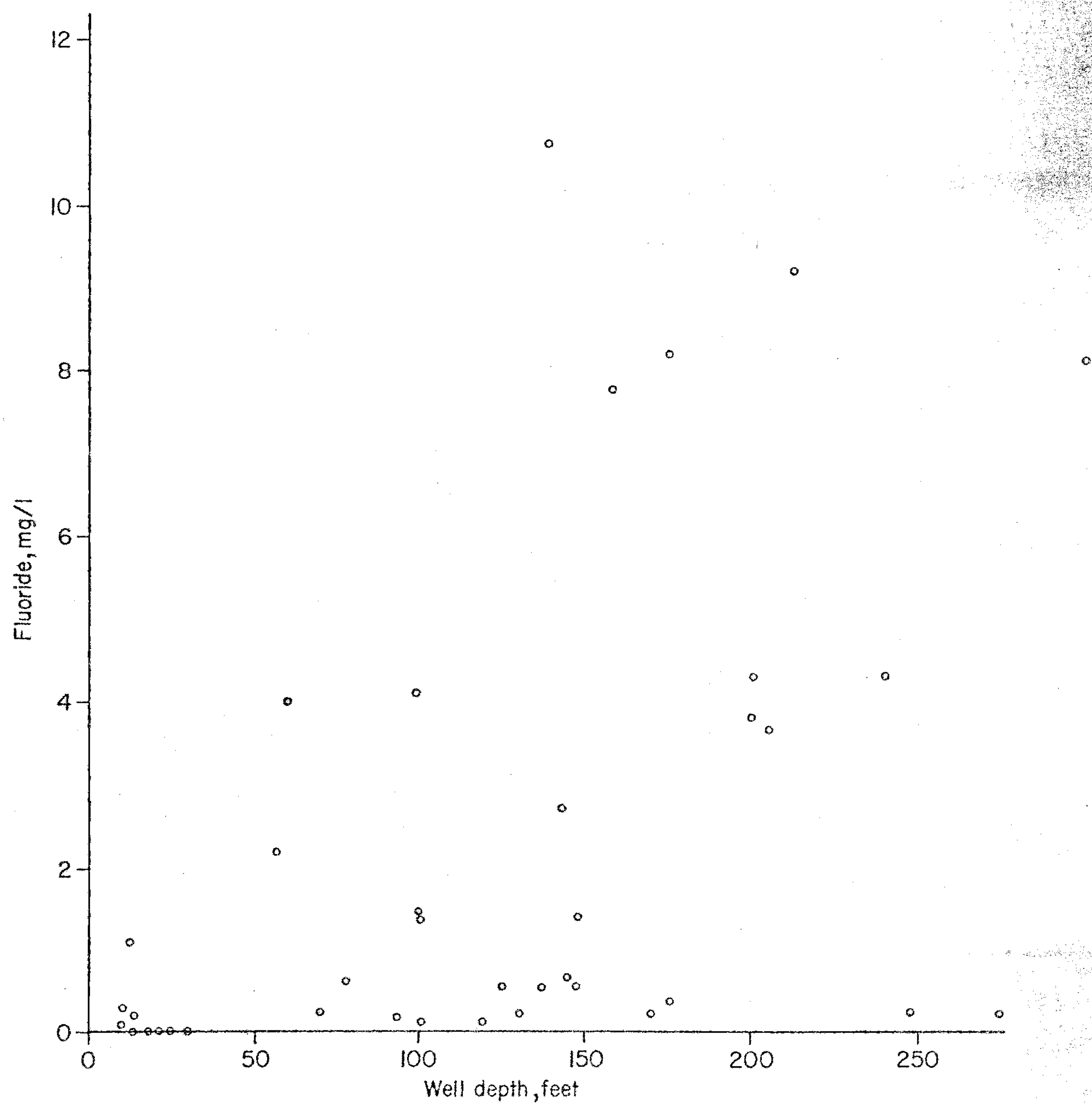


Figure 14. Fluoride as related to well depth.

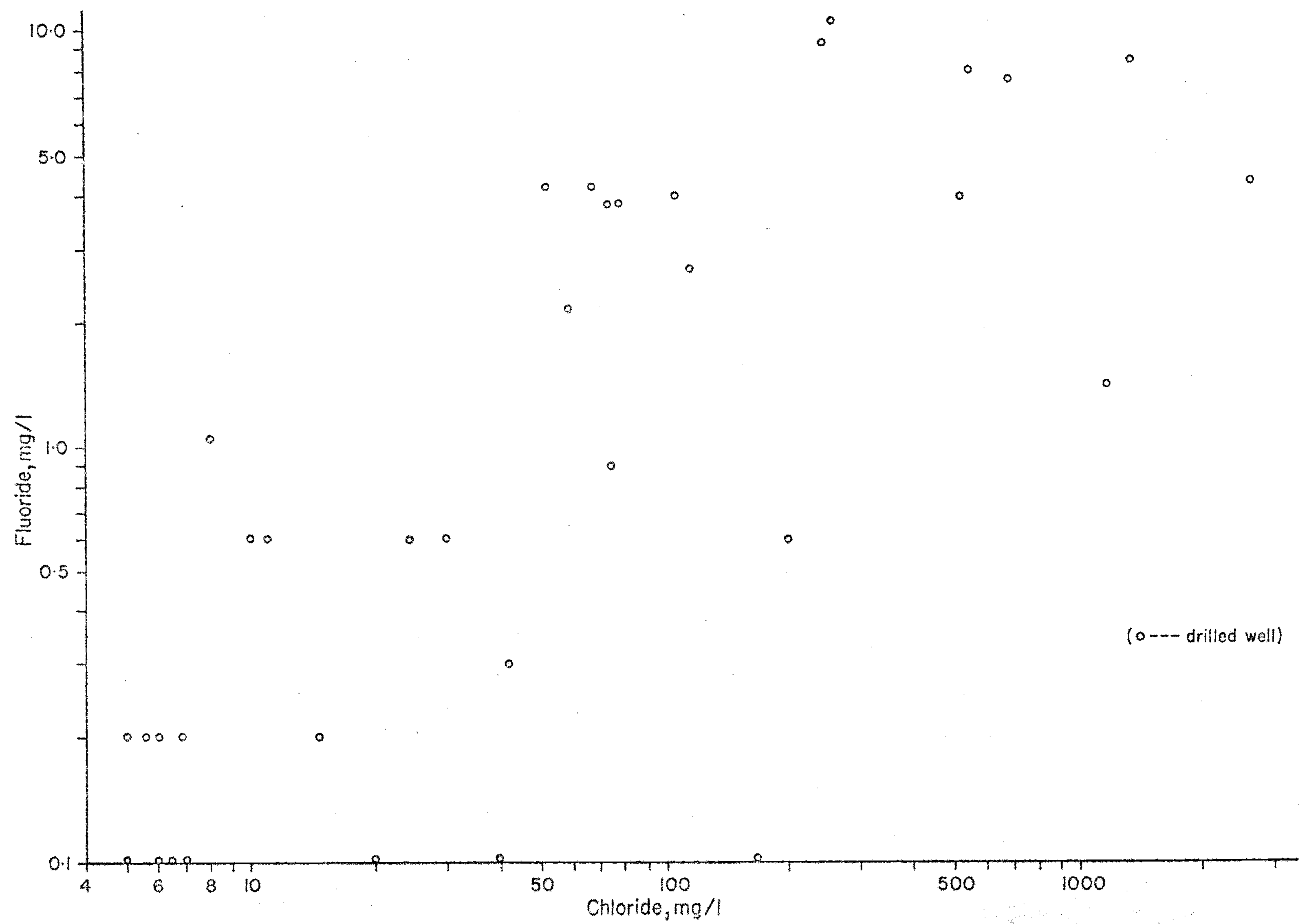


Figure 15. Fluoride as related to chloride.

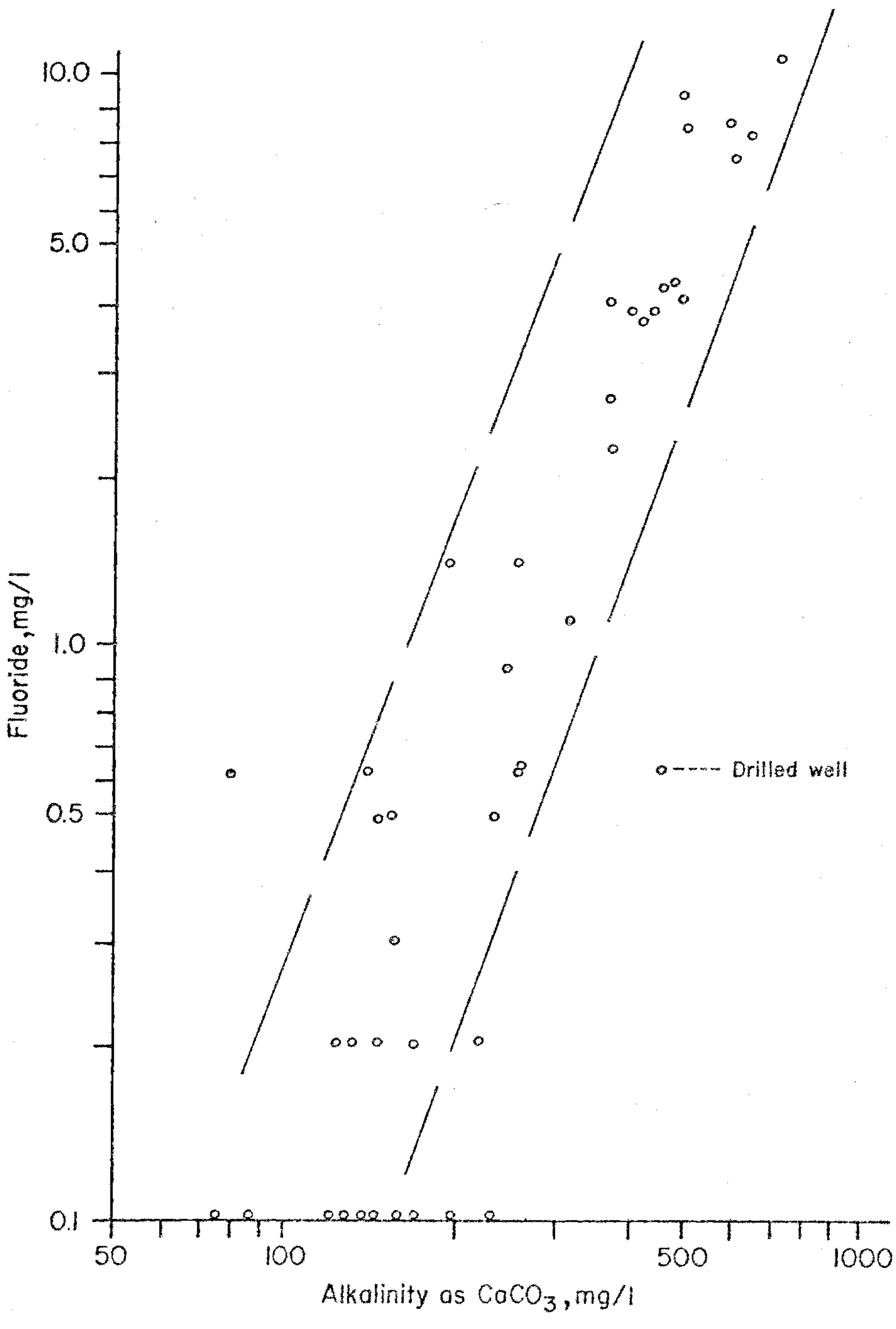


Figure 16. Fluoride as related to alkalinity.

