Province of British Columbia
Ministry of Environment
INVENTORY AND ENGINEERING BRANCH

MEMORANDUM

To: H.I. Hunter, Head
Hydrology Section

Date: August 6, 1980

File: 92 F 8

Re: Contamination of Well Water, Nanoose Area

At the request of Mr. O. Hals, Regional Engineer with the Environmental Engineering Division a preliminary groundwater investigation was undertaken to assess the possible source of the reported ammonia nitrogen and phosphorous levels found in the Beachcomber Water System wells near Brynmarl in the Nanoose area. In the course of this investigation all available groundwater information was reviewed including water quality analyses provided by the Central Vancouver Island Health Unit for wells in the area. An air photograph analysis of the area was undertaken to delineate surface drainage features, groundwater discharge areas (springs and seepage areas) and local geologic conditions. On April 3, 1980 a one day field visit was made to the area to assess the local groundwater conditions and verify field features observed on air photographs of the area. Following this field visit, eleven water samples were collected on April 8, 1980 from groundwater discharge points and surface drainage sites located upslope and east of the Beachcomber wells. This memorandum reviews the nature of the water quality problem, outlines the hydrogeologic conditions of the area, suggests possible sources for the nitrogen and phosphorous levels and makes reommendations for further investigations and monitoring which might be given consideration.

Topographic and Geologic Setting

The Beachcomber wells (Figure 1) are sited along an east-west trending topographic knoll lying some 200 to 300 feet above sea level. This knoll forms a local drainage divide whereby runoff originating on the upland to the east is diverted northwesterly towards Northwest Bay and also southwesterly into a low lying area that eventually discharges eastward into Nanoose Harbour.

The Beachcomber wells are underlain by a succession of unconsolidated glacial and alluvial deposits (Fyles, 1963) occurring along the western flank of a bedrock upland (Figure 1) comprised of Middle Pennsylvanian rocks including argillite, greywacke, conglomerate, minor limestone and tuff (Muller and Carson, 1969). Available well records indicate up to 220 feet of unconsolidated deposits overlie bedrock in the area of the Beachcomber wells. A geologic cross section showing the relationship of the surficial deposits and the bedrock is shown in Figure 2.

Groundwater Conditions

The Beachcomber #1 and #2 wells have been completed at depths of 163 and 175 feet respectively and screened within a thick, confined sand and gravel aquifer ranging in thickness from 48 to 60 feet occurring between

100 and 180 feet below ground. This confined aquifer is overlain by silty clay, glacial till and interbeds of sand. The aquifer materials appear to belong to the Quadra Sediments (Fyles, 1963) as these are found exposed at the surface below the 200 foot elevation at Nanoose Harbour and west of Northwest Bay. Non-pumping water levels in the deep aquifer have been reported in the range 93 to 107 feet below ground surface. Groundwater also occurs under shallow water-table conditions within the surface sand and gravel deposit which overlies glacial till locally. Some shallow dug wells (e.g. Terrien well) have been completed in this aquifer. A summary of the well logs in the area is shown in Table 1. On the bedrock upland east of the Beachcomber wells shallow groundwater is found within a thin veneer of sediments occupying a local depression in D.L.64 (Figure 3). Several small springs and seepage areas occur in this area.

Chemical Analyses of Well Waters

Results of water quality analyses completed on samples taken from the three Beachcomber wells and other wells in the area are listed in Table 2. In general, water quality in the deep aquifer is of the calcium-sodium-bicarbonate, or sodium-calcium-bicarbonate types with total dissolved solids in the range 174 to 275 mg/L. Reported total phosphorous levels range from 0.438 to 1.65 mg/L, phosphorous as orthophosphate from 0.417 to 0.562 mg/L and total Kjeldahl nitrogen in the range 0.6 to 19 mg/L. Nitrogen as ammonia NH_3 has been reported in the range 0.56 to 2.66 mg/L. Nitrogen as NO_2^- (nitrite) and NO_3^- (nitrate) has been essentially absent with levels of NO_3^- generally less than 0.02 mg/L and NO_2^- less than 0.005 mg/L. From these analyses it is apparent that nitrogen in water from the deep aquifer occurs primarily as ammonia NH_3 and as some organic nitrogen, with phosphorous primarily occurring in the dissolved orthophosphate form. Samples obtained from the shallow water-table aquifer (Terrien wells) indicate water of the calcium-bicarbonate type, low in total phosphorous (0.014 to 0.03 mg/L) and low in Kjeldahl nitrogen (0.15 to 0.33 mg/L). Nitrate nitrogen in the old Terrien well was however reported at 1.23 mg/L in December 1979.

Sources of Nitrogen and Phosphorous

There are in general three possible sources, one or more of which may be contributing to the observed concentrations of nitrogen and phosphorous in the Beachcomber wells. These possible sources are:

1. atmospheric precipitation.

