GOVERNMENT OF BRITISH COLUMBIA

MEMORANDUM

TO J. C. Fowraker
Head
Groundwater Section

FROM A. P. Kohut
Senior Geological Engineer
Groundwater Section

September 14 1976

SUBJECT Ladysmith Groundwater Study

OUR FILE 0239013

YOUR FILE

As directed by Mr. Brady, in his letter of June 24, 1976 to the Town of Ladysmith, a review of available groundwater information and a limited field inventory has subsequently been completed of the Ladysmith area. The area examined was within a three mile radius of the Town (Figure 1) as this has been considered the approximate economic limit for a source of water supply (pers. comm., T. Pollard, Chief Engineer, Community Water Supply Division).

The investigation included a review of existing well log data, updating of well logs, examining surficial geology maps and reports, air photograph analysis, water sampling of representative wells, field checking of local geology and well inventories in specific areas. This report summarizes the available groundwater data and recommends sites where test drilling is warranted with anticipated costs for drilling and aquifer testing programs.

GENERAL GEOLOGY

The Ladysmith area is primarily underlain by Upper Cretaceous rocks of the Nanaimo Group comprised of shale, sandstone, conglomerate, arkose and coal. Immediately west of Ladysmith the upland region is underlain by Jurassic intrusive rocks (Island Intrusions) including granodiorite, quartz diorite, gabbro and granite (Rice, 1959; Bostock, 1963; Muller, 1971). Surficial deposits of glacial, fluvial and marine origin mantle the bedrock over most of the area although thickness of these materials varies locally. Bedrock for example is exposed on islands in Ladysmith harbour, over much of the upland west of Ladysmith and lies only under a thin drift cover northeast of Ladysmith harbour (Figure 2).

SURFICIAL DEPOSITS

The surficial geology of the region has been described by Halstead (1963, 1966) and mapped at a scale of one-inch to one mile. Major features only of the surficial deposts within the area of concern are reviewed here along with information, obtained on the nature, stratigraphy and distribution of the deposits, from an examination of air photographs, well logs and field checks. These deposits are considered the most favourable for locating any large producing wells.

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Fluvial Sand and Gravel Deposits

Terraced fluvial deposits of gravel, sand and lag gravel with cobbles occur at the head of Ladysmith harbour, immediately northeast of Ladysmith town along Bush Creek in the area of Ivy Green Provincial Park and locally along creek valleys south of Ladysmith (Figure 2). The area at the head of Ladysmith harbour represents the southern extremity of a large low lying region to the north underlain by sands and gravels locally referred to as the "North Oyster Aquifer". Maximum thickness of the deposits near Ladysmith harbour are not known as most wells are commonly completed within the upper 20 to 40 feet of the deposits. Further north, thicknesses of sand and gravel up to 170 feet have been reported in test holes drilled for the Harmac pulp mill (Odynsky, 1950). Elsewhere for example in the Ivy Green Park area the deposit is not very thick (13 feet) and is found to overlie clay.

The gravels are buff to brown in colour, somewhat silty, cross-bedded locally and moderately sorted with well rounded pebbles and cobbles of varying mineralogy including granitic, volcanic and sandstone rock types. Where exposed the gravels commonly overlie a laminated buff silt interbedded with medium to coarse sand.

Marine Deposits

A gravel and sand marine veneer mantle older ground moraine deposits and/or bedrock west of Ladysmith. The deposits are extensive along the flank of the bedrock upland and are mainly found below an elevation of 400 feet. Maximum thickness of the deposit is not known but the unit probably varies from a few feet to several tens of feet locally.

Ground Moraine Deposits

Glacial till with lenses of gravel, sand and silt occurs adjacent to the marine deposits flanking the bedrock upland west of Ladysmith. The unit probably varies considerably in thickness throughout the area. Associated outwash glacio-fluvial deposits of sand and gravel may also occur with till deposits in the area immediately west of Ladysmith where there is some evidence of a hummocky, kettled topography between elevations of 350 and 450 feet.