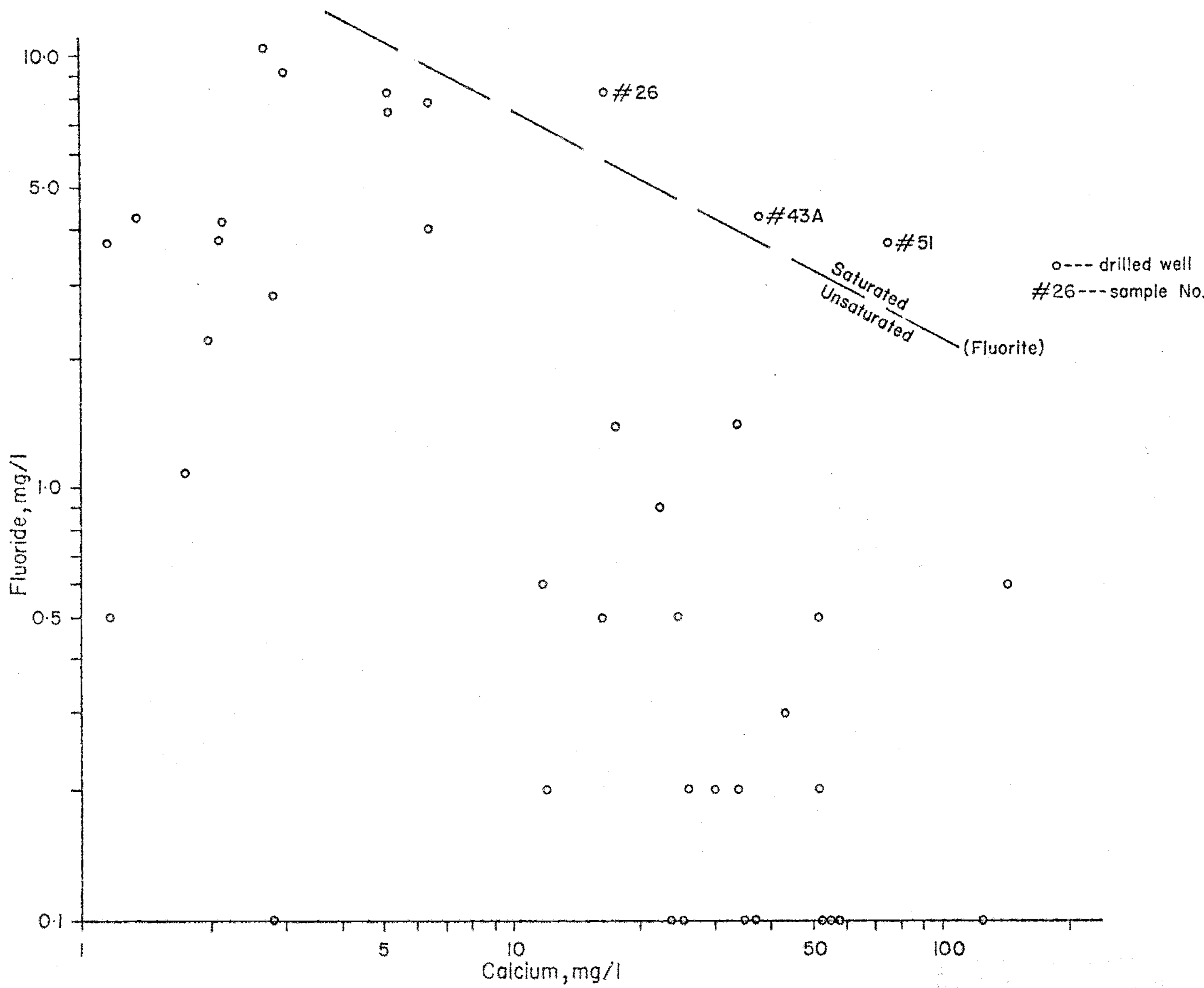


Figure 17. Fluoride as related to calcium.

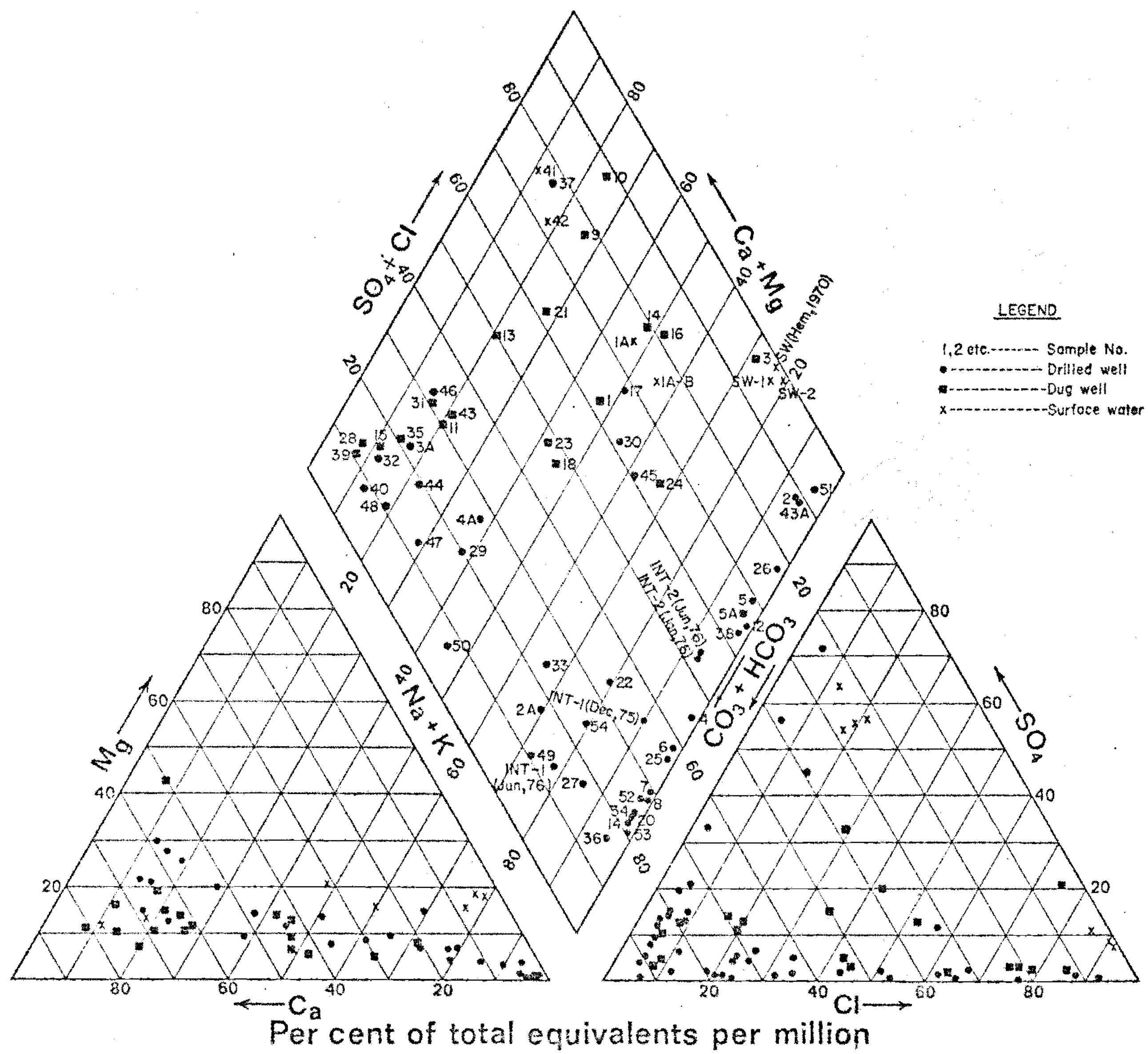


Figure 18. Trilinear plot of groundwater chemical composition.

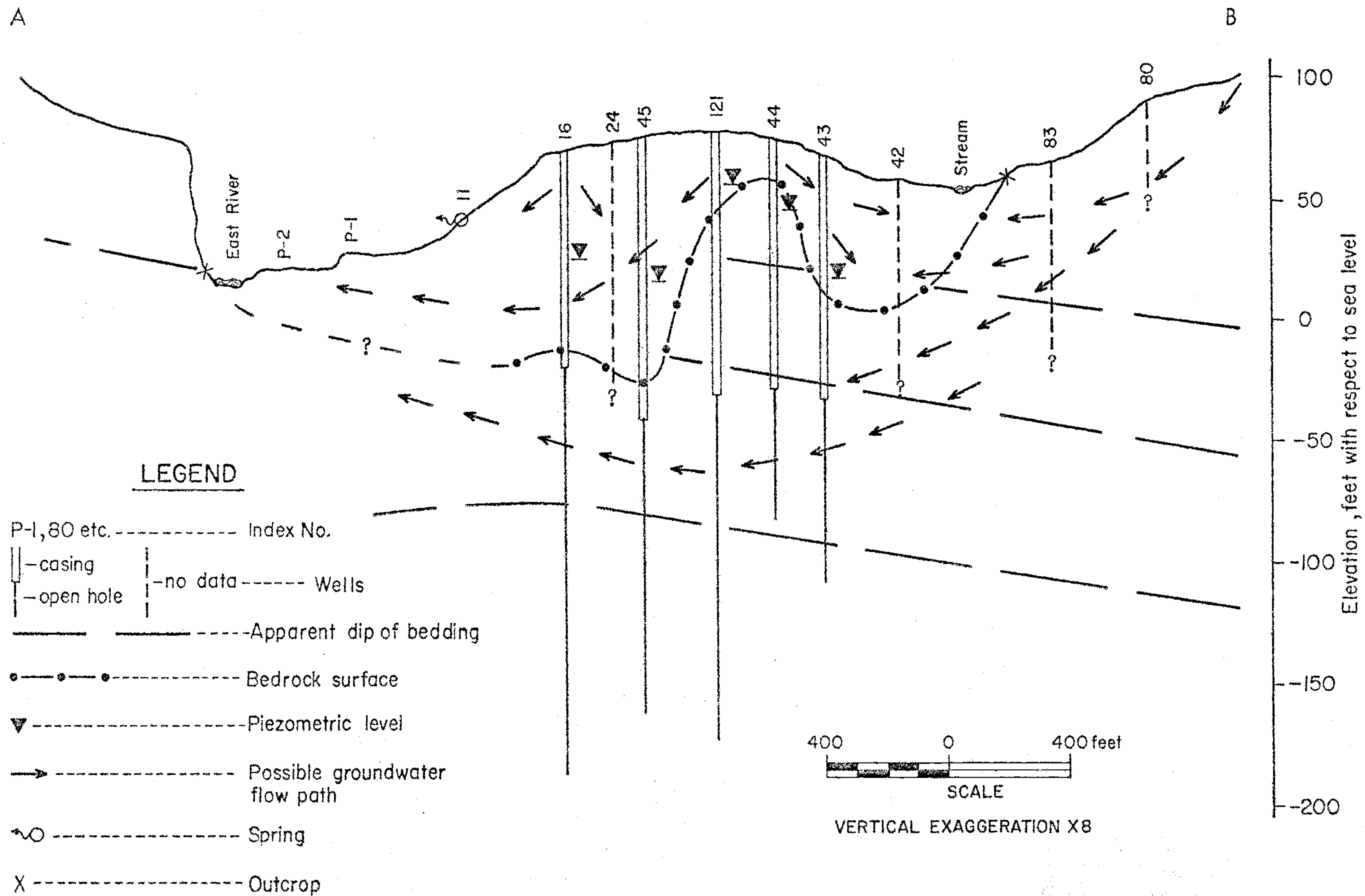


Figure 19. Cross section A-B.

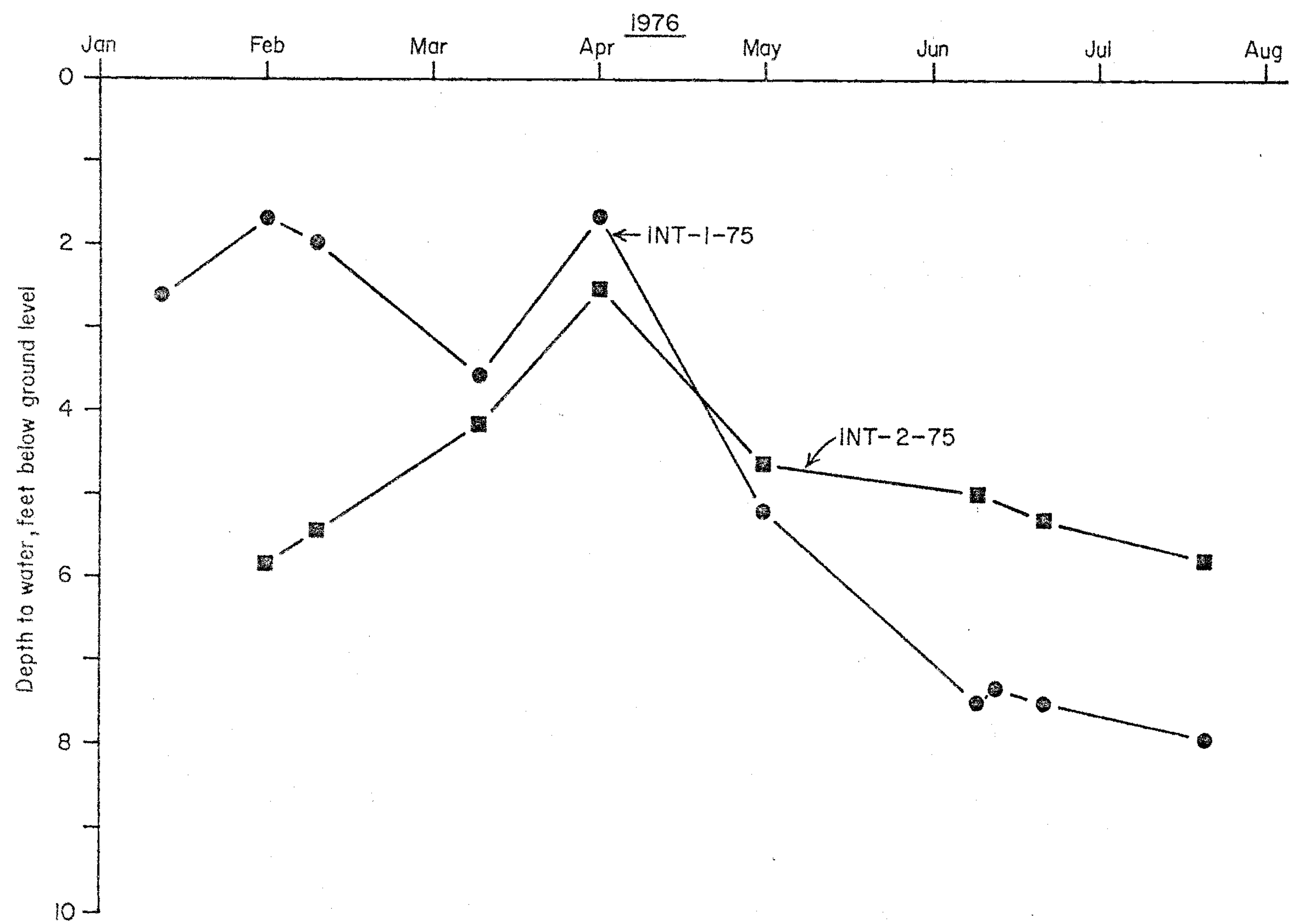


Figure 20. Water level fluctuations in testholes, January to July 1976.