2. man's activities, including the disposal and/or spreading of animal wastes, domestic sewage, fertilizers or industrial chemicals on the land surface or into the subsurface (i.e., landfills).

3. naturally occurring deposits (minerals, organic matter) within the aquifer, in adjacent deposits or at the land surface (soils, compost).

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A discussion of each of these possible sources is given below:

1. Atmospheric Precipitation

Nitrogenous compounds generally reported in the forms NH_3(ammonia), NH_4^+ (ammonium), NO_3^- (nitrate) and total nitrogen are always present in the atmosphere and are carried down in precipitation falling on the earth's surface (Carroll, 1962). Originally these compounds would be derived from terrestrial sources, introduced into the atmosphere for example in the form of organic matter in soil dust or as a result of industrial air discharges. Data on nitrogen concentration in rainfall over England and Wales for example indicates levels in the range 1 to 4 mg/L with higher levels associated with rainfall over urban areas (Central Water Planning Unit, 1977). Carroll (1962) has reported nitrate and ammonia levels in rainfall in northern Europe ranging from 0.27 to 1.6 mg/L and 0.41 to 8.7 mg/L respectively. From several localities in the conterminous United States, Carroll (1962) also reported nitrate concentrations in the range 0.72 to 4.68 mg/L and ammonia levels in the range 0.05 to 2.21 mg/L. From the above examples it would appear to be plausible that the levels of ammonia and total nitrogen in the Beachcomber wells might be derived from recharge to the aquifer of precipitation containing these constituents. If derived from the atmosphere, i.e., one common source, the levels of nitrogen in the aquifer however, would not be expected to vary considerably from well to well as shown in Table 2. Levels of ammonia and nitrogen in the shallow water-table aquifer should also be similar to the levels reported in the deeper aquifer if precipitation were the source of these constitutents.

Data on phosphorous levels in precipitation are not readily available. From the variability in levels and differences observed in the deep aquifer and the water-table aquifer it would appear that precipitation would not be the major source of the phosphorous levels observed in the deep aquifer.

2. Man Activities

Dissolved nitrogen in the form of nitrate (NO_3^-) is one of the most common contaminants found in groundwaters as a result of man's agricultural activities and the disposal of sewage on or beneath the land surface (Freeze and Cherry, 1979). Nitrates that enter the groundwater system may originate as nitrates in wastes or fertilizers applied to the land surface (direct sources) or through the conversion of organic nitrogen sources into ammonium and nitrate. The process of conversion of organic nitrogen to NH_4^+ is known as ammonification and through the process of nitrification, NH_4^+ is converted to NO_3^-. Ammonification and nitrification are processes that normally occur above the water-table generally in the soil zone, where organic matter and oxygen are abundant. Nitrate because of its anionic form is very mobile in groundwater and may migrate large distances from input areas (Freeze and Cherry, 1979). NH_4^+ on the other hand because of its positive valence can be readily adsorbed on clay or silt-sized particles in geologic materials and does not migrate as readily as nitrate in the subsurface environment. Given a source of organic matter and abundant NO_3^-, bacterial systems in soil above the water-table are moreover capable of denitrifying large amounts of NO_3^- to N_2O and N_2 and possibly NH_4^+ (Freeze and Cherry, 1979). In animal wastes nitrogen is present in urea and through the process of hydrolysis under dry aerobic soil conditions transformation to NH_4^+ and eventually NO_3^- (through nitrification) can occur. In situations where the soil is essentially saturated with water and anaerobic conditions are prevalent, NH_4^+ may not be converted to NO_3^- (Robertson et al, 1974).

Phosphorous may be introduced into groundwaters through the widespread use of fertilizers and disposal of sewage on land. Dissolved inorganic phosphorous in water occurs primarily as H_3PO_4, $H_2PO_4^-$, $H\ PO_4^{2-}$, and PO_4^{-3} with the dominant species in the normal pH range of groundwater being $H_2PO_4^-$ and HPO_4^{2-} (Freeze and Cherry, 1979). As these species are negatively charged, the mobility of dissolved phosphorous in groundwater below the organic-rich horizons of the soil zone is not strongly limited by adsorption. Dissolved phosphorous in groundwater therefore could migrate considerable distances. In the well drilling industry, polyphosphate additives are occasionally used during drilling and well development to disperse clay particles around the well screen to increase well efficiency. Any phosphate compounds introduced into the aquifer, however, would be expected to be removed with prolonged well pumping.