WELL DATA

Available well data for a limited number of shallow dug and drilled wells (15 to 30 feet deep) in the region underlain by fluvial sands and gravels at the head of Ladysmith harbour indicate yields up to 30 gpm may be readily

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obtainable. Water levels are generally in the range six to fifteen feet below ground surface with seasonal fluctuations of a few feet anticipated. Although no wells have apparently been completed in the surficial sands and gravels along Bush Creek, a 74-foot 6-inch diameter well completed in fractured sandstone underlying the unit in Ivy Green Park was pump tested at 30 U.S.gpm with 19 feet of drawdown in 1959. Maximum yield of the well may be several tens of gallons per minute. The high capacity of the well may be related to proximity of the well to adjacent sand and gravel deposits and/or Bush Creek. Elsewhere in the region supplies from individual wells are generally obtainable for domestic purposes (1 to 5 gpm) throughout the area underlain by marine deposits and/or from the bedrock.

Water Quality

Water samples were collected from representative wells and laboratory analyses were conducted for major ions. No bacteriological tests were conducted. Results of the analyses are listed in Table I. Conductivity values of the samples were plotted in Figure 2 to indicate regionally the mineralization of groundwater in the area.

In general, the quality of the groundwater appears to be very good. Total dissolved solids are less than 200 ppm and total hardness is low.

There are two exceptions to the above statement, however. Two wells sampled showed a high sodium bicarbonate concentration together with a higher total dissolves solids content. One of these wells also contained a high nitrogen content.

RECOMMENDED DRILLING SITES

Test drilling is recommended at sites A, B, C and D shown in Figure 2. The best prospects are at site A. Although this locality may be at the economic limit for a source of supply, indications are that a well capable of yielding several hundred gallons per minute could be developed in the area. The remaining sites should be regarded as exploratory sites. They are, however, more attractive from the standpoint of a distribution system and there are some prospects of developing wells capable of yielding several tens of gallons per minute in these areas. All testholes should be cased with minimum 6-inch diameter casing to facilitate adequate pump testing and should be drilled by the cable-tool or air rotary method with casing hammer. Larger diameter casing (8-inch) could be considered to complete test production wells in which case it would be preferable to install the wells by the cable-tool method to obtain reliable samples for screen analysis and well design. Testholes should be completed to bedrock at each of the sites or up to 200 feet if bedrock is not encountered and depending upon the materials penetrated. Anticipated drilling conditions and proposed program at each of the sites are as follows:

Site A

It is anticipated the testhole will encounter a few feet of clay at the surface underlain by 20 to 30 feet or more of gravel. The gravel may overly silt or clay and drilling should be continued through these deposits to explore for sand and gravel at greater depths. Surface casing should be installed in case artesian conditions are encountered at depth. The well should be screened with 5 to 10 feet of screen and pump tested for at least four to eight hours and completed as an observation well. Should conditions prove favourable an eight-inch diameter production well should be drilled at the site north of the observation well and pump tested for a minimum of 24 hours. In this manner the observation well could be utilized to monitor any possibilities of sea water encroachment that may occur due to the proximity of the site to the sea.

Site B

It is anticipated the drilling at Site B will encounter surficial sands and gravel overlying clay silt and/or till with the possibility of sand and gravel at depth resting on bedrock. Bedrock, however, may also occur at a relatively shallow depth at this site. Surface casing should be installed in case artesian conditions are encountered at depth. Should conditions look favourable the well should be screened and pump tested for at least 24 hours if completed in sand and gravel to test for boundary conditions and for a longer period (2 to 3 days) if completed in bedrock.

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Site C

Drilling is anticipated to encounter glacial till and/or sand and gravel at this site. If conditions are favourable the well should be screened and pump tested for 24 hours.

Site D

Surficial sands and gravels are expected to occur at this site underlain by silt and/or glacial till. The hole, however, should be continued to bedrock to explore for gravel and sand at depth. If conditions are favourable the well should be screened and pump tested for 24 hours to test for boundary conditions. The testhole should be located as close to Holland Creek as possible near Creek elevation. It should be noted that Site D is situated opposite the abandoned Ladysmith garbage dump and provision should be made for establishing water quality moniotr wells if a production well is contemplated at the site.