APPENDICES

INDEX NO.	OWNER	TYPE OF WELL	WELL DEPTH FEET	CASING LENGTH FEET	DIAMETER	WATER LEVEL FEET BELOW GROUND	REPORTED YIELD GPM	GEOLOGIC LOG	FIELD ANALYSES Alkalinity mg/l as $CaCO_3$	Chloride mg/l	Total hardness mg/l as $CaCO_3$	Temperature °F	CONSTRUCTION	COMMENTS & REPORTED QUALITY PROBLEMS
1.	David McKay	Dug	9.25		2.5	5.6			85	60	119		Cracked, unsealed, no apron, Wooden cover	Dry occasionally
2.	William Malloy	Drilled							40	35	60			
3.	Albert McKay	Dug	10.5		1.5	6.9			15	35	40		Cracked, unsealed, no apron	Water hard
4.	Helen McKenzie	Dug	11.2		2.0	7.6			5	15	20		Cracked to 1.1 ft. above ground, no apron	
5.	C.Urqhart	Drilled	147	20.3		10.0	1.5-2	Bedrock conglomerate, soft at finish	192	1120	113	58		Salt and iron taste
6.	C.Urqhart	Dug	9.7		1.75	6.9			12	95	40		Cracked to 0.75 ft. above ground, iron cover	
7.	Allan McKay	Dug	8.75		2.5	5.9			10	115	69	60	Cracked to 3 feet above ground	
8.	Roy MacQuarrie	Drilled							190	145	10			Sulfur odor, salt, iron, sediment and corrosion.
9.	Russell Henderson	Dug	12-14						30	45	65			Tap sample due to heavy cover. Bored well on property not used due to iron problems.
10.	Henry Heighton	Dug	26		2.75	7.75		0-26 sand, clay, gravel & large boulders	30	25	50		Cracked to 1.9 ft.above ground, cement apron	
11.	R.Cunningham	Spring							48	240	300	68		Possible surface runoff from neighbour's sink drain
12.	Roland Narin	Dug	10		2.3	4.7			70	35	80		Cracked. Located 15 ft. from and 1-2 ft.below road level.	Possible surface runoff and oil contamination.
13.	Elaine Rhyno	Dug	12.5		2.0	8.75			50	65	100		Cracked to ground level	Located 20 ft. and 1 ft. downslope from road
14.	John Gillis	Drilled	213		4"				488	246	10	51		Drilled by Dept. of Highways since dug well had road salt. Drilled well has sulfur odor.
15.	John Gillis	Dug	13.9		2.0	7.25			20	25	80	49	Cracked to 1.3 ft. above ground, no apron	
16.	Gordon Fraser	Drilled	260	90		48	3.5	0-85 mixed clay and gravel 85-260 soft conglomerate with bands of red shale	585	740	19		Well later reamed out and gravel packed from 122-260 ft. Flow reduced to 1 1/2 gpm.	
17.	Gordon Fraser	Dug	8.2		2.5	3.4			175	10	180			Well in basement
18.	Debruyn	Dug	21.3		2.0	11.3			100	42	157	49	Cracked to 0.5 ft. above ground	Located 4 ft. from and level with road.
19.	G. Fraser	Dug	19		2.0	4.0			105	10	130			Located in basement and used for drinking.
20.	Scott McDonald	Dug	22.5		2.0	11.0			128	24	144	58	Cracked to ground level	
21.	Mrs. Glen	Dug	6.0		3.0				120	165	340		Cracked to 2.0 ft. above basement level	

INDEX NO.	OWNER	TYPE OF WELL	WELL DEPTH FEET	CASING LENGTH FEET	DIAM-ETER	WATER LEVEL FEET BELOW GROUND	REPOR-TED YIELD GPM	GEOLOGIC LOG	FIELD ANALYSES Alkalinity mg/l as $CaCO_3$	Chloride mg/l	Total hardness mg/l as $CaCO_3$	Tempe-rature °F	CONSTRUCTION	COMMENTS & REPORTED QUALITY PROBLEMS
22.	Hugh Russell	Dug	7.7		2.5	4.7			40	110	90		In basement	Dry occasionally
23.	J.Robertson	Dug	24		3.0	low			125	25	40			
24.	Raymond McKay	Drilled	99		4"				485	112	8	60		
25.	C.V.Ramscar	Drilled	143	81	4"	38	3	Gravel, then bands of conglomerate, shale, and red sandstone	357	125	9	56		
26.	A.McMillan	Drilled	150	100				0-60 clay, 60-90 fine sand Bedrock - fine grained siltstone	393	78	5	58		Sediment
27.	A.McMillan	Dug							120	265	366	67		Tap sample.
28.	L.Urquhart	Dug	18.7		2.0	8.9			90	110	200		Extends 0.75 ft. above ground, wooden cover	
29.	T. Stroud	Drilled	24		3"				140	110	260		Drilled through an old 3 ft. diameter dug well	
30.	E.Kellock	Dug	14.9		2.6	8.7			20	5	25	50	Cracked to 1.5 ft. above ground wooden cover	
31.	E. Kellock	Dug	3.75		1.75	2.5			132	393	318	58	Cracked, no apron, 3 ft. downslope from road	Not used because of odour and taste
32.	E. Cameron	Dug	10.75		1.75	6.7			15	10	30	50	Cracked to 0.75 ft. above ground, no apron, steel cover	
33.	G. Naugler	Drilled	60						360	535	23	56		
34.	B. Taylor	Dug	12.3		2.0	7.0		Encountered sand & gravel when digging	10	10	40	50	Top 2.7 ft. above ground	Abundant water supply
35.	J. Duncan	Dug	14.9		2.0	9.7			10	7.5	20	50		Dry in summer
36.	L. Dunbar	Dug	16.95		2.0	11.6			70	27.5	95	49	Cracked to 0.9 ft. above ground, no apron, tin cover	Dry in summer
37.	W. Clark	Dug	15.25		1.5sq	8.4			90	10	100	50	Cracked to 1.6 ft. above ground no apron	Rust, odour
38.	B. Allen	Dug	16.25		1.5	15			200	10	213	50	Top 1.5 ft. above ground. Well gravel-packed	Dry occasionally
39.	V. Taylor	Dug	7.5		1.5	2.9			150	35	200	56		Dry occasionally
40.	H. Conway	Dug	14.2		1.75	7.7			153	413	384	52	Cracked to 2.5 ft. above ground, no apron	40 ft. from and level with road - possible salt contamination
41.	J. Taylor	Dug	13.75		2.0	6.5			60	25	100	52	Top 0.6 ft. above ground	
42.	S. Stewart	Drilled	138-140						720	252	10	56		Sulfur odor, mineral taste
43.	R. Foote	Drilled	175	100	6"	46	5	0-50 mud & sand, 50-90 mud, sand & red shale, 100-175 red shale	584	1390	55	56		

Appendix 1 (continued).

INDEX NO.	OWNER	TYPE OF WELL	WELL DEPTH FEET	CASING LENGTH FEET	DIAMETER	WATER LEVEL FEET BELOW GROUND	REPORTED YIELD GPM	GEOLOGIC LOG	FIELD ANALYSES: Alkalinity mg/l as $CaCO_3$	FIELD ANALYSES: Chloride mg/l	FIELD ANALYSES: Total hardness mg/l as $CaCO_3$	FIELD ANALYSES: Temperature °F.	CONSTRUCTION	COMMENTS & REPORTED QUALITY PROBLEMS
44.	R. Boehk	Drilled	158	105	4"	30	2	0-8 ovbn, 8-16 gravel, 16-45 soft red sh, 45-62 black coal sh, 62-85 soft red sh, 85-102 soft grey sh, 102-158 red sh	628	700	23	60		
45.	J. Wadden	Drilled	240	119	6"	60	2	0-108 clay & gravel, 108-160 red sh, 160-200 gray sh, 200-240 red sh	465	2670	138	58		Gassy
46.	J. Darroch	Dug	14		2.5				50	5	70		Cracked to 2 ft. above ground	Filled with town water ~ 1 week before sampling.
47.	J. McDonald	Dug	16		1.75	5.0			130	7.5	130	52	Cracked to 2.3 ft. above ground	
48.	W. Fraser	Dug	19.5		2.0	11.0			70	15	80	48	Cracked to 6.5 ft. above ground	
49.	G. Atwater	Drilled	247	>100	6"				212	14	90	58		Previous analysis, Jan. 12/72: hard 165 mg/l, alk 150, Fe 0.5, Cl 20, SO_4 30, NO_3-N 3, pH 7.8
50.	R. Polson	Drilled	247	107	6"	20	1	0-105 gravel & bldrs, 105-194 red ss, 194-245 gray sh, 245-247 red sh	309	8	6.3	62		
51.	A. Ross	Dug	13.6		2.0	10.0			20	7.5	15	49	Rocked to ground level, wooden cover	Dry in summer.
52.	M. Conway	Drilled	123	21	5	18	5	0-18 mud & bldrs, 18-123 red shale	165	7.5	170	62		
53.	R. MacDonald	Drilled	160	61	5	35	1	0-54 ovbn, 54-120 hard red ss 120-130 gray ss, 130-160 red ss	170	5	150	60		
54.	A. Weir	Drilled	135	72	4	43	3	0-30 ovbn, 30-70 mud, bldrs, gravel 70-90 red sh, 90-135 red ss	225	7	11	62		Water softener installed.
55.	L. Rogers	Dug	12						100	7.5	120	63	3-4 tile crocks with cover, in basement	
56.	C. Ramscar	Dug	20		2.5	7.0		Clay and some shale	30	7.5	50		Galvanized crock to 4 feet above ground	Well overflows in spring.
57.	B. Nelson	Dug	4		2.0				75	10	50		Cracked to 0.5 ft. above ground, wooden cover	Two old drilled wells exist - 35 6-385 ft. hit salt water.
58.	G. Adamson	Dug	14		2.0			Red clay	81	5	88		Covered with cement then sod. Considerable gravel around well	
59.	S. Young	Dug	10.75		1.2	8.0			35	12.5	35	54	Cracked to 1.7 ft. above basement floor.	
60.	H. Doucette	Dug	16.25		2.0	9.9		0-12 clay, sand, bldrs. Gravel vein with water at 12 feet.	130	5	145			1971 analysis: hard 176 mg/l, alk. 175 mg/l, Fe 0.11, Cl 27, SO_4 7, NO_3N 5.6, pH 7.7
61.	J. Stewart	Dug	14.6		2.0	6.7			50	17.5	80	53	Cracked to 0.6 ft. above ground, wooden cover	

Appendix 1 (continued).