A field check of local agricultural activities in the area of the Beachcomber wells and subsequent water quality sampling of springs and surface runoff (Figure 3) indicated the presence of moderate levels of ammonia (0.200 to 0.210 mg/L) and organic nitrogen (2.0 mg/L) in runoff originating from a livestock holding area located in the southwest corner of D.L. 64 along Stewart Road. These analyses are listed in Table 3. In April 1980 runoff from the area of the livestock operation was flowing westerly through a culvert under Stewart Road towards D.L. 84. Much of this runoff appears to be generated by locally high water-table conditions and natural groundwater discharge in D.L. 64 (Figure 3). On the west side of Stewart Road this runoff was observed to disappear into the subsurface. Further west downslope runoff reappears and is directed into a dugout east of Claudet Road. The ammonia and organic nitrogen levels observed in the dugout (0.022 and 0.34 mg/L respectively) and in the runoff flowing into the pond (0.021 and 0.26) are however, considerably less than those observed in runoff from the livestock operation upslope. Nitrite plus nitrate levels in the runoff from the livestock operation were found to be low and not greater than 0.08 mg/L. Phosphorous levels in the runoff from the livestock holding area were also low with total phosphorous in the range 0.090 to 0.105 mg/L and orthophosphate not greater than 0.005 mg/L. From these results it would appear that the runoff from the livestock holding area could be a source for the ammonia and organic nitrogen levels observed in the Beachcomber wells.

Although present, the ammonia levels however, in the Beachcomber wells are an order of magnitude higher than those observed in the runoff. This runoff moreover does not appear to be a major source of phosphorous. In April 1980 only a few head of livestock (cattle) were being kept in D.L. 64. It is not known whether larger numbers of livestock may have been maintained in this area in the past and whether the water quality of the runoff may have varied accordingly. Seasonal variations in nitrate-nitrogen and Kjeldahl nitrogen levels in feedlot runoff and groundwater adjacent to feedlots for example, have been reported elsewhere (Irwin and Robinson, 1974; Staley et al, 1976). Seasonal changes in the concentrations of these parameters may be related to several factors such as, changes in precipitation, seasonal water-table fluctuations, changes in animal density and waste loading, climatic variations including temperature and evaporation changes, variations in waste spreading methods, thickness of waste pack, etc. As the aquifer supplying the Beachcomber wells is overlain by relatively low permeability materials such as silt, clay and glacial till and the non-pumping water levels are close to 100 feet below ground it is unlikely that any contaminants are being introduced from the ground surface in the immediate vicinity of the wells. If the wells were not properly sealed along the casing above the screen contaminated runoff or contaminated shallow groundwaters could readily make their way into the aquifer along the well casing. There is no evidence however, to suggest that these wells are not adequately sealed above the aquifer. Waste disposal on the other hand at or near the boundaries of the aquifer away from the well sites and over the fractured bedrock in adjacent upland areas where the water-table is close to ground surface could facilitate the relative rapid movement of contaminants into the aquifer zone.

3. Naturally Occurring Deposits

The aquifer (Quadra Sediments) in which the Beachcomber wells are completed is known to contain organic remains (Fyles, 1963) which could be the source of the organic nitrogen and through subsequent microbiological activity, the observed ammonia levels in the groundwater. Fyles (1963) reports the occurrence of driftwood and peaty beds within the Quadra Sediments specifically near the head of Nanoose Bay. Chunks of wood have also been reported in the Kent well at a depth of 61 to 85 feet (Table 1). According to Fyles (1963) "the peaty materials of the plant-bearing silt-gravel unit of the Quadra sediments consist essentially of finely divided plant material mixed with a small to large proportion of mineral sediment....flattened branches, stems, and roots of woody plants are present in most of the peaty beds but only locally are they abundant". Fyles (1963) suggests a fresh-water mode of deposition for the plant-bearing deposits with possible accumulation in a river plain or lagoonal environment.

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Naturally occurring deposits that contain appreciable amounts of phosphate (termed phosphorites) are generally of fresh-water origin (Huang, 1962). The most common form of sedimentary phosphate is collophane, a cryptocrystalline phosphatic admixture of several varieties of apatite, $Ca_5(PO_4)_3(F, Cl, OH)$. Much collophane is of organic origin and is present in bones and teeth of animals, in shell material and fecal residues. The presence of naturally occurring phosphates within the Quadra sediments is presently unknown although the mode of deposition was favourable for its possible presence. Deep wells completed in the unconsolidated deposits at the head of Nanoose Bay for West Bay Estates also show phosphorous (0.144 mg/L) present in the groundwater (Table 2). Limestones and shales deposited by biochemical agents under conditions of slow sedimentation in restricted areas where reducing conditions prevail, including submarine volcanism, development of hydrogen sulfide, etc., may also be phosphatic (Huang, 1962). Limestones associated with volcanic rocks are reported in the immediate area (Muller and Carson, 1969) but their chemical composition has not been documented to ascertain whether they may be a source of phosphorous.

Conclusions

Available background evidence suggests that the presence of both ammonia nitrogen and dissolved phosphorous in the Beachcomber wells could be derived respectively from the oxidation of naturally occurring nitrogen-rich organic matter within the aquifer and from possible presence of in situ phosphatic mineral matter in the aquifer or in adjacent bedrock sources hydraulically connected to the aquifer. Runoff containing ammonia and organic nitrogen from a livestock holding area located upslope and east of the Beachcomber wells may also be recharging the aquifer directly along the aquifer boundaries and/or through adjacent fractured bedrock materials. Dissolved phosphorous however, is not evident in this latter source.