ESTIMATED COSTS OF DRILLING AND AQUIFER TESTING

Cost estimates for drilling and aquifer testing programs can be based primarily on whether 6-inch or 8-inch diameter wells are completed as follows:

(a) 6-inch diameter well

1.	Drill and case 8-inch to 30 feet at $23/foot.	$ 690
2.	Drill and case 6-inch to 170 feet at $14/foot.	2,380
3.	Overlap casing 30 feet at $10/foot.	300
4.	One 8-inch drive shoe	75
5.	One 6-inch drive shoe	30
6.	40 hours of hourly work at $30/hour.	1,200
7.	10 feet of nominal diameter well screen	600
8.	24-hour pump test	2,000
	Total	$ 7,275

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(b) 8-inch diameter well

1.	Drill and case 10-inch to 30 feet at $30/foot.	$ 900
2.	Drill and case 8-inch to 170 feet at $23/foot.	3,910
3.	Overlap casing 30 feet at $12/foot.	360
4.	One 10-inch drive shoe	150
5.	One 8-inch drive shoe	75
6.	40 hours of hourly work at $30/hour.	1,200
7.	10 feet of nominal diameter well screen.	700
8.	24 hour pump test	2,000
	Total	$ 9,295

Suggested drilling and testing programs which might be considered to assess and prove up the groundwater prospects in the Ladysmith area are as follows:

A. Complete one 6-inch diameter test well to 200 feet northwest of Ladysmith harbour in Area A as an observation well. If conditions are favourable, install an 8-inch diameter well for production purposes. Estimated cost should be a maximum of $16,600. Moreover, it is not anticipated that the second well would be drilled necessarily to 200 feet so costs should remain below this figure. If conditions are not favourable the other sites should be explored with total costs therefore ranging from $14,600 to $29,100 depending on the number of sites investigated.