INDEX NO.	OWNER	TYPE OF WELL	WELL DEPTH FEET	CASING LENGTH FEET	DIAMETER	WATER LEVEL FEET BELOW GROUND	REPORTED YIELD GPM	GEOLOGIC LOG	FIELD ANALYSES Alkalinity mg/l as $CaCO_3$	Chloride mg/l	Total hardness mg/l as $CaCO_3$	Temperature °F	CONSTRUCTION	COMMENTS & REPORTED QUALITY PROBLEMS
62.	R. Jackson	Dug	5						50	7.5	70	60	Spring	
63.	J.O'Haggen	Drilled	123						165	5	135	61		
64.	G. Cameron	Dug	11.5		2.0	8.25			35	20	125	55	One cement crock to 0.9 ft. above ground, 1.0 ft. below	
65.	M. Williams	Drilled							139	20	478	52		
66.	F. MacIntosh	Dug	20.1		2.0	9.2			15	5	140	52	Crocked to 0.4 ft. above ground, wooden cover	
67.	W. Murphy	Drilled							160	5	95	56		
68.	W. Murphy	Dug							110	7.5	120	53	Level with ground	
69.	L.Delmotte	Drilled	84	16	4"	12	2	0-9 overburden, 9-84 red limestone	95	10	110	55		
70.	H.Sutherland	Drilled							130	15	145	58		Supplies approximately 13 trailers (Hemlock Trailer Court).
71.	A. Boudoux	Drilled	100						150	5	140	56		
72.	J.MacKay	Dug	9.6		2.5	8.3			80	7.5	95	53	Crocked to 4.7 ft. above ground	
73.	F.MacDonald	Drilled	183	26	5	0	2	0-11 mud, 11-139 red & gray shale, 139-149 green shale, 149-155 red shale, 155-168 green shale, 168-183 red shale	110	10	30	63		
74.	G.Vickers	Drilled	148	21	5	10	3	0-7 mud & boulders, 7-148 red shale	160	5	20	56		
75.	C.Poulain	Drilled	>100						300	>900	120	59		
76.	C.Poulain	Dug	25						100	15	135			
77.	E.Kellock	Dug							90	20	140			Not used for drinking.
78.	G.Gillis	Dug	15					Fine grained sand near bottom	105	40	115		5 crocks on bed of brook	
79.	D.Gould	Dug	11		2.0	6.0			100	25	100	54	Crocked to 2.3 ft. above basement floor.	
80.	W.J.Conway	Drilled	36						200	14.5	30	68	Drilled 16 ft. through a 20 ft. dug well in the basement	
81.	D.Anderson	Dug							60	62	59	63		
82.	A.J.Post	Dug	26		5.5	12.0			252	25	46	52	Rocked to ground, wooden cover, Located behind barn.	
83.	G.Thompson	Drilled	78						235	35	40	58		
84.	Plymouth School	Dug	14.4		2	8.4			40	10	60	53		Presently using a 300 foot drilled well.
85.	S.MacFarlane	Dug	10		2.5	5.3			30	27.5	30	55	Crocked, iron cover	

Appendix 1 (continued)

INDEX NO.	OWNER	TYPE OF WELL	WELL DEPTH FEET	CASING LENGTH FEET	DIAMETER	WATER LEVEL FEET BELOW GROUND	REPORTED YIELD GPM	GEOLOGIC LOG	FIELD ANALYSES Alkalinity mg/l as $CaCO_3$	Chloride mg/l	Total hardness mg/l as $CaCO_3$	Temperature °F.	CONSTRUCTION	COMMENTS & REPORTED QUALITY PROBLEMS
86.	J.W. Thompson	Dug	8.3		2.0	6.5			70	10	100	55	Cracked to 1.6 ft above ground	
87.	G. DeYoung	Dug	7.25		2.5	4.0			40	10	40	65		Dry in summer.
88.	R. Bonvie	Dug	14		3.0				261	17	264	59		
89.	F. Blackie	Drilled	70	41	4"	6	5	0-35 overburden, 35-70 red shale	80	52.5	130	60		Supplies two houses.
90.	R. McGrath	Drilled	123	84	5"	31	7	0-25 mud & Boulders, 25-50 broken rock, 50-90 soft red shale, 90-123 hard red shale	120	5	100	56		
91.	C. Praw	Bored	30						138	6	133	60		
92.	W. Larade	Dug				Overflow			220	10	90	58	3-4 cracks to 3 ft. above ground, gravel packed	
93.	G. McLellan	Dug	8.9		2.0	3.4			40	20	60	55	Four - 2 1/2 ft. cracks to 1.6 ft. above ground, wooden cover	8 ft. below road - possible salt problem in winter.
94.	E. Brennan	Dug	4.7		2.0	1.2			100	5	90	60	Two dug wells connected.	
95.	I. Brennan	Spring				Overflow			60	10	62	62		
96.	R. Grant	Drilled	98	21	5"	Overflow	15	0-98 red conglomerate	130	10	130	71		
97.	A. McDonald	Dug	25.3		2.0	14			145	18	183	49	Cracked to 1.7 ft. above ground	
98.	J. Turnbull	Dug	18.9		1.75	11.5			150	7.5	180		Cracked to 0.9 ft. above ground	Sulfur odour.
99.	L. Adams	Drilled	90						170	7.5	120	59		
100.	R. McKeon	Drilled	130	52	6"	Overflow	40	0-50 mud & boulders, 50-130 red shale	120	6	98	54		Supplies three houses and still overflows at approximately 2 gpm into the ditch.
101.	J. Fraser	Drilled	147	86	6"	6	12	0-72 mud & boulders, 72-147 red conglomerate	150	7.5	90	67		
102.	C. Robinson	Drilled	118	32	4"	18	1	0-25 clay & boulders, 25-118 conglomerate	140	10	90	59		
103.	D. Monroe	Drilled	120	22	6"	35	5	0-10 clay, 10-120 red shale	120	5	60	54		Supplies two families
104.	D. Mason	Drilled	245	55	5"	20	3	0-50 mud & boulders, 50-245 red shale	139	11	159	58		
105.	E. Benoit	Drilled	145	69	5"	22	3	0-55 clay & boulders, 55-145 conglomerate	75	188	485	59		
106.	L. Benoit	Drilled	147	44	6"	20	3.5	0-32 mud & boulders, 32-147 conglomerate	100	10	90	56		
107.	F. McDonald	Dug	18		2.5	7.0			100	88	124		Galvanized crock to 1.2 ft. above ground, gravel packed.	
108.	F. McDonald	Dug	47?		1.7	1.9			100	65	130		Cracked to 1.75 ft. above basement floor.	

Appendix 1 (continued)

INDEX NO.	OWNER	TYPE OF WELL	WELL DEPTH FEET	CASING LENGTH FEET	DIAMETER	WATER LEVEL FEET BELOW GROUND	REPORTED YIELD GPM	GEOLOGIC LOG	FIELD ANALYSES Alkalinity mg/l as $CaCO_3$	Chloride mg/l	Total hardness mg/l as $CaCO_3$	Temperature °F	CONSTRUCTION	COMMENTS & REPORTED QUALITY PROBLEMS
109.	W. McWilliam	Spring	4.5		4.5			Sand and gravel	30	35	70	71		Supplies 65 cattle.
110.	E. McDonald	Dug	8.75		2.5	6.6			50	12.5	65	70	Cracked to 1.25 ft. above ground	
111.	J. Norris	Drilled	83	40	5"	24	4	0-10 loose ground, 10-20 gravel, 20-35 clay, 35-60 shale, 60-83 sandstone	220	30	0	60		Sulfur odor.
112.	F. Norris	Drilled	73	30	5"	18	4	0-25 overburden, 25-73 shale	240	77	70	56		
113.	L. Meisner	Drilled	200	45	5"	24	1	0-28 overburden, 28-40 soft gray shale, 40-65 black shale, 65-200 gray shale	432	76	8.5	54		
114.	G. McKenzie	Drilled	50	23	5"	15	3	0-21 overburden, 21-50 shale	370	60	7	66		
115.	R. Kellock	Dug	14.7		2.5	10			132	80	123	56	Galvanized crock to 1.3 ft. above ground.	Oily film on top.
116.	R. Fulton	Drilled							127	165	196	58		
117.	H. Moore	Drilled	136	21	4"	21	1.5	0-15 overburden, 15-136 coal shale	120	5	75	74		
118.	D. Wilkinson	Dug	15		2.5	4.5			50	7.5	50		Galvanized crock to 3.5 ft. above ground	
119.	B. Hines	Drilled #1	215	60	4"	50	1	0-18 overburden, 18-25 gray shale, 25-215 red shale,						Yield too low.
		#2	235	150	4"	81	1.5	0-146 red shale, soft bands; 146-235 red shale & conglomerate						Salt water.
120.	J. Haydn	Drilled	94	21	4"	12	6	0-14 mud & boulders, 14-51 gray shale, 51-58 red shale, 58-75 gray shale, 75-90 red shale, 90-94 gray shale	75	5	71			
121.	J. Williams	Drilled	250	109	4"	21	1.5	0-30 overburden, 30-70 soft red shale, 70-82 coal shale, 82-87 hard red shale, 87-93 soft grey shale, 93-106 gray shale, 106-112 hard red shale, 112-250 sticky red shale.	419	4250	263	56		
122.	L. Mason	Drilled	100	15	4"	25	2.5	0-11 overburden, 11-23 coal shale, 23-27 gray shale, 27-90 coal shale, 90-95 gray shale, 95-100 coal shale	250	52	66	65		
123.	A. Nugent	Drilled	100	21	4"	15	5	0-14 overburden, 14-73 red shale, 73-100 conglomerate	155	39	182	60		
124.	E. McMillan	Drilled	100	43	5"	32	30	0-16 mud & gravel, 16-25 broken rock, 25-30 mud & broken rock, 30-100 red shale	115	5	95	63		
125.	S. Kellock	Drilled	171	68	5"	14	7	0-30 clay & gravel, 30-45 gravel & boulders, 45-47 broken rock, 47-171 hard red shale	132	5	100	60		

Appendix 1 (continued)

INDEX NO.	OWNER	TYPE OF WELL	WELL DEPTH FEET	CASING LENGTH FEET	DIAMETER	WATER LEVEL FEET BELOW GROUND	REPORTED YIELD GPM	GEOLOGIC LOG	FIELD ANALYSES: Alkalinity mg/l as $CaCO_3$	Chloride mg/l	Total hardness mg/l as $CaCO_3$	Temperature °F.	CONSTRUCTION	COMMENTS & REPORTED QUALITY PROBLEMS
126.	L. Rafuse	Drilled	273	22	6"	3	2	0-12 mud & boulders, 12-273 red shale	142	5.5	40	55		
127.	R. Boudreau	Drilled	147	22	6"	Overflow	3	0-16 mud & boulders, 16-147 conglomerate	150	30	5	63		
128.	H.Wynards	Drilled	175	95	5"	50	3	0-60 overburden, 60-90 soft red shale, 90-175 red conglomerate	153	43	142	52		
129.	NUMBER NOT GIVEN BY MISTAKE.													
130.	E.Fillmore	Drilled	98	38	5"	Overflow	15	0-28 clay & boulders, 28-98 red shale						
131.	B. Conway	Drilled	240	35	5"	20	3.5	0-28 mud, clay & boulders, 28-240 red shale						
132.	F.Davis	Drilled	70						167	6.7	153	60		
133.	J.Chennal	Drilled							164	6.7	130	63		
134.	Plymouth Fire Dept.	Dug	14	14	2.5	9.1			155	8.5	107		Galvanized crock to 2.2 ft. above ground.	
135.	J.Kerley	Drilled	119	44	5"	20	8	0-35 mud & broken rock, 35-119 red shale	195	6.5	174	59		
136.	G.Purvis	Dug	10						228	44	251			Abundant supply.
137.	A.Sutherland	Drilled	125	45	5"	3	3	0-40 mud & gravel, 40-70 red shale, 70-95 quartzite, 95-125 red shale						

Appendix 1 (continued).