Recommendations

Long-term monitoring (monthly samples for one year for example) of water quality in the Beachcomber wells should be undertaken to determine whether any of the chemical parameters vary seasonally and to what extent. If the levels of ammonia and phosphorous are found to be increasing dramatically, detailed test drilling may be required to pinpoint the source area for these constituents. Routine chemical analyses should include:

Nitrogen	NO_2, NO_3
Nitrogen	ammonia
Nitrogen	Kjeldahl
Nitrogen	organic
Nitrogen	total
Phosphorous	orthophosphate
Phosphorous	total

Consideration should also be given to sampling the wells for Tritium analysis. Tritium analyses would indicate whether or not young waters (less than 25 years old) are entering the wells. If present, Tritium would indicate possible contamination from near surface sources. Costs for Tritium analysis are presently $50 per sample. Two or three samples only would be required.

Runoff from the livestock holding area along Stewart Road should be retained on the property D.L. 64 and not allowed to flow downslope in the direction of the Beachcomber wells or any neighbouring wells. Runoff from this operation should be controlled in accordance with the Environmental Guidelines prepared by the Ministry of Agriculture.

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APK/jm

References

Carroll, D. (1962) Rainwater as a Chemical Agent of Geologic Processes - A Review, U.S. Geological Survey Water-Supply Paper 1535-G.

Central Water Planning Unit (1977) Nitrate and Water Resources with Particular Reference to Groundwater, Reading, United Kingdom.

Freeze, R.A. and Cherry, J.A. (1979) Groundwater, Prentice-Hall Inc., New Jersey.

Fyles, J.G. (1963) Surficial Geology of Horne Lake and Parksville Map - Areas, Vancouver Island, British Columbia, Geological Survey of Canada, Memoir 318.

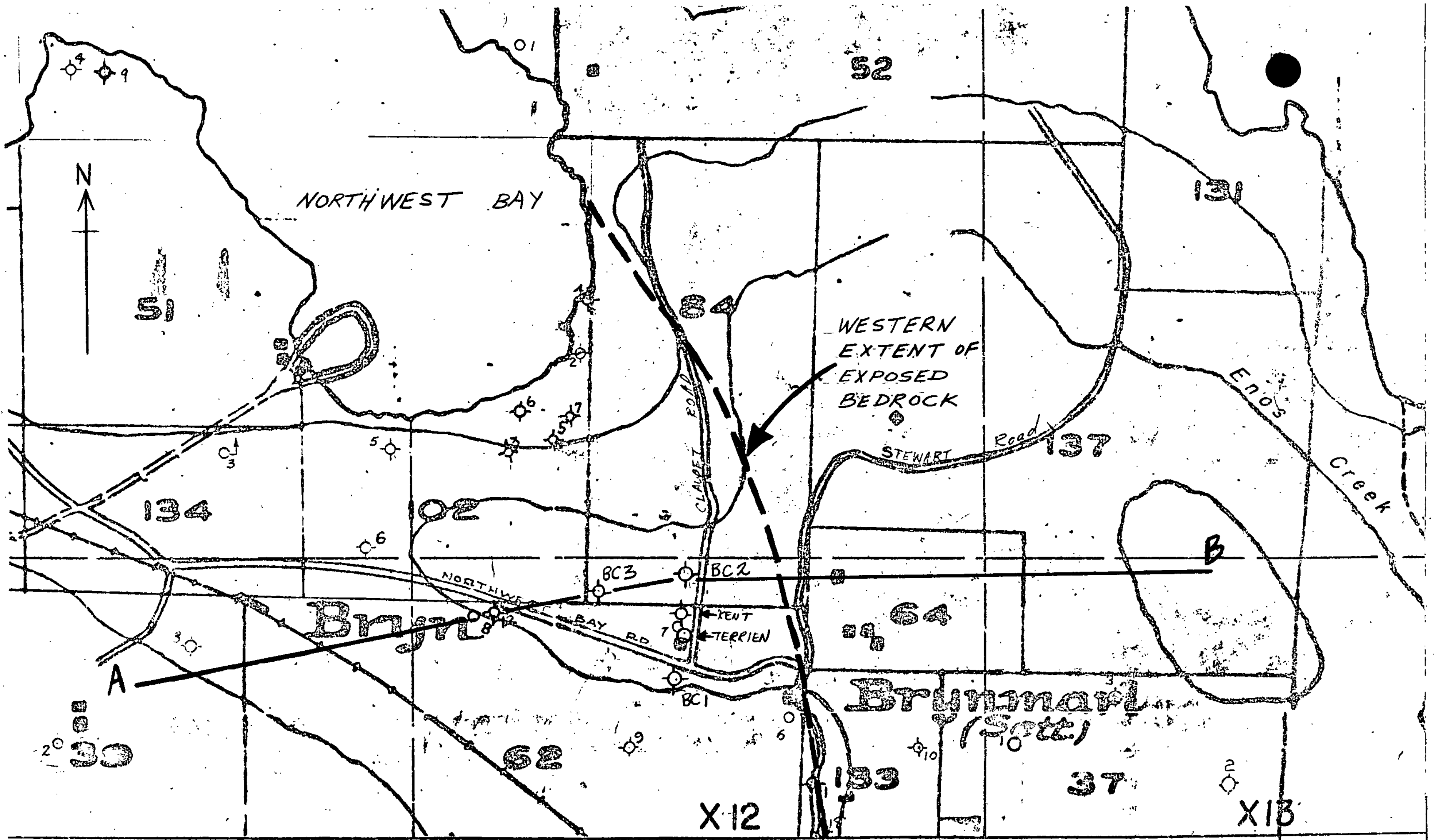
Huang, W.T. (1962) Petrology, McGraw-Hill Book Company.

