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NICOLA BASIN STRATEGIC ENVIRONMENTAL PLAN

FROM

GROUNDWATER SECTION

WATER MANAGEMENT BRANCH

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GROUNDWATER

Introduction

The purpose of this section is to assess the groundwater resources of the Nicola watershed, to identify water producing areas and to recommend locations for further investigation. The available data consists of water well drillers' records, groundwater reports by government and groundwater consulting engineers and hydrogeologists and bedrock and surficial geology reports on file in the Groundwater Section of the Ministry of Environment.

Geology

Bedrock Geology

Mapsheets of the bedrock geology for the Nicola (GSC Map No. 856A) and Ashcroft (GSC Map No. 1010A) areas show the Nicola River basin is underlain mostly by volcanic rocks mainly andesite and basalt of the Nicola and Kingsvale Groups, and by granitic rocks known as the Coast Intrusions. These rocks occur in zones that may be described as having roughly north to south trends. Also an area of sedimentary rocks, mostly argillite, possibly belonging to the Cache Creek Group, occurs in the east part of the basin to the east of Stump and Douglas Lakes. For further information on the bedrock geology of the area the reader is referred to reports by Cockfield (1948); Duffell and McTaggart (1952).

Surficial Geology

Surficial geology mapsheets for Merritt (GSC Map No. 1393A) and Vernon (GSC Map No. 1392A) show unconsolidated deposits, primarily of glacial origin, cover much of the area (Fulton, 1975). These deposits comprise, (a) mainly till, commonly an unsorted mixture of clay, silt, sand and boulders with some sand and gravel occuring mostly in upland areas, and the following types of deposits occuring mainly in valley features, (b) glacial lacustrine silt and sand deposits, (c) non-glacial fan deposits of sand and gravel, and (d) alluvial deposits of sand, gravel and silt.

Unconsolidated deposits are considered to be thin across much of the basin because of the numerous, and sometimes large, bedrock exposures mapped in upland areas. However, within the valleys surficial deposits may be very thick and are known to be about 1200 feet thick in parts of the Highland Valley (Klohn Leonoff, 1982). The glacial history of the region is quite complex in places and from work by Brown, Erdman & Associates (1980) it is known that deposits occur which are attributable to four periods of glaciation. These deposits consist of clay or silt, sand and gravel, and till, all of which may occur as layers of considerable areal extent and thickness or else as deposits of more local occurrence.

Hydrogeology

Source, Occurrence and Movement of Groundwater

The sources from which groundwater supplies are known to be obtained are predominantly sand and gravel beds or lenses. However, groundwater supplies could also probably be obtained from granitic, volcanic and sedimentary rocks in the area.

Groundwater occurs in the void or open spaces in the unconsolidated deposits and in the bedrock. The capacity of the bedrock or unconsolidated deposits to act as reservoirs of groundwater depends upon porosity which is the percentage of the total volume of a rock type or materials such as sand and gravel occupied by open spaces. Porosity is commonly low in fractured bedrock so that relatively lower volumes of groundwater occur in bedrock compared to surficial deposits to a given depth. Similarly well yields are commonly lower from bedrock sources than from wells in the surficial deposits. Extensive, thick, clean, saturated sand and gravel beds form major aquifers in contrast to fractured granitic rocks that are commonly only minor sources of groundwater supply.

The movement of groundwater is controlled chiefly by topography and is modified by geology with flow being from areas of topographic highs to topographic lows. On a regional scale groundwater flow is from upland areas (areas of groundwater recharge) to lowland areas or river valleys (areas of groundwater discharge). It should also be mentioned that recharge to aquifers in the main valleys may occur by loss of water from tributary creeks into and through sand and gravel deposits lining creek beds.

Groundwater Data

Only a limited number of records for water wells, about 180, are available on file in the Groundwater Section for the Nicola River Basin and only one of these is for a well drilled into bedrock (Appendix A). These records provide information mainly on well depth, water levels, well use, reported well yields, and a well log listing the materials encountered during drilling. There is very little pump test data available for calculating well yields or for aquifer evaluation, and some laboratory chemical analyses of groundwaters (Appendix B) for well waters only in the Highland Valley, at Logan Lake and for one well at Stump Lake.