CHEMICAL ANALYSES OF GROUNDWATERS

Index No.	Sample No.	Present Owner	Well Depth feet	Aquifer *	Date Sampled	Analyses in mg/l **																								Ions in meq/l **					
						Na	K	Ca	Mg	Alkalinity as $CaCO_3$	SO_4	CL	F	Sr	I.	SiO_2	NO_3 + NO_2 as N	NH_3 as N	PO_4 ortho	Fe	Mn	Pb	Cu	Zn	Total Solids	Total dissolved solids	Conductivity µmhos/cm	pH	Eh milli-volts	Cations: Na + K	Cations: Ca	Cations: Mg	Anions: CO_3 HCO_3	Anions: SO_4	Anions: Cl
	SW-1	sw-freshwater mix. Abercrombie area			15/9/75	150	6.9	14	16	11	51	262	0.1	<0.1	0.03	7.2	<0.1	<0.1	<0.02	0.3	0.1	0.005	0.02	0.009	621	610	990	7.0	433	6.7	0.7	1.32	0.22	1.06	7.39
	SW-2	sw-Northumberland Str., off Caribou I.			15/9/75	9175	385	364	1093	97	2330	16500	2.7	5.3	0.05	<1.0	<0.1	0.4	0.07	3.0	0.4	Tr	Tr	Tr*	31025	30960	44000	8.2	465	409	18.2	90.0	1.9	48.5	465.6
1A	1A	claypit		coal, shale	16/7/75	92	3.6	66	23	133	270	5	0.3			1.0	26.3	<0.1	<0.02	<0.1	0.07	Tr	0.01	0.01	670	667	902	7.8		4.09	3.29	1.89	2.66	5.62	0.14
					15/9/75	174	3.2	62	24	140	357	6.5	0.3	0.9	<0.01	<1.0	35.8	<0.1	<0.02	0.1	0.05	Tr	0.02	Tr	918	910	1254	8.4	413	7.65	3.09	1.97	2.80	7.43	0.20
137	2A	A.Sutherland	125	red shale +	16/7/75	78	8.1	17	6.5	227	34	10	0.5			4.4	<0.1	0.1	<0.02	4.9	0.2	Tr	0.02	0.04	299	294	473	8.3		3.60	0.85	0.53	4.49	0.17	0.28
				sandstone	16/9/75							7.2	0.5	0.3	<0.01													7.9	401						
120	3A	J.Hayden	94	red/grey shale	16/7/75	6.1	1.4	24	2.8	75	11	5	0.1			3.3	0.4	0.2	<0.02	0.8	0.05	Tr	0.05	0.04	546	91	176	8.3		0.32	1.20	0.23	1.48	0.23	0.14
100	4A	R.MacKean	130	red shale	16/7/75	24	3.6	30	5.5	120	32	6	0.2			9.0	0.1	<0.1	<0.02	0.2	<0.05	Tr	0.02	Tr	181	180	308	8.1		1.13	1.50	0.45	2.39	0.67	0.17
84	5A	Plymouth Sch.	300	bedrock	17/7/75	578	1.6	5.4	1.5	498	28	560	8.1			6.1	0.4	0.2	0.2	0.2	<0.05	Tr	0.009	0.04	1528	1520	2750	8.7		25.19	0.27	0.12	9.54	0.56	15.80
					15/9/75	2175	2.3	89	20	375	6	3400	6.0	2.3	0.10	5.7	0.3	<0.1	0.04	0.3	0.07	Tr	0.04	0.04			10,340	8.1	386	94.67	4.39	1.65	7.49	0.12	95.91
1	1	D.MacKay	9.3	overburden	29/7/75	46	3.7	39	5.0	85	43	60	0.1			7.3	2.8	<0.1	<0.02	0.1	<0.05	Tr	0.56	0.15	269	267	550	6.9		2.09	1.95	0.41	1.70	0.89	1.69
5	2	C.Urquhart	147	shale	29/7/75	770	1.5	35	6.0	192	11	1120	1.4			8.6	<0.1	0.5	<0.02	0.6	0.5	Tr	Tr	0.09	2023	2016	3680	7.5		33.54	1.75	0.49	3.84	0.23	31.60
					15/9/75							880	1.4	0.4	0.02													7.5	411						
7	3	A.McKay	8.4	overburden	29/7/75	79	2.6	20	4.2	10	50	115	<0.1			7.5	6.3	<0.1	<0.02	0.1	<0.05	.006	0.18	0.34	325	322	561	6.1		3.51	1.00	0.35	0.20	1.04	3.24
14	4	J.Gillis	213	bedrock	29/7/75	375	0.9	3.2	0.6	498	11	246	9.2			7.8	<0.1	<0.1	0.29	0.1	0.2	Tr	Tr	0.01	928	924	1540	8.7		16.32	0.16	0.05	9.54	0.23	6.94
					15/9/75							275	9.6	<0.1	0.03													8.9	399						
33	5	G.Naugler	60	bedrock	29/7/75	490	1.2	6.8	1.4	360	20	535	4.0			7.6	<0.1	<0.1	0.08	0.1	<0.05	Tr	0.02	0.006	1291	1281	2200	8.5		21.35	0.34	0.12	7.10	0.42	15.09
					15/9/75							880	5.0	0.2	0.04													8.6	403						
25	6	C.Ramscar	143	Cg,sh,ss	29/7/75	255	1.1	2.8	0.5	357	25	125	2.7			8.0	<0.1	<0.1	0.53	0.1	0.05	Tr	0.01	Tr	619	614	1100	9.0		11.12	0.14	0.04	6.83	0.52	3.53
					15/9/75							85	2.5	<0.1	0.01													9.2	380						
24	7	R.McKay	99	bedrock	29/7/75	295	0.9	2.2	0.6	485	23	112	4.1			6.2	<0.1	<0.1	0.17	<0.1	<0.05	Tr	Tr	0.01	745	740	1265	8.8		12.85	0.11	0.05	9.43	0.40	3.16
					15/9/75							98	4.6	<0.1	0.02													8.7	396						
26	8	A.McMillan	150	siltstone	29/7/75	235	1.6	1.2	0.4	393	26	78	3.8			7.2	<0.1	<0.1	0.37	0.6	0.1	Tr	Tr	0.007	616	594	990	9.1		10.26	0.06	0.03	7.85	0.54	2.20
					15/9/75							71	3.7	<0.1	<0.01													9.2	391						
27	9	A.McMillan	<20	overburden	29/7/75	62	1.9	126	12	120	14	265	0.1			8.6	0.7	<0.1	<0.02	1.2	0.05	Tr	0.17	4.75	893	890	1100	7.4		2.75	6.29	0.99	2.40	0.29	7.45
					15/9/75							275	0.1	0.3	<0.01													7.3	485						
11	10	R.Cunningham	spring	overburden	29/7/75	46	2.1	100	12	48	12	240	<0.1			6.0	1.1	<0.1	<0.02	0.7	0.1	Tr	0.26	0.72	728	695	836	6.6		2.05	4.99	0.99	0.96	0.25	6.77
20	11	S.MacDonald	22.5	overburden	27/7/75	13	5.8	52	3.4	128	19	24	0.1			8.7	0.9	0.1	0.14	0.2	0.1	0.02	0.02	0.01	275	270	351	7.3		0.72	2.59	0.28	2.56	0.40	0.65
					16/9/75							40	0.1	0.3	<0.01													7.4	411						
16	12	G.Fraser	260	cg/red sh	29/7/75	690	0.9	5.4	1.2	585	4	740	7.2			6.0	<0.1	0.2	0.23	0.1	0.1	Tr	0.02	0.03	1717	1714	3025	8.6		30.04	0.27	0.10	11.69	0.05	20.88
					15/9/75							700	7.4	0.2	0.04													8.8	407						
18	13	Debruyn	21.3	overburden	29/7/75	18	3.0	52	6.4	100	31	42	0.1			4.4	2.5	<0.1	<0.02	0.1	<0.05	Tr	0.01	0.16	280	278	385	7.0		0.86	2.59	0.53	2.00	0.65	1.18
40	14	H.Conway	14.2	overburden	29/7/75	160	2.2	132	13	154	24	413	0.2			9.5	0.5	<0.1	<0.02	0.2	0.07	Tr	0.01	0.02	1069	1066	1610	6.7		7.02	6.59	1.07	3.06	0.50	11.65
					16/9/75	214	2.8	210	25	173	32	625	0.2	0.6	0.01	11.0	0.3	0.1	<0.03	0.1	0.2	0.009	0.01	0.03			3190	6.8	426	9.38	10.48	2.06	3.46	0.67	17.63
38	15	B.Allen	16.3	overburden	29/7/75	10	2.0	68	10	200	24	10	0.1			8.3	0.3	<0.1	<0.02	0.1	0.05	Tr	0.30	0.03	254	249	418	7.6		0.49	3.39	0.82	3.99	0.50	0.28
31	16	E.Kellock	3.8	overburden	29/7/75	150	3.0	110	10	132	14	383	0.1			9.4	0.9	0.1	<0.02	0.3	0.1	Tr	0.03	Tr	977	972	1540	7.3		6.67	5.49	0.82	2.64	0.29	10.80
					16/9/75	265	3.4	206	20	148	13	760	0.2	0.5	<0.01	11.0	1.0	0.1	0.21	2.2	0.6	0.03	0.04	0.02			2530	7.0	426	11.62	10.25	1.65	2.96	0.27	21.44
116	17	R.Fulton		bedrock	29/7/75	92	5.2	58	12	127	45	165	0.1			4.1	0.1	<0.1	<0.02	1.0	1.3	Tr	0.02	0.01	495	493	825	6.2		4.13	2.89	0.99	2.54	0.94	4.65
115	18	R.Kellock	14.7	overburden	29/7/75	52	1.0	41	5.1	132	4.8	80	0.1			4.9	<0.1	0.2	<0.02	0.9	3.9	Tr	0.02	2.04	280	273	495	6.8		2.30	2.05	0.42	2.64	0.10	2.26
114	19	G.McKenzie	50	shale	29/7/75	205	1.2	2.0	0.5	370	3.4	60	2.2			7.2	<0.1	0.2	0.16	0.2	0.05	Tr	0.02	0.06	503	497	825	9.0		8.95	0.10	0.04	7.08	0.07	1.69
					15/9/75							70	3.1	<0.1	0.01													9.1	393						