Irwin, R.W. and Robinson, J.B. (1974) Runoff Volumes and Ground Water Quality From a Beef Feedlot, Canadian Society of Agricultural Engineering Paper No. 74-410, Annual Meeting 1974 Laval University, Quebec.

Muller, J.E., and Carson, D.J.T. (1969) Geology and Mineral Deposits of Alberni Map - Area (92F), Geological Survey of Canada, Paper 68-50.

Robertson, J.A., McQuitty, J.B., and Barber, E.M. (1974) Feedlot Pollution, Nitrogen Under Some Central Alberta Feedlots, Department of Agricultural Engineering, University of Alberta, Research Bulletin, 74-2.

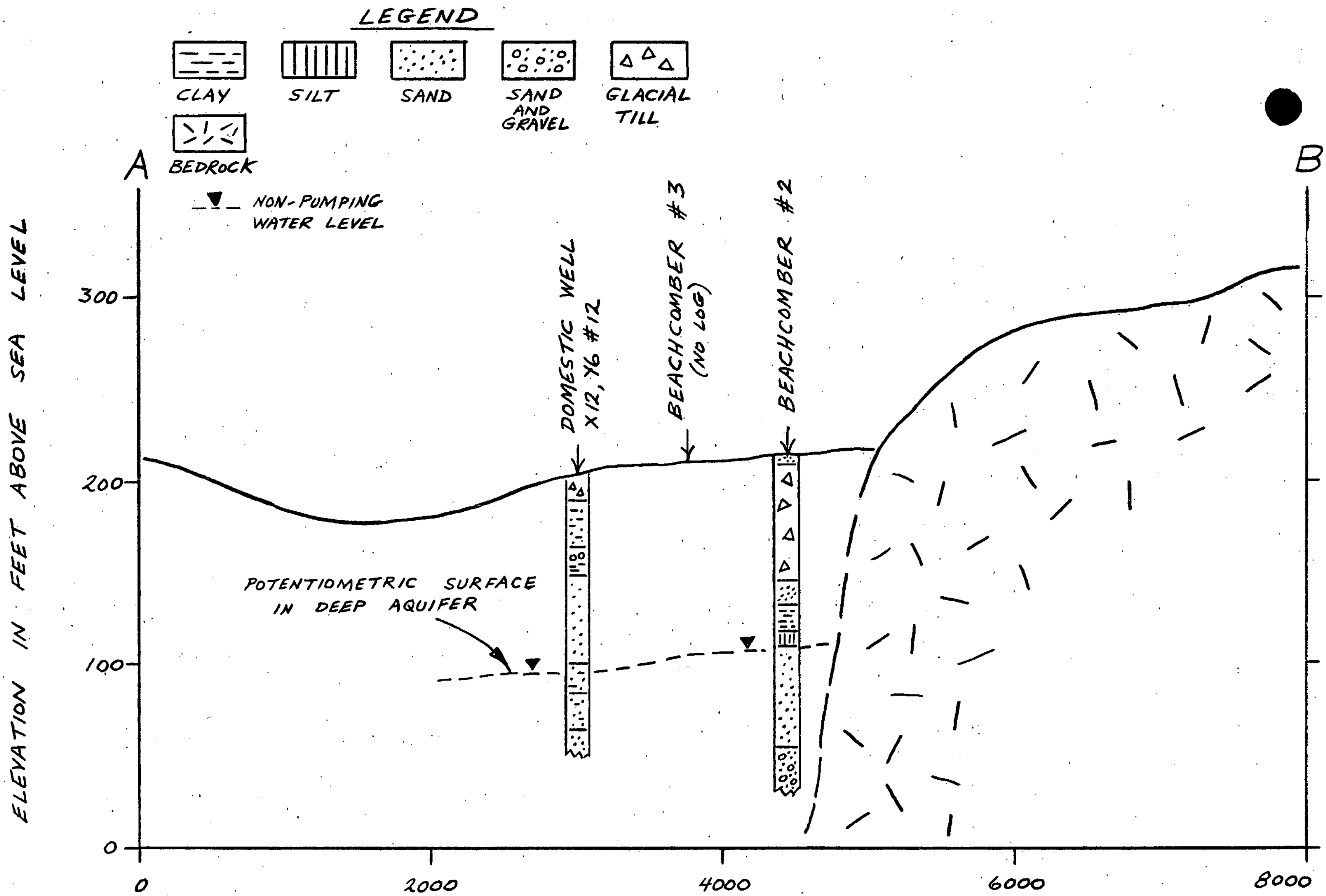
Staley, L.M., Podmore, T.H. and Cappelaere, B. (1976) Influences of Land Spreading Livestock Wastes on Groundwater Quality, Canadian Society of Agricultural Engineering Paper No. 76-204, Annual Meeting 1976, Halifax, Nova Scotia.