Groundwater Use

From the available information groundwater resources in the basin are known to be developed to supply domestic, municipal, irrigation and industrial requirements. The majority, about one-third, of the wells have been installed to meet domestic needs assumed to be about 0.25 L/s (litres per second) or 3 Igpm (Imperial gallons per minute). Also, for about another one-third of the wells there is no reported use. Of these 2 groups of wells 30 produce 1½ L/s (20 Igpm) or less and 6 others are reported to yield up to or over 7½ L/s (100 Igpm). Yields for most of these wells are not available. As many of these wells only just penetrate an aquifer the use or reported yield may not be representative of potential well yields at many of these well sites.

Some wells have been installed at Merritt, Lower Nicola and Logan Lake to serve municipal water supply requirements and are considered to give a more reliable indication of groundwater supplies. Two of the Merritt wells yield over 75 L/s (over 1000 Igpm) and 3 others yield from 15 to 30 L/s (200 to 400 Igpm). The well at Lower Nicola yields 38 L/s (500 Igpm) and 2 wells for Logan Lake yield 15 and 60 L/s (200 and 800 Igpm).

Only one well is known to produce water for irrigation and its yield is estimated to be about 15 L/s (200 Igpm) based on a water supply need of 0.4 L/s (5 Igpm) per acre per day to irrigate 40 acres.

Groundwater resources are also developed for industrial use. The extraction of groundwater for this purpose occurs mainly in the Highland Valley for mill water supply for the three existing mines, Bethlehem Copper Corporation Ltd., Lornex Mining Corporation Ltd., and Highmont Operating Corporation Ltd., and exploration drilling has been conducted for a fourth mine, Valley Copper Ltd. Well yields are known to range from about 7½ to 75 L/s (100 to 1,000 Igpm).

Exploratory drilling for groundwater supply was also conducted for Brenda Mines Ltd. in Pennask Valley near Pennask Lake. Results obtained from the exploratory program showed well yields ranged from close to 2 L/s (25 Igpm) to 23 L/s (355 Igpm). Test pumping of a groundwater supply for Craigmont Mine in Guichon Valley indicated a well yield of about 2 L/s (25 Igpm), a second test well was abandoned. A similar yield is reported for a well for a power sub-station about 5 miles upstream of Nicola Lake in the Nicola Valley.

From some estimates or calculations of well yields for various water supply requirements it is known that moderately high to high yield wells occur in river valleys at various locations distributed across the basin.

Groundwater Prospects

Human settlement in the basin is unevenly distributed and is concentrated in the valleys of the major tributaries and the mainstem Nicola. Most wells are therefore located in the major valley bottoms and many occur in large groups. These groups and some individual wells are shown in Figure . The data for each well are presented in Appendix A and many well records show wells only just penetrate an aquifer. The distribution of and the type of data available permit little delineation of the extent and thickness of aquifers in the study area, and therefore offer but little scope for commenting on groundwater resources.

Some idea of the limitations in delineating the extent and thicknesses of aquifers can be seen from the shallow depths of many well records shown on the cross-section (Figure) drawn from Nicola to Canford. Only 3 moderately deep wells, deeper than about 60 metres (200 feet) occur along a rather steeply falling profile. The section does display the occurrence of confined aquifers, units A and C, water-bearing zones which occur below low permeable materials primarily till of units B and D, and of a shallow aquifer unit E which locally begins at ground surface and may be in hydraulic continuity with surface waters.

One aquifer unit C, 6 metres (20 feet) thick and encountered about 60 metres (200 feet) below ground level between 2 till units, may extend the full length of the cross-section, a distance of 30 kilometres (18½ miles). This aquifer may be suited to meeting only domestic or livestock water supply requirements as indicated by 2 wells up to 0.75 L/s (10 Igpm).

An important aquifer unit A, capable of yielding water to wells at up to about 37 L/s (500 Igpm) underlies till unit B and