* Aquifer: sh = shale; ss = sandstone; cg = conglomerate

Tr = Trace = <0.005 mg/l

** mg/l = milligrams per liter; meq/l = milliequivalents per liter

APPENDIX 2

CHEMICAL ANALYSES OF GROUNDWATERS

Analyses in mg/l — Ions in meq/l

Index No.	Sample No.	Present Owner	Well Depth feet	Aquifer	Date Sampled	Na	K	Ca	Mg	Alkalinity as $CaCO_3$	SO_4	CL	F	Sr	I	SiO_2	NO_3 + NO_2 as N	NH_3 as N	PO_4 ortho	Fe	Mn	Pb	Cu	Zn	Total Solids	Total dissolved Solids	Conductivity µmhos/cm	pH	Eh milli-volts	Cations Na + K	Cations Ca	Cations Mg	Anions CO_3 + HCO_3	Anions SO_4	Anions Cl
113	20	L.Meisener	200	black+grey sl	29/7/75	245	1.0	2.2	0.7	432	4.8	76	3.8			7.4	<0.1	0.2	0.15	0.7	0.08	Tr	0.04	0.01	632	628	1010	8.9		10.70	0.11	0.08	8.34	0.10	2.14
	21	F.Barber		townwater	29/7/75	5.4	0.6	11	1.2	16	13	8.5	<0.1			1.0	<0.1	<0.1	<0.02	<0.1	0.09	Tr	0.05	Tr	80	75	99	7.9		0.25	0.55	0.10	0.32	0.27	0.24
112	22	F.Norris	73	shale	29/7/75	125	1.1	23	3.4	240	J	77	0.9			9.7	<0.1	0.2	<0.02	0.1	0.1	Tr	0.01	Tr	389	386	660	8.0		5.43	1.15	0.28	4.80	0.02	2.17
					17/9/75							95	1.1	0.2	0.01													8.2	415						
107	23	F.McDonald	18	overburden	29/7/75	40	3.2	38	6.8	100	11	88	0.1			5.3	0.2	0.1	<0.02	0.1	0.7	Tr	Tr	13.1	316	314	495	7.0		1.82	1.90	0.56	2.00	0.23	2.49
81	24	D.Anderson		overburden	29/7/75	48	1.5	20	2.3	60	20	62	<0.1			4.1	0.2	<0.1	<0.02	0.1	0.09	Tr	0.54	0.07	186	185	353	6.6		2.13	1.00	0.19	1.20	0.42	1.75
					16/9/75							93	<0.1	0.1	<0.01													6.6	469						
42	25	S.Stewart	138	red shale	29/7/75	485	1.1	2.8	0.7	720	7.3	252	10.8			6.4	<0.1	<0.1	0.08	<0.1	<0.05	Tr	Tr	Tr	1168	1165	1980	8.6		21.13	0.14	0.06	14.14	0.15	7.11
					15/9/75							258	10.9	<0.1	0.03													8.7	401						
43	26	R.Foote	175	red shale	29/7/75	1170	1.4	17	3.3	585	3.5	1390	8.2			5.7	<0.1	0.4	0.04	0.2	<0.05	Tr	0.02	0.02	2958	2952	5200	8.3		50.97	0.85	0.27	11.59	0.07	39.2
					15/9/75							1430	8.4	0.4	0.07													8.5	396						
83	27	G.Thompson	78	bedrock	30/7/75	115	1.0	12	3.5	252	20	25	0.6			10	<0.1	<0.1	0.05	0.1	0.1	Tr	0.008	Tr	316	315	550	8.5		5.03	0.60	0.29	4.97		0.71
					17/9/75							26	0.7	<0.1	<0.01													8.8	392						
88	28	R.Bonvie	14	overburden	30/7/75	8.7	1.1	92	8.2	261	13	17	<0.1			10	0.4	<0.1	<0.02	0.3	0.06	Tr	0.01	0.02	304	302	495	7.3		0.41	4.59	0.67	5.21	0.27	0.48
125	29	S.Kellock	171	red shale	30/7/75	26	3.4	34	3.8	132	24	5	0.2			12	<0.1	<0.1	<0.02	0.2	<0.05	Tr	0.03	0.03	175	173	269	7.9		1.22	1.70	0.31	2.63	0.50	0.14
					16/9/75							7.2	0.3	-1.5	<0.01													7.9	401						
104	30	D.Mason	245	red shale	30/7/75	87	5.1	52	7.0	139	200	11	0.6			9.8	0.1	<0.1	<0.02	0.2	0.1	Tr	0.01	0.07	443	442	650	7.9		3.91	2.59	0.58	2.78	4.16	0.31
					17/9/75							11	0.8	1.5	<0.01													7.9	427						
97	31	A.McDonald	25.3	overburden	30/7/75	17	1.6	56	10	145	28	18	0.1			6.6	2.9	<0.1	<0.02	0.2	0.1	Tr	Tr	0.29	248	248	429	7.6		0.78	2.79	0.82	2.90	0.58	0.51
					16/9/75							20	0.2	0.3	<0.01													7.6	410						
91	32	C.Brow	30	bedrock	30/7/75	7.4	1.7	35	11	138	14	6	0.1			7.8	0.1	<0.1	<0.02	0.1	<0.05	Tr	Tr	0.14	141	137	269	8.1		0.36	1.75	0.90	2.74	0.29	0.17
49	33	G.Atwater	247	bedrock	30/7/75	78	3.8	26	6.2	212	37	14	0.2			12	<0.1	<0.1	<0.02	0.1	0.08	Tr	0.009	Tr	298	297	484	8.2		3.49	1.30	0.51	4.21	0.77	0.39
50	34	R.Polson	247	red ss+shale	30/7/75	165	1.4	1.5	0.4	309	73	8	1.1			7.8	<0.1	<0.1	0.05	0.1	<0.05	Tr	Tr	0.01	412	410	660	8.9		7.22	0.09	0.03	5.97	.52	0.23
					15/9/75							7.9	1.2	<0.1	0.01													9.1	391						
58	35	C.Adamson	14	overburden	30/7/75	6.2	0.5	31	2.6	81	13	5	<0.1			9.1	0.6	<0.1	<0.02	<0.1	0.1	Tr	0.24	0.74	107	107	203	6.8		0.28	1.55	0.21	1.62	0.27	0.14
54	36	A.Weir	135	red ss+shale	30/7/75	110	3.8	2.8	0.8	225	33	7	0.1			12	<0.1	<0.1	<0.02	<0.1	<0.05	Tr	Tr	0.009	289	289	460	7.8		4.89	0.14	0.07	4.49	0.69	0.20
					16/9/75							18	0.1	<0.1	<0.01													7.8	391						
65	37	M.Williams	75	bedrock	30/7/75	38	4.8	126	39	139	430	20	0.1			10	<0.1	<0.1	<0.02	<0.1	0.3	Tr	Tr	0.08	770	768	1320	7.6		1.77	6.29	3.21	2.78	8.95	0.56
					16/9/75							10	0.1	<0.1	<0.01													7.6	398						

APPENDIX 2 (continued)

CHEMICAL ANALYSES OF GROUNDWATERS

Analyses in mg/l

Index No.	Sample No.	Present Owner	Well Depth feet	Aquifer	Date Sampled	Na	K	Ca	Mg	Alkalinity as $CaCO_3$	SO_4	CL	F	Sr	I	SiO_2
44	38	R.Boehk	158	red shale	30/7/75	750	1.1	6.8	1.3	628	12	700	7.8			7.0
					15/9/75	760	0.8	5.8	1.4	685	<1	710	7.4	0.2	0.05	5.7
134	39	Plymouth Fire Dpt.	14.0	overburden	15/9/75	5.2	0.9	35	4.6	155	6.6	8.5	<0.1	0.1	0.04	7.8
135	40	J.Kerley	119	red shale	16/9/75	10	2.8	52	10	195	8.2	6.5	<0.1	0.7	<0.01	7.7
138	41 E	River at Ferrona		surface water	16/9/75	7.7	0.6	48	4.5	36	100	14	<0.1	0.3	<0.01	1.1
139	42 E	River at Plymouth		surface water	16/9/75	8.6	0.7	29	3.6	30	59	15	<0.1	0.2	<0.01	<1.0
136	43	G.Purvis	<10	overburden	17/9/75	30	1.2	86	8.6	228	41	44	0.3	0.2	<0.01	10
45	43A	K.MacLeod	240	red-grey shale	17/9/75	1925	1.7	40	9.2	465	9.4	2670	4.3	1.4	0.13	5.7
132	44	F.Davis	70	bedrock	22/9/75	19	2.4	52	5.5	167	29	6.7	0.2	0.5	<0.01	13
128	45	H.Wynards	175	red sh + cg	22/9/75	100	5.6	44	7.8	153	176	43	0.3	1.1	0.01	8.3
123	46	A.Nugent	100	conglomerate	22/9/75	13	2.4	54	11	155	13	39	<0.1	0.2	<0.01	9.5
133	47	J.Chennal		bedrock	22/9/75	19	8.0	37	8.6	164	16	6.7	<0.1	0.4	<0.01	13
124	48	E.McMillan	100	red shale	22/9/75	7.7	3.7	25	7.6	115	6.3	5.0	0.1	0.1	<0.01	13
126	49	L.Rafuse	273	red shale	22/9/75	46	3.3	12	2.4	142	8.2	5.5	0.2	0.2	0.01	7.5
117	50	H.Moore	136	coal shale	22/9/75	30	0.7	25	3.6	142	<1.0	6.2	0.5	0.1	<0.01	8.9
121	51	J.Williams	250	red shale	22/9/75	2800	2.5	78	16	418	10	4250	3.7	2.5	0.06	5.7
127	52	P.Boudreau	147	conglomerate	22/9/75	87	1.6	1.2	0.4	150	9.2	30	0.5	<0.1	<0.01	7.6
113	53	L.Meisner	200	bedrock	22/9/75	250	0.6	1.4	0.4	455	8.0	68	4.3	<0.1	0.02	6.9
122	54	L.Mason	100	coal shale	23/9/75	119	0.9	18	5.3	250	2.4	52	1.4	0.3	<0.01	6.1
105	55	E.Benoit	145	conglomerate	28/2/75	325	11.0	148	19	80	765	200	0.6			7.0
NT-1-75		NSDOE testhole	100	siltstone	16/12/75	498	5.8	34	8.9	786	22	300	0.8			3.2
					13/1/76	390	3.8	37	14	730	33	200	0.8			4.2
					11/2/76	320	3.6	48	16	705	25	145	0.7			5.2
					1/4/76	275	3.7	44	16	700	25	93	0.6			6.2
					30/4/76	265	3.6	46	17	720	19	80	0.5			6.6
					10/6/76	260	4.2	48	14	685	15	65	0.5			5.8
					14/6/76	262				649	15	72	0.6			5.8
					5/8/76	275	3.9	13	9.6	630	13	70	0.5			3.6
					13/10/76	265	4.1	8.1	9.4	600	10	64	0.4			1.0
INT-2-75		NSDOE testhole	50	shale	15/1/71	520	8.0	18	11	580	20	435	0.4			4.0
					11/2/76	445	6.5	33	14	555	14	410	0.3			3.2
					1/4/76	330	5.8	22	10	450	9	325	0.3			2.1
					30/4/76	390	5.8	21	12	570	6.9	388	0.3			2.2
					10/6/76	385	6.5	9.2	9.0	465	5	365	0.7			1.8
					14/6/76	420				555		400	0.3			
					5/8/76	415	6.0	13.7	11	515	5.8	355	0.3			2.7
					13/10/76	400	5.9	4.0	5.3	461	2.3	353	0.3			15.0

Ions in meq/l

Index No.	Date Sampled	NO_3 + NO_2 as N	NH_3 as N	PO_4 ortho	Fe	Mn	Pb	Cu	Zn	Total Solids	Total dissolved Solids	Conductivity µmhos/cm	pH	Eh milli-volts	Cations: Na + K	Cations: Ca	Cations: Mg	Anions: CO_3 HCO_3	Anions: SO_4	Anions: Cl
44	30/7/75	<0.1	0.3	0.04	0.2	0.05	Tr	Tr	Tr	1863	1858	3190	8.4		33.66	0.34	0.11	12.47	0.25	19.75
	15/9/75	<0.1	<0.1	0.03	0.1	<0.05	.006	0.04	0.01			3410	8.5	393	33.08	0.29	0.12	13.69	0	20.03
134	15/9/75	<0.1	0.2	<0.02	1.2	7.0	Tr	Tr	26.2	194	190	329	6.7	444	0.25	1.75	0.38	3.10	0.14	0.24
135	16/9/75	<0.1	<0.1	0.08	0.3	0.2	.006	0.09	0.13	236	234	355	7.6	413	0.51	2.59	0.82	3.90	0.17	0.18
138	16/9/75	<0.1	<0.1	<0.02	0.1	0.05	Tr	Tr	0.02	227	226	338	7.8	407	0.35	2.40	0.37	0.73	2.08	0.39
139	16/9/75	<0.1	<0.1	<0.02	<0.1	0.05	Tr	Tr	Tr	125	124	242	7.9	402	0.39	1.45	0.30	0.60	1.23	0.42
136	17/9/75	1.5	<0.1	0.04	0.1	0.05	Tr	0.03	0.04	367	364	517	7.2	329	1.34	4.29	0.71	4.56	0.85	1.24
45	17/9/75	<0.1	1.0	0.09	0.5	0.05	Tr	0.01	0.04	4916	4909	8140	8.1	366	83.9	2.0	0.8	9.30	0.20	75.3
132	22/9/75	<0.1	<0.1	<0.02	1.1	0.1	.006	0.03	0.02	227	224	385	7.6	416	0.89	2.60	0.45	3.34	0.60	0.19
128	22/9/75	<0.1	<0.1	<0.02	0.1	0.06	.009	0.04	0.02	444	443	715	7.8	399	4.49	2.20	0.64	3.06	3.66	1.21
123	22/9/75	1.4	<0.1	<0.02	<0.1	0.05	Tr	0.02	0.09	266	265	436	7.6	397	0.63	2.69	0.90	3.10	0.27	1.10
133	22/9/75	<0.1	0.4	<0.02	0.2	0.1	Tr	0.04	0.02	209	208	352	7.7	411	1.03	1.85	0.71	3.28	0.33	0.19
124	22/9/75	<0.1	<0.1	<0.02	0.3	0.2	Tr	0.01	Tr	128	127	231	7.7	392	0.42	1.25	0.63	2.30	0.13	0.14
126	22/9/75	0.1	<0.1	0.03	0.1	0.06	.006	0.01	Tr	172	170	286	8.3	437	2.08	0.60	0.20	2.84	0.17	0.16
117	22/9/75	<0.1	0.2	0.03	1.0	0.1	0.02	0.04	0.30	171	162	275	7.5	427	1.33	1.25	0.30	2.84	0.02	0.17
121	22/9/75	<0.1	1.4	0.11	1.4	0.2	.007	0.07	0.50	7357	7343	12760	7.8	415	121.9	3.89	1.32	8.35	0.21	119.9
127	22/9/75	<0.1	<0.1	0.09	0.1	0.05	.007	0.04	0.09	248	245	303	8.8	416	3.82	0.06	0.03	3.00	0.19	0.85
113	22/9/75	<0.1	0.3	0.36	0.2	0.06	Tr	0.04	0.02	633	628	990	9.0	412	10.92	0.07	0.03	9.10	0.17	1.92
122	23/9/75	<0.1	0.6	0.04	0.6	0.08	Tr	0.02	0.15	342	338	605	7.5	445	5.24	0.90	0.46	5.00	0.05	1.47
105	28/2/75	<0.1	0.1	<0.02	0.3	0.2	Tr	0.02	Tr	1619	1619	2185	7.0		14.42	7.39	1.56	1.60	15.93	5.64
NT-1-75	16/12/75	<0.1	1.7	0.02	7.7	0.5	0.02	0.14	0.05	1546	1322	2240	7.8		21.81	1.70	0.73	15.70	0.46	8.46
	13/1/76	0.5	0.1	<0.02	9.5	0.2	Tr	0.02	0.06	1205	1143	1944	7.6		17.07	1.85	1.15	14.59	0.69	5.64
	11/2/76	<0.1	1.0	0.02	9.7	0.2	Tr	0.07	0.01	1033	995	1650	8.1	290	14.01	2.40	1.32	14.09	0.52	4.09
	1/4/76	<0.1	0.9	<0.02	5.4	0.2	0.03	0.07	0.05		887	1508	8.0		12.05	2.20	1.32	13.99	0.52	2.62
	30/4/76	<0.1	0.8	<0.02	3.0	0.5				1079	1037	1350	7.6	290	11.62	2.30	1.40	14.39	0.40	2.26
	10/6/76	1.0	0.7	0.05	20.0	0.5	0.04	0.03	0.12	914	818	1117	7.6		11.42	2.40	1.15	13.69	0.31	1.83
	14/6/76												7.8		11.40			12.97	0.31	2.03
	5/8/76	<0.1	0.6	0.03	12.2	0.4	.008	0.03	0.09	852	719	1183	8.4		12.06	0.65	0.79	12.59	0.27	1.97
	13/10/76	<0.1	0.7	0.03	2.7	0.1	Tr	0.02	0.03	710	691	1110	8.9		11.63	0.40	0.77	11.99	0.21	1.81
INT-2-75	15/1/71	0.1	0.6	<0.02	23.0	1.0	<0.05	0.06	0.03	1960	1345	2310	7.9		22.82	0.90	0.90	11.59	0.42	12.27
	11/2/76	<0.1	0.5	0.02	31.0	0.7	.006	0.05	0.01	1642	1319	2300	8.2	270	19.53	1.65	1.15	11.09	0.27	11.57
	1/4/76	<0.1	0.4	0.02	12.7	0.4	0.03	0.08	0.02		985	1740	8.2		14.51	1.10	0.82	8.99	0.19	9.17
	30/4/76	<0.1	0.3	<0.02	2.9	0.1				1170	1117	1944	8.3	290	17.12	1.05	0.99	11.39	0.14	10.95
	10/6/76	<0.1	0.4	0.05	17.0	0.6	0.01	0.05	0.12	1327	1030	1760	8.9		16.92	0.46	0.74	9.29	0.10	10.30
	14/6/76																			
	5/8/76	<0.1	0.4	0.03	1.5	0.1	Tr	0.02	0.02	1121	1106	1944	8.6		18.20	0.68	0.90	10.29	0.12	10.01
	13/10/76	<0.1	0.6	0.03	3.1	0.08	<0.1	0.10	.006	1044	1022	1740	9.3		17.55	0.20	0.44	9.21	0.05	9.96