A-B LINE OF GEOLOGIC CROSS SECTION

Province of British Columbia Ministry of the Environment ENVIRONMENTAL AND ENGINEERING SERVICE WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON GROUNDWATER CONTAMINATION NANOOSE AREA	SCALE: VERT. NA HOR. 1" = 1000' APK ENGINEER FILE No. 92F8 DWG. No. FIGURE 1	DATE 5 AUG. 1980

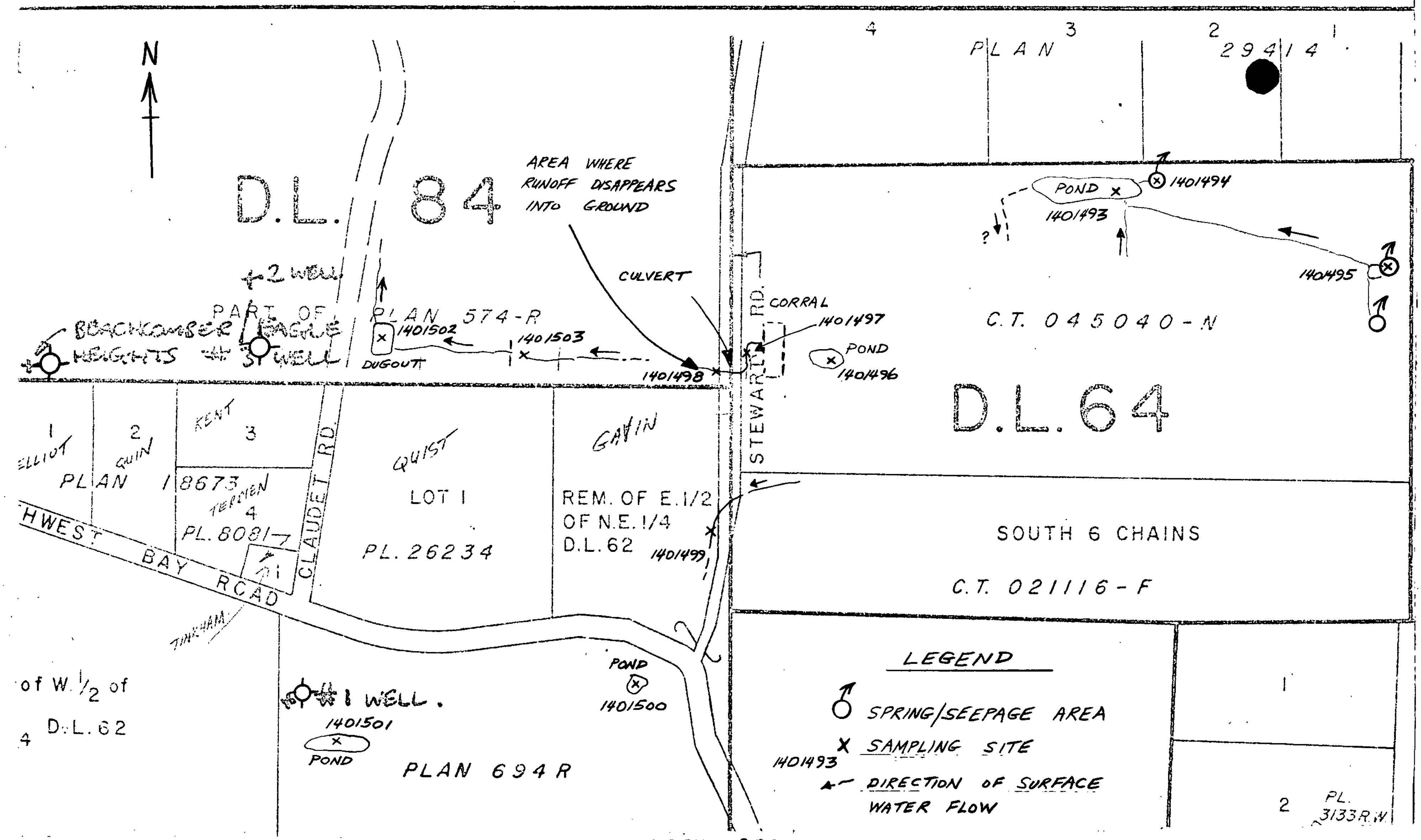
bcil 6661 wrs



GEOLOGIC CROSS SECTION LOOKING NORTH, BEACHCOMBER WELLS

Province of British Columbia Ministry of the Environment ENVIRONMENTAL AND ENGINEERING SERVICE WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON GROUNDWATER CONTAMINATION NANOOSE AREA	SCALE: VERT. 1" = 100' HOR. 1" = 1000'	DATE 5 AUG 1980
		APK ENGINEER	
		FILE No. 92 F8	DWG. No. FIGURE 2

bcil 6661 wrs



LOCATION OF WATER SAMPLING SITES, APRIL 1980

Province of British Columbia
Ministry of the Environment
ENVIRONMENTAL AND ENGINEERING SERVICE
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON
GROUNDWATER CONTAMINATION
NANOOSE AREA

SCALE: VERT. NA