B. Complete one 6-inch diameter test well at each of the four sites A, B, C and D. Estimated costs should be a maximum of $29,100 if drilling is completed to 200 feet at each site.

C. Complete one 8-inch diameter test production well to 200 feet in Area A where conditions are the most favourable and investigate the remaining sites. Estimated costs will range from $9,300 to $31,000 depending on results at Site A and number of additional sites investigated.

Of the above, program A is preferred since the prospects in Area A are the most favourable for obtaining large amounts of water (100 to 600 gpm) and additional exploration costs elsewhere may not be necessary. The area is, however, furthest of the sites from Ladysmith and it may be worthwhile to investigate some of the other sites which if favourable, would reduce pipeline costs.

The above costs do not include supervisory costs which may be tentatively estimated at 15 percent of the drilling costs. This would include one engineer and one technician as required during the project.

REFERENCES

Bostock, H. H. (1963) - Geology, Squamish, British Columbia, Map 42-1963, Geological Survey of Canada.

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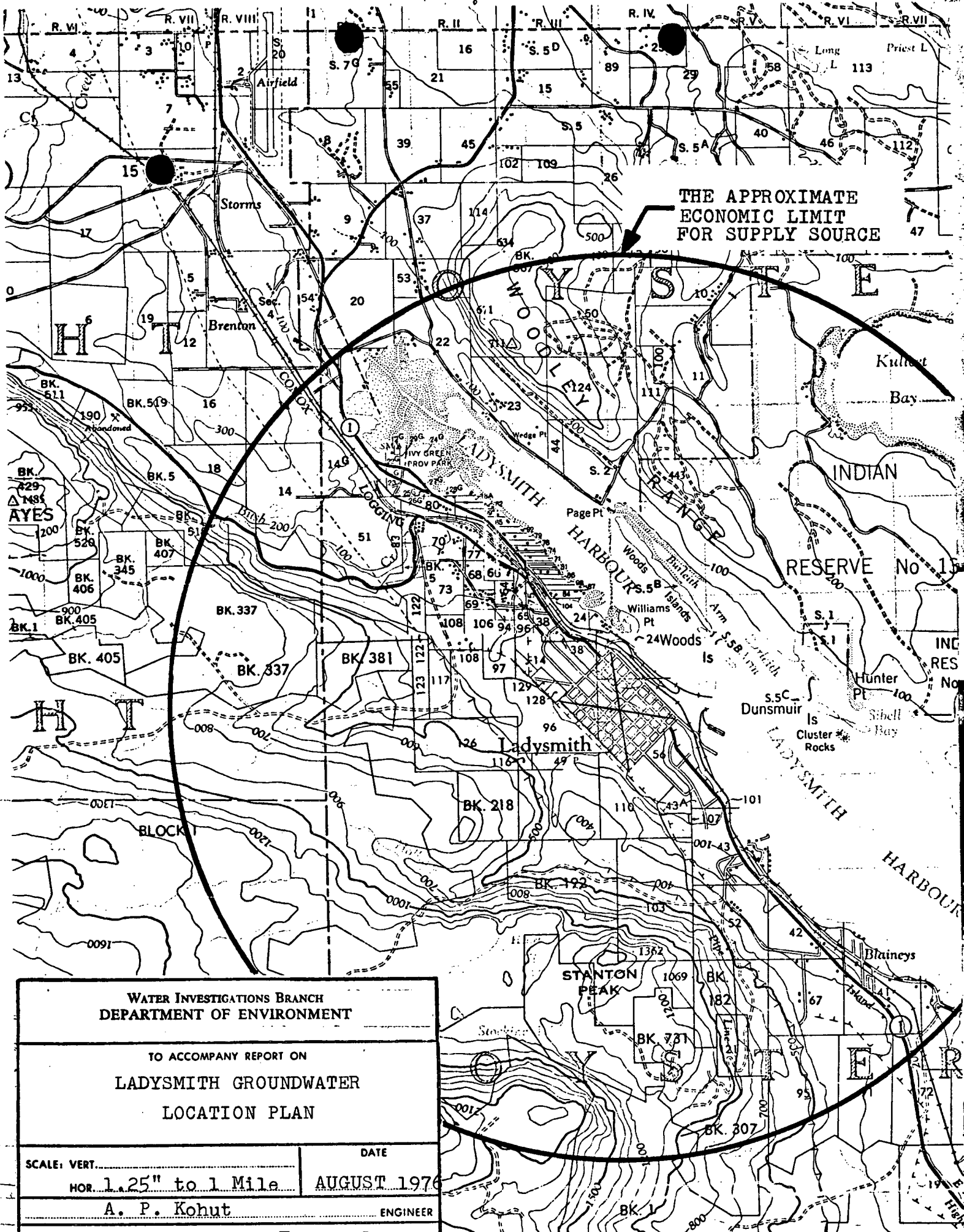
Muller, J. E. (1971) - Geological Reconnaissance Map of Vancouver Island and Gulf Islands, Geological Survey of Canada, Open File Map.