APPENDIX 2 (continued)

APPENDIX 3

SUMMARY LOGS OF WELLS DRILLED ON THE STELLARTON INTERVAL, NOVA SCOTIA DEPARTMENT OF THE ENVIRONMENT AND NOVA SCOTIA DEPARTMENT OF MINES.

INT - 1 - 75 (Dec. 9-15, 1975, N.S.Dept. of the Environment testhole)

Total Depth:	100 feet
Diameter:	8inches to 20 feet, 6 inches to 100 feet
Casing:	21 feet 10 inches of 6 1/4 inch ID casing, to approximately 20 feet below ground.
Water at:	20 feet - 2-5 gpm; 25-30 - ≥ 5 gpm
Water level:	at finish approximately at ground level
Log:	0-5 silt & fine sand 5-20 stratified sand, gravel and boulders 20-35 silty to clayey till 35-45 fine sand & gravel 45-75 find sand, silt & clay 75-80 green grey siltstone & sandstone 80-100 mainly red brown siltstone & fine grained sandstone, minor hydro carbon Bedrock at approximately 75 feet

INT - 2 - 75 (Dec. 15-16, 1975, N.S.Dept. of the Environment testhole)

Total Depth:	50 feet
Diameter:	8 inches to 20 feet, 6 inches to 50 feet
Casing:	22 feet, driven to 21.0 feet below ground
Water at:	11 feet
Log:	0-6 silt & clay 6-15 stratified sand, gravel & pebbles 15-25 gravel and clay 25-39 mainly clay; possibly thin gravel bed 32-35 ft. 39-50 bedrock - alternating, soft & hard grey shale, minor hydrocarbon

N.S.DEPT. OF MINES testhole (June 9, 1964)

0-1 topsoil
1-4 fine to medium grained sand
4-10 gravel
10-20 sand, gravel & clay (fine sand; fine gravel)
20-24 blue-grey clay
24-50 gray shale
50-60 carbonaceous shales. Thin coal bed (1") at 52 feet
60-90 silty shale

APPENDIX 4

SUMMARY LOGS OF BACKHOE TESTPITS, September 29 - October 1, 1975

#P1

0-2 till, silt-fine sand, dry & compact.
2-9 till, sandy to gravelly
9-12 coarse gravel and silt. Boulder layer at 11 feet
12-13 gravel and boulders
13-14 clay and gravel
14 greyish green, friable siltstone . Water at 13 feet.

#P2

0-4 sandy till with coarse gravel lenses
4-6.5 coarse sand, gravel and boulders. Water
6.5 greenish grey, hard siltstone.

#P3

0-1 silt
1-4.3 stratified sand, gravel and boulders. Water at 3.0 feet
4.3- 5 gravel
5-7 weathered bedrock (red sandstone)

#P4

0-2 sandy till
2-5 sand and gravel. Water
5-7 very coarse gravel and boulders
7 bedrock - red sandstone.

#P5

0-3.5 silty to clayey, red brown till
3.5 -4 sand, gravel and boulders
4-6 large boulders and clay
6-6.5 well rounded pebbles, sand and gravel with minor clay
6.5 Bedrock ?

#P6

0-4 silty to clayey till. Gravel lens at 2 feet
4-6 sandy, gravelly till
6-7 boulders
7 bedrock - red sandstone

#P7

0-3 silt and clay, possibly till
3-7 sand, gravel and boulders. Water at 7 feet
7-8.5 stratified clay and gravel. Clay hard and compact
8.5-9.5 clay with minor gravel.
9.5 bedrock ?

#P8

0-2 silt
2-6.5 stratified clay, sand, gravel and pebbles
6.5 - 7 clay
7-7.5 gravel, clay
7.5 - 8 clay
8-8.5 coarse gravel
8.5-10 hard, compact clay with gravel
10-13.5 hard clay
13.5 possibly bedrock

#P9

0-6.5 silt
6.5 - 8.5 coarse sand and fine gravel
8.5 - 11.5 pebbles and sand. Water at 8.5 -9 feet
11.5-12 hard clay

#P10

0-4.5 coarse gravel and boulders . Water at 1-2 feet
4.5-7.5 hard clay and silt, minor sandy lenses
7.5 Too hard to dig further

#P 11

0-4.5 sand, silt and clay
4.5 -8 sand, gravel and pebbles
8-15 sand, gravel and clay
15 either hard clay and boulders or bedrock

#P 12

0-2 fine sand and silt
2-13 stratified sand, gravel and pebbles
13-16 medium to coarse sand and coarse sand to fine gravel layers.

#P 13

0-3 silt
3-5.5 clayey gravel and boulders
5.5-6 boulders
6 -8.5 stratified medium sand and clay

#P 14

0-3 clayey gravel and boulders
3-7 coarse gravel and boulders
7-7.5 boulder layer
7.5-8 clayey gravel.
8-10 quicksand, with minor clay layers
10-10.5 soft, laminated clay and silty clay.

#P 15

0-4 sandy gravelly till with fine gravel lenses
4-6.3 stratified sand, gravel, pebbles
6.3-10.5 hard green clay and silty clay
10.5 bedrock or boulders

#P 16

0-2 silty till
2-5.5 stratified gravelly sand and pebbles
5.5-7 loose gravel and boulders
7-9 stratified sand, gravel and pebbles
9-11 fine sand and silt
11-15 soft, laminated silt and clay

#P 17A

0-2 sandy till
2-5 stratified sand and silt
5-6 gravel and pebbles, caving due to water inflow

#P 17B

0-1 topsoil
1-4.5 stratified sand, gravel and pebbles
4.5-7.5 gravel and pebbles
7.5 - 8 silty clay
8-11 clay and silty clay, minor sand and gravel
11-13 hard clay with gravel
13 hard - either bedrock or boulder layer

#P 18

0-2 sandy silt
2-7 stratified sand, gravel, boulders
7-12.5 laminated silt and clay
12.5 hard layer

#P 19

0-4.5 gravel and boulders
4.5 - 14 laminated fine sand, silt and clay
14 hard layer

#P 20

0-2.5 sandy silt
2.5 -8 coarse sand, gravel and boulders, crudely stratified
8-15 layered soft clay and silt

#P 21

0-5 stratified sand (fine) and silt
5-6 coarse sand and fine gravel
6-10 stratified gravel and boulders
10-11 boulder layer, some sand.

#P 22

0-1.5 sandy silt
1.5-4 stratified sand and silt
4-10.5 crudely stratified coarse sand, gravel, and pebbles. Boulder layer at 7 feet. Water at 10 feet.
10.5-15 clay and clayey silt, soft, laminated

#P 23

0-3 crudely stratified coarse sand, gravel and boulders. Water at 3 feet.
3-8.5 hard clay with gravel.

#P 24

0-5 silty sand
5-11.3 stratified sand, gravel and silt
11.3-11.5 clay
11.5-14.5 sandy silt

#P 25

0-4.3 sandy silt
4.3-5 coarse sand and fine gravel
5-7 layered fine to medium sand and silt
7-11.5 gravel and pebbles
11.5 hard layer - boulders or bedrock

#P 26

0-3.5 silty sand and pebbles
3.5-7 stratified fine sand and sandy silt
7-11 stratified gravel, pebbles and clayey sand
11-13 hard clay with gravel
13 hard layer

#P 27

0-5 silty sand
5-8 stratified sand and gravel
8-10 boulder layers
10-15 laminated soft clay and silt

#P 28

0-4 hard clay with gravel.

#P 29

0-3.5 stratified sand, gravel and boulders
3.5-5 laminated soft clay with minor silt

#P 30

0-1 clay till
1-3.5 sandy silt
3.5-11.5 clayey gravel and boulders

#P 31

0-1.5 stratified sand, gravel and boulders
1.5-4 hard clay with gravel
4-6.5 soft clay
6.5 hard layer - possibly bedrock

APPENDIX 5

NOVA SCOTIA DEPARTMENT OF HIGHWAYS BOREHOLE RECORDS

#H 1

0-2 sand and gravel with small cobbles
2-4 brown stiff sandy clay with small stones
4-7 hard brown sandy clay with small stones
7-13.5 hard dark clay with broken shale
13.5-18.5 bedrock - soft dark shale

#H 2

0-4 loose brown silty sand with small cobbles
4-7 loose brown silty sand with wood and organic fibres
7-10 hard dark broken slate shale rock
10-12 hard dark brown shale rock
12-17 shale bedrock

#H 3

0-2 sand, gravel and small cobbles
2-4 brown fine sand with small stones
4-6 brown fine sand with stones and broken shale
6-9 hard dark clay with broken shale
9-11 broken soft shale
11-15 hard dark clay with layers of shale
15-30 shale bedrock

#H 4

0-2 sand, gravel and small cobbles
2-4 brown silty clay with small stones
4-6 stiff brown silty clay with small stones
6-12.5 hard dark clay with layers of broken shale
12.5-18 bedrock - shale

#H 5

0-2 loam with sand and organic fibres
2-4 sand with small stones and clay
4-11 brown silty clay with small stones
11-16.5 hard dark clay with layers of shale
16.5-36 bedrock

#H 6

0-5 loose brown fill with small cobbles
5-8 stiff brown silty clay with small stones
8-12 loose brown silt with silty clay and small stones
12-17 dark grey clay with small stones and broken rock
17-20 dark grey broken layers of soft shale
20-26 bedrock - black shale

Holes H 1 to H 6 are from the STELLARTON INTERVAL BRIDGE over the East River.

#H 7

0-2 boulders and gravel
2-7 clay
7-12 clay and gravel
12-17 clay, gravel and broken shale
17-19 broken shale
19-24 harder shale bedrock

#H 8

0-4 gravel
4-8 silt
8-13 gravel and some clay
13-18 broken shale and clay
18-27 broken shale
27-33 harder shale bedrock

Holes H 7 to H 10 are from the ALBION MINES BRIDGE over the East River.

#H 9

0-9 sand and gravel
9-14 sand, gravel and broken shale
14-19 sand and gravel
19 22 sand and broken shale
22-29 broken shale
29-34 harder shale bedrock

#H 10

0-2 gravel
2-12 sandy clay
12-15 sand, gravel and some clay
15-17 broken shale
17-23 harder shale bedrock

Holes H 11 to H 20 are from the TRANS CANADA HIGHWAY 104 overpass. The exact locations of the holes is not known.