HOR. 1" = 400'

DATE
5 AUG 1980

APK ENGINEER

FILE No. 92 F 8 DWG. No. FIGURE 3

bcil 6661 wrs

TABLE 1. SUMMARY OF WELL LOG INFORMATION, NANOOSE AREA

WELL NUMBER (Figure 1)	OWNER	DATE COMPLETED	TYPE	DIAMETER (inches)	COMPLETED DEPTH (feet)	SCREENED INTERVAL (feet)	SCREEN SLOT SIZE	WATER LEVEL BELOW GROUND (feet)	REPORTED YIELD (gpm)	REMARKS (CHEMISTRY SITE NO.)
Beachcomber BC1	Nanaimo Regional District	1978	Drilled	8	163	148 - 153 158 - 163	50	93	200 to 300	Drilled to 226' (1401472)
Beachcomber BC2	"	1978	Drilled	8	175	159 - 175	60	107	300	Drilled to 184'
Beachcomber BC3	"	-	-	-	-	-	-	-	-	No log available
X12, Y6 #6	Herseley	Prior to 1962	Dug	4 feet x 5 feet	20	-	-	4	-	-
X12, Y6 #7	Terrien	Prior to 1962	Dug	-	15	-	-	4 to 7	-	-
X12, Y6 #8	Strudviech	Prior to 1962	Dug	3 feet x 3 feet	16	-	-	5	-	-
X12, Y6 #9	Good	1967	Drilled	6	146	136 - 141 141 - 146	30 40	83	50	-
X12, Y6 #12	McGee and Kalnin	1977	Drilled	6	156	Nil	-	105	25	-
-	Kent	-	Drilled	6	170	Nil	-	106	25	Chunks of wood at 61 - 85 feet (1401474)