Odynsky, P. G. (1950) - Preliminary Report on Groundwater Resources of the Cassidy Area, British Columbia Water Resources Service, File 0172183.

Rice, H. M. H. (1959) - Geology, Victoria-Vancouver, British Columbia, Map 1069A, Geological Survey of Canada.

J C Fowler

for A. P. Kohut



WATER INVESTIGATIONS BRANCH
DEPARTMENT OF ENVIRONMENT

TO ACCOMPANY REPORT ON

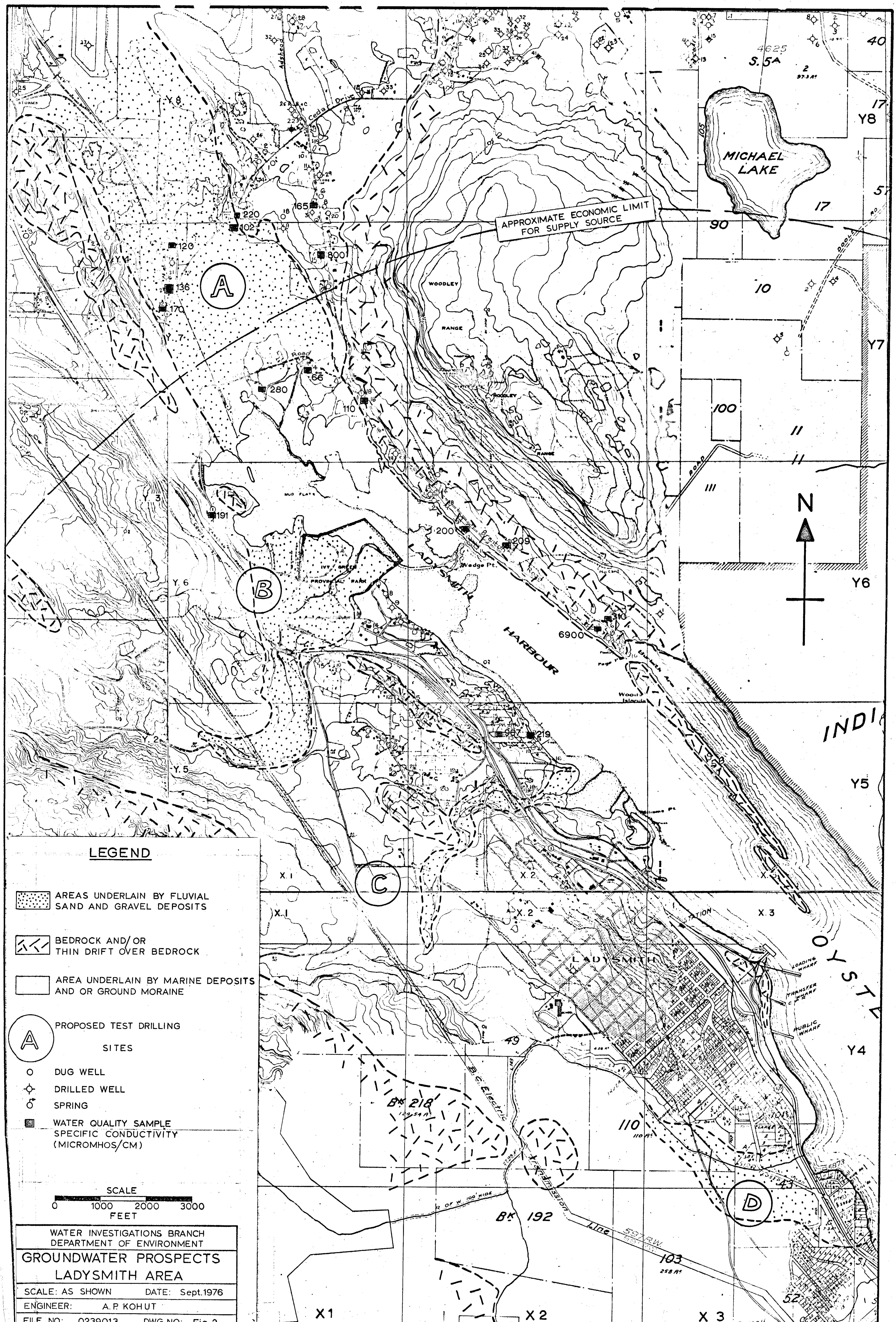
LADYSMITH GROUNDWATER LOCATION PLAN

SCALE: VERT.	DATE
HOR. 1.25" to 1 Mile	AUGUST 1976
A. P. Kohut	ENGINEER
FILE No. 0239013	DWG. No. Figure 1

Chemical Analyses of Water Samples: Ladysmith Area

* Units in mg/l except pH (relative units)