#H 11

0-10 coarse sand and gravel
10-18 sand, gravel and boulders
18-46 soft red clay
46-56 solid gray shale

#H 12

0-4 coarse gravel in river bed
4-38 soft red sandy clay
38-48 gray shale

#H 13

0-7 sand and fine gravel
7-21 coarse river gravel
21-39 hard red clay embedded with small stones
39-50 soft gray shale

#H 14

0-7 fine sand and silt
7-9 coarse gravel
9-30 hard red clay embedded with small stones and boulders
30-45 soft gray shale

#H 15

0-4 water
4-12 sand and gravel with small boulders (river bed)
12-34 soft clay
34-36 gravel and clay
36-42 gravel, shale and clay mixed
42-44 soft shale and clay (fault gouge)
44-55 shale

#H 16

0-6 soft red sand
6-16 coarse gravel
16-31 boulders, clay and gravel
31-40 soft gray shale

#H 17

0-7 water
7-10 boulders and gravel
10-40 soft clay
40-44 gravel and clay
44-54 shale

#H 18

0-9 very fine grained sand
9-14 gravel and clay
14-30 shale

#H 19

0-4 very soft clay
4-11 gravel and clay
11-30 very soft shale with seams of clay
30-45 shale

#H 20

0-7 clay
7-11 gravel
11-25 soft shale

NOVA SCOTIA DEPARTMENT OF MINES BOREHOLE RECORDS

#1019
0-2 surface
2-4 blue shale
4-17.6 blue shale with limestone stringers
17.6 -52 red sandy shale with limestone stringers

#1020
0-3 surface
3-30 grey limestone
30-53 blue shale with limestone stringers

#1039
0-3 surface
3-14.6 gray limestone
14.6-48 grey limestone & red clay
48-50 fine grained red sandstone

#1040
0-10.6 surface
10.6-37 fine grained red sandstone

#1041
0-10 surface
10-18 fine grained red sandstone
18-21 grey sandstone with limestone stringers
21-27 fine grained red sandstone

#1042
0-7 surface
7-12 limestone with some sandstone bands
12-21 grey & red sandstone
21-50 red sandstone

#1043
0-10 boulders & clay
10-15 sand & boulders
15-22 red sandstone

#1044
0-20 boulders & clay
20-30 red sandstone with bands of grey clay

#1045
0-20 surface
20-40 red sandstone

#2466
0-55 overburden
55-65 grey shale
65-82 red sandstone
82-123 red & grey shale
123-125 grey shale with some coal
125-230 grey sandstone
230-237 grey sandstone with small conglomerate bands
237-265 red & grey sandstone
265-277 red & grey shale
277-288 red sandstone
288-330 red & grey sandy shale
330-336 black shale with lines of coal
336-368 red & gray sandy shale
368-371 gray shale with 2 inch asphalt in a calcite stringer
371-378 soft grey shale

#3108
0-49 overburden
49-59 soft gray shale
59-76 sandy gray shale
76-87 dark shale
87-96.5 black & brown oil shale
96.5-105 splint & coal
105-130 black coal, dirty sections
130-131 soft gray shale
131-145 soft gray shale, little coal
145-147.5 coal & splint
147.5-168.5 soft gray shale
168.6-172.5 coal & splint
172.5-210 shale
210-317 shale, sandy in places
317-408 gray shale, sandy in places
408-415 oil shale & coal
415-426 gray & dark shale
426-441 oil shale & coal
441-573 gray shale, sandy in places
573-593 fine-grained gray sandstone
593-616 gray shale
616-622 dark shale (oil shale)
622-649 gray shale
649-653.5 oil shale & coal

	Overburden thickness, feet
#3584	17
#3585	20
#3586	23
#3587	20
#3588	22
#3589	15
#3590	16
#3591	17
#3592	20
#3593	21
#3594	16
#3595	15
#3596	18
#3597	15
#3598	15
#3599	18
#3600	15
#3601	18
#3602	18

#4135

0-13 overburden - reddish clay with small rocks & shale
13-36 dark gray soft, slaty shale
36-40 shaly red, firm conglomerate

#4136

0-10 overburden- red clay, gravel, red siltstone or shale
10-18.5 red sandy shale
18.5 - 24 red siltstone
24-41 red shale, somewhat sandy

#4137

0-13 overburden - red silt, sand & clay
13-17 red sandy shale
17-22.5 red siltstone
22.5- 25 red sandy shale
25-29 red siltstone
29-41 red sandy shale

#4138

0-13 overburden - clay, sand, small rocks
13-36.5 gray & red sandy shale

#4139

0-12 overburden - red silt, dark gray clay, & gravel
12-33 gray sandy shale

#4140

0-10 overburden - red clay, gray clay, gravel & shale
10-32 shale or slate

#4141

0-10 overburden - gravelly earth & reddish shale
10-33 shale or slate

#4142

0-10 overburden - reddish clay & gravel
10-32 shale or siltstone

#4143

0-49 overburden - reddish clay & small rocks
49-72 gray slaty shale, sandy in places; minor red shale

#4144

0-14 overburden - gravel, red clay & soft gray shale
14-32 slaty shale

#4145

0-5 overburden - gravel & sand
5-13 dark gray shale
13-15.5 reddish shaly conglomerate
15.5-29 dark gray shale

#4146
0-10.5 overburden - sand, gravel, gray clay & shale
10.5-15 gray shale

#4147
0-50 overburden - reddish clay & small rocks
50-73 red & gray shale, soft in places and sandy in places

#4148
0-12 overburden - red & gray sandy clay & gravel
12-33 reddish shale

#4149
0-12 overburden - clay & small rocks
12-37 fractured reddish sandstone
37-62 red & gray shale, some soft

#4713
0-21 red clay
21-35 coal & black shale
35-54 gray shale
54-55 brown sandstone

#4714
0-21 red clay
21-35 coal & black shale

#4715
0-27 red clay
27-37 black coal shale

#4716
0-27 red clay
27-33 coal & black shale

#4717
0-29 red clay
29-35 black coal shale

#4718
0-22 red clay
22-35 coal & black shale

#4719
0-22 red clay
22-25 coal & black shale

#4720
0-21 red clay
21-36 coal & black shale

#4721
0-19 red clay
19-36 coal & black shale

#4722
0-20 red clay
20-36 coal & shale

#4723
0-28 red clay
28-38 coal & black shale

#4724
0-28 red clay
28-34 coal & black shale

#4725
0-28 red clay
28-29 coal & black shale

#4726
0-28 red clay
28-35 coal & black shale

Atomic Energy of Canada Limited
L'Énergie Atomique du Canada, Limitée

Chalk River Nuclear Laboratories
Laboratoires nucléaires de Chalk River

Chalk River, Ontario,
Canada, K0J 1J0
(613) 584-3311 (via Deep River)
(613) 687-5581 (via Pembroke)

BIOLOGY AND HEALTH PHYSICS DIVISION

11 March, 1976

Miss Heather Cross,
Hydrogeologist,
Nova Scotia Department of the Environment,
P.O. Box 2017,
HALIFAX, Nova Scotia.

Dear Miss Cross:

Tritium and deuterium data for the water samples from Stellarton that you submitted last fall are listed in the attached table.

The tritium concentrations give some idea of the time scale of infiltration. The shallow samples - 16, 14 - have tritium contents characteristic of precipitation of the last few years in this region. Samples 19 and 31 show the admixture of some water of the last 20-year period to older tritium-free water. All samples from below 75 ft. depth have 0 ± 10 Tritium Units indicating more than 20 years since any of this water was in the atmosphere. Carbon-14 analyses would be required to say anything more. The negative tritium values result from the statistical distribution of counting data and are to be taken as zero tritium content.

The mean deuterium content of all the ground water samples is - 63.4 $^{o}/_{oo}$ with a small standard deviation of ± 2.2 $^{o}/_{oo}$. This concentration is quite similar to that of local precipitation of the cool part of the year. There is no significant difference in deuterium content of old and young water. Thus, the isotope data indicate that these saline waters are not entrapped or intruded marine water (0 $^{o}/_{oo}$ δD) but probably normal recharge water leaching out deposits of marine (or other) salts.

The deuterium content of the East River reflects the presence of more summer precipitation than is present in the ground waters, presumably due to greater surface runoff from summer storms. The water in Pictou harbour must have a relatively small proportion of sea water in view of the similarity of its deuterium and tritium contents to those of the East River. The tritium and deuterium contents of water from the Northumberland Strait differ from those of true sea water (0 $^{o}/_{oo}$ δD, 10-15 TU) because of the influence of continental drainage.

I did not think that ^{18}O values would add to the information obtained from the deuterium results. They would indicate if the present ground waters had undergone significant evaporation before infiltration. However, the low D values, similar to those of local precipitation, indicate that such evaporation is unlikely. Mr. R.E. Jackson looked over the chemical and isotope data briefly when he was here a few weeks ago. You may wish to talk to him about the significance of the chemical data, although he did not have a change to go into them in great detail.

I think these results illustrate the sort of information you can get from isotope measurements. I doubt if further work at this particular site will give more information unless you want to delineate the old and the recent water more closely. I will be glad to have any comments you may have on these results and the significance of my interpretation of them.

Yours sincerely,

R. M. Brown

RMB/dt
Encl.

R.M. Brown,
Environmental Research Branch.

TABLE OF SAMPLES

...ample ...umber	Name	Well Depth	Casing Length	*Bedrock	Comments	TU	δD
...A-C	Alex Sutherland	125	45	S	Drilled well <u>not</u> in park, quality fairly normal, low F	-7.±6.	-68
...A-C	Plymouth School	300		S	High NaCl,F, deepest well	10±5	-63
...I-C	Scott MacDonald	22'		S	Dug well, normal, in park	55±8	-65
...I-C	Harry Conway	14		S	Dug well, salty, in park	65±5	-64
...5-C	Earl Kellock	3.8'		S	Dug well, possible road salt, in park	69±7	-64
...7-C	George MacKenzie	56		S	high NaCl, F, HCO_3, <u>not</u> in park	20±7	-62
...5-C	Sheldon Stewart	138		S	High Na, HCO_3, F, near park	-5±6	-63
...5-C	Ralph Foote	175	100	S	High NaCl, F, shallower drilled well near park	-1±6	-59
...7-C	G.Thompson	78		S	Quality normal, but near boundary of problem wells	10±6	-62
...I-C	Alex MacDonald	25.2		W	Dug well over Windsor Group, Bedrock	28±5	-63
...7-C	N. Williams	75		W	Drilled well in Windsor Group Bedrock	0±6	-64
...2-C	East River			S	Surface water at park bridge.	48±5	-48
...W-1	Sea Water				Seawater - freshwater mixture from Pictou Harbour.	45±9	-51
...W-2	Sea Water				Seawater from Northumberland Strait	29±7	-18
		<u>1967-69 Precipitation:</u>			Halifax: Summer Ave. (½ year)		-37
					Winter Ave.		-67
					Fredericton: Summer Ave.		-50
					Winter Ave.		-94
					Gander: Summer Ave.		-58
					Winter Ave.		-74

...S - Stellarton Series
... - Windsor Group

APPENDIX 8

DEPARTMENT OF PUBLIC HEALTH
NOVA SCOTIA

N.S. DEPT. OF ENVIRONMENT
APR 30 1976
RECEIVED

April 29th, 1976

Mr. John F. Jones
Chief, Groundwater Section
Water Planning and Management Division
Department of Environment
Province of Nova Scotia

Dear Mr. Jones:

RE: Flouride in well water
Plymouth area, Pictou County

I am writing with reference to our consultations with respect to the identification of flouride in well water in the Plymouth area of Pictou County last Fall.

As you know, the matter was referred to our Division of Dental Health Services, and since that time the Director of the Division, with the assistance of his staff has been looking into the possible ramifications of the presence of flouride in drinking water, on the basis of on-site visits and investigations.

By way of update the Dental Hygienist has now completed examinations of 77 school children at the Dr. W.A. MacLeod School in Riverton. These children, ranging in age from 5 to 12 years of age were found to be essentially free of dental fluorosis. On the basis of a scale ranging from normal through questionable, very mild, moderate, to severe, all except three were considered to be in the normal range. In three instances questionable fluorosis was identified. Individuals in this category could only be identified on the basis of examination by a highly trained examiner. Any relationship to exposure to high concentrations of flouride in these instances is also questionable.

Further attention to this situation will be maintained by the Division of Dental Health Services. Certainly at the present time there would appear to be no cause for concern.

Yours truly,

C.E. Tupper, P.Eng.
Administrator
Health Engineering Services

CET:bah