TABLE 2. SUMMARY OF WATER ANALYSES OF WELLS, NANOOSE AREA

SITE	SAMPLING* DATES	Na^+	Ca^{2+}	Mg^{2+}	K^+	SO_4^{2-}	Cl^-	TOTAL ALKA-LINITY	HARD-NESS	pH	TDS	Nitrogen							Phosphorous	
												NO_2+NO_3	NO_2	NO_3	Kjeld-ahl	Organ-ic	Ammon-ia	Total	Ortho	Total
Beachcomber BC 1 (1401472)	Jul.24/78	17.4	31.4	9.89	2.22	3.1	5.1	182	119	8.2	253	-	-	<0.1	-	-	-	-	-	1.65
	Aug.22/79	15.8	30.0	11.4	2.1	<5.0	5.1	148	122	8.3	174	<0.02	<0.005	<0.02	0.64	-	-	0.64	-	0.487
	Nov.27/79	-	31.6	9.6	-	-	-	148	118	8.1	-	<0.02	<0.005	<0.02	0.6	0.03	0.575	-	0.436	0.456
	Dec.10/79	-	-	-	-	-	-	-	-	8.0	-	<0.02	<0.005	0.02	1	-	0.560	-	0.430	0.456
	Jan.16/80	15.9	32.2	10.5	-	-	-	153	-	8.2	-	0.02	<0.005	0.02	1	-	0.605	-	0.417	0.438
Beachcomber BC 2	Oct.30/78	30.3	23.7	5.74	3.39	4.0	5.9	-	82.8	8.2	275	0.003	-	-	-	-	-	-	-	1.41
	Aug.29/79	32	26.9	6.3	3.0	<5.0	7.0	158	93.1	8.2	188	<0.02	<0.02	<0.005	19	-	-	19	0.548	0.58
	Nov.27/79	-	25.9	6.0	-	-	-	159	89.4	8.0	-	<0.02	<0.005	<0.02	3	-	1.76	-	0.555	0.565
	Dec.10/79	-	-	-	-	-	-	-	-	8.0	-	0.02	<0.005	0.02	2	-	1.75	-	0.534	0.562
	Jan.16/80	33.7	24.3	6.0	-	-	-	160	-	8.2	-	<0.02	<0.005	<0.02	3	-	1.92	-	0.562	0.580
	Jan.17/80	32.5	26.1	6.3	-	-	-	157	-	7.9	-	<0.02	<0.005	<0.02	2	-	1.75	-	0.555	0.567
	Jan.21/80	32.6	25.9	6.3	-	-	-	160	-	8.0	-	<0.02	<0.005	<0.02	2	-	1.74	-	0.562	0.580
Beachcomber BC 3	Jan.21/80	52.2	26.5	10.4	-	-	-	225	-	7.9	-	<0.02	<0.005	<0.02	3	-	2.66	-	0.93	1.49
Kent (1401474)	Dec. 3/79	31.1	30.9	7.7	2.9	<5.0	5.3	176	109	8.1	204	<0.02	<0.005	<0.02	1.35	-	1.20	-	0.514	0.64
McGee and Kalnin	Dec.20/79	20.5	31.4	12.2	2.2	<5.0	3.4	181	128	8.1	210	<0.02	<0.005	<0.02	2	-	1.07	-	0.520	0.676
Terrien (Old Well)	Sept. /79	-	52.6	12.6	-	-	-	196	183	7.9	236	-	-		-	-	-	-	0.7	-
	Dec.20/79	4.8	13.0	4.2	0.5	<5.0	3.4	50	49.7	7.2	86	1.23	<0.005	1.23	0.15	-	0.011	-	0.005	0.014
(New Well)	Jan.16/80	6.3	33.8	7.0	-	-	-	114	-	7.7	-	0.03	<0.005	0.03	0.33	-	0.116	-	0.015	0.030
West Bay Estates	Feb. 5/79	116	46	12.6	2.5	<5.0	216	129	167	8.2	526	<0.02	<0.005	<0.02	-	-	-	-	0.144	-

* All units in mg/L except pH (relative units).

TABLE 3

SUMMARY OF WATER ANALYSES FROM SPRINGS AND SURFACE RUNOFF

NANOOSE AREA, APRIL 1980

SITE NO. (FIGURE 3)	DESCRIPTION	RESIDUE FILTERABLE (mg/L)	TURBIDITY (J.T.U.)	NITROGEN (mg/L)							PHOSPHOROUS (mg/L)	
				NO_2+NO_3	NO_2	NO_3	KJELDAHL	ORGANIC	AMMONIA	TOTAL	ORTHO	TOTAL
1401493	North Pond on D.L. 64	148	3.4	<0.02	<0.005	<0.02	0.49	0.45	0.036	0.49	<0.003	0.023
1401494	Spring	134	1.4	<0.02	<0.005	<0.02	0.23	0.21	0.024	0.23	<0.003	0.008
1401495	Spring	100	1.4	<0.02	<0.005	<0.02	0.41	0.39	0.021	0.41	<0.003	0.016
1401496	West Pond on D.L. 64	122	16	<0.02	<0.005	<0.02	2	2	0.200	2	<0.003	0.090
1401497	Runoff from Corral	122	16	0.02	<0.005	0.02	2	2	0.210	2	<0.003	0.104
1401498	Runoff at Culvert	130	17	0.08	0.007	0.07	2	2	0.208	2	0.005	0.105
1401499	Runoff at Culvert	82	2.5	0.05	<0.005	0.05	0.32	0.30	0.024	0.37	<0.003	0.011
1401500	East Pond on D.L. 62	88	5.7	<0.02	<0.005	<0.02	0.59	0.56	0.028	0.59	<0.003	0.053
1401501	West Pond on D.L. 62	102	3.6	<0.02	<0.005	<0.02	0.74	0.69	0.051	0.74	0.004	0.046
1401502	Dugout	98	2.2	0.07	<0.005	0.07	0.36	0.34	0.022	0.43	<0.003	0.011
1401503	Runoff	102	2.3	0.07	<0.005	0.07	0.28	0.26	0.021	0.35	<0.003	0.012

Cribbing at spring at east end of D.L. 64
Looking South - Nanoose Contamination Problem
April 3, 1980   92 F/8

Cribbing at spring at East end of D.L. 64

Looking West

Nanoose Contamination Problem

April 3, 1980   92 F/8

North Pond on D.L. 64 - Looking West to Stewart Road
Drainage ditches from springs at East end of D.L. 64
Nanoose Contamination Problem
April 3, 1980 92 F/8