Site	Location	Sampling Depth (feet)	Laboratory Analysis *	pH	Specific Conductivity (micromhos/cm)	Filterable Residue	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	SO_4^{2-}	Cl^{-}	Total Iron	Total Manganese	Total Phosphorus Dissolved	Nitrogen Nitrate plus Nitrate	Total Alkalinity	Total Hardness as $CaCO_3$	pH (Field Test)	Specific Conductivity (Field Test)	Temperature °C (Field Test)
Manana Lodge	X2,Y6,#6	46	26/7/76	-	310	192	21.5	4.8	41.5	0.9	< 5.0	5.3	0.2	0.02	0.028	-	-	73.4	8.75	295	17
Reiber	X2,Y6,#15	42	26/7/76	-	200	138	21.5	5.2	10.1	0.8	19.4	12.5	0.2	0.02	0.007	-	-	75.1	6.75	210	12
Fowler	X2,Y6,#20	200	26/7/76	-	209	142	5.0	1.1	42.2	0.4	8.7	9.0	0.7	0.02	0.006	-	-	17.0	6.75	200	19
Kuusisto	X1,Y7,#4	15	26/7/76	-	66	50	6.1	1.3	4.6	0.9	< 5.0	3.6	0.4	< 0.02	0.007	-	-	20.6	6.50	70	16
Weatherell	X1,Y7,#16	80	26/7/76	-	110	84	14.6	1.8	4.5	0.2	< 5.0	3.2	0.3	< 0.02	0.007	-	-	43.9	6.75	120	19
Public Works Department	X1,Y6,#4	Surface	26/7/76	-	191	118	23.8	7.7	5.7	0.6	6.3	2.1	0.1	< 0.02	0.018	-	-	91.1	7.75	200	9
Bourgne	X1,Y7,#15	235	23/7/76	9.3	800	500	0.80	0.08	199.0	0.3	< 5.0	13.3	0.1	< 0.02	0.018	0.02	408.0	2.33	9.25	750	19
Russel	X1,Y7,#9	8	23/7/76	7.1	102	70	10.9	2.8	4.5	0.5	< 5.0	5.1	0.2	< 0.02	0.007	0.08	41.2	38.7	6.75	100	17
Nowell	X1,Y7,#22	20	23/7/76	6.8	136	110	14.0	3.3	5.5	0.5	< 5.0	20.7	0.1	< 0.02	0.003	0.22	29.9	48.5	6.0	140	14
Mortella	X2,Y5,#26	80	11/8/76	9.3	967	566	0.97	0.23	213.0	0.5	< 5.0	118	8.8	-	0.155	< 0.02	308.0	3.37	-	-	-
Covick	X4,Y3,#4	17	11/8/76	6.9	194	134	23.6	5.4	6.4	0.3	9.1	15.2	0.6	-	0.003	0.03	64.8	81.2	-	-	-
Johnson	X2,Y5,#8	56	11/8/76	7.3	219	138	36	2.4	6.3	1.3	< 5.0	5.6	6.4	-	0.003	< 0.02	102	99.8	-	-	-
Martella	X2,Y5,#13	50	11/8/76	6.6	228	168	21.2	5.6	10.4	0.8	6.2	26.1	0.3	-	0.003	2.4	55.7	76.0	-	-	-
Hargreaves	X4,Y3,#3	60	11/8/76	8.4	220	128	16.8	1.5	18.8	3.3	5.0	37.2	42.6	-	0.006	0.11	65.5	48.1	-	-	-
Allin	X2,Y6,#22	90	11/8/76	7.6	6900	4586	294.0	97.0	1050.0	3.6	204.0	2180.0	0.2	-	0.005	0.72	158.0	1130.0	-	-	-
Scouler	X1,Y7,#12	20	18/8/76	7.3	178	112	12.0	3.20	17.2	0.7	5.0	23.9	2.4	0.12	0.003	0.02	44.4	43.1	7.0	170	17
Westover	X1,Y8,#16	14	18/8/76	7.2	214	150	23.7	5.8	8.1	0.7	14.3	12.5	0.1	0.02	0.012	2.10	67.2	83.1	6.5	220	13
Tremblay	X1,Y7,#5	16	18/8/76	6.7	119	82	10.4	2.4	7.3	0.4	5.0	13.5	0.2	0.03	0.003	0.28	32.2	35.8	6.5	120	14
Ken's Auto	X1,Y7,#22	54	18/8/76	6.6	129	108	12.1	3.0	5.7	0.7	5.0	15.8	0.1	0.02	0.004	0.15	33.2	42.6	5.75	125	14
Davis H	X1,Y8,#7	28	18/8/76	6.7	166	110	14.9	3.9	10.9	0.8	14.3	5.6	0.4	0.05	0.003	0.91	57.0	53.3	6.25	165	16
Schon Timber	X1,Y7,#23	19	18/8/76	6.7	289	194	29.8	7.9	14.3	2.2	11.9	19.4	1.1	0.20	0.031	0.37	106.0	107.0	6.5	280	13


APPROXIMATE ECONOMIC LIMIT
FOR SUPPLY SOURCE
MICHAEL LAKE
S. 5A
4625
WOODLEY
RANGE
MUD FLATS
IVY GREEN PROVINCIAL PARK
LADYSMITH HARBOUR
Wedge Pt.
Woods Islands
INDI
OYSTE
LADYSMITH
LOADING WHARF
TRANSFER WHARF
PUBLIC WHARF
STATION
Cedar Drive
Adshead
Road
Brenton
B.C. Electric
Transmission Line
Russell
Y8
Y7
Y6
Y5
Y4
Y.8
Y.7
Y.6
Y.5
Y.4
Y.3
Y.2
X.1
X.2
X.3
X1
X2
X3
BK 218
BK 192
10
11
100
111
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105
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103
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102
120
136
170
165
800
280
66
110
191
200
209
310
6900
967
219
A
B
C
D
N
LEGEND
AREAS UNDERLAIN BY FLUVIAL SAND AND GRAVEL DEPOSITS
BEDROCK AND/OR THIN DRIFT OVER BEDROCK
AREA UNDERLAIN BY MARINE DEPOSITS AND OR GROUND MORAINE
PROPOSED TEST DRILLING SITES
DUG WELL
DRILLED WELL
SPRING
WATER QUALITY SAMPLE SPECIFIC CONDUCTIVITY (MICROMHOS/CM)
SCALE
0 1000 2000 3000
FEET
WATER INVESTIGATIONS BRANCH
DEPARTMENT OF ENVIRONMENT
GROUNDWATER PROSPECTS
LADYSMITH AREA
SCALE: AS SHOWN DATE: Sept.1976
ENGINEER: A.P. KOHUT
FILE NO: 0239013 DWG.NO: Fig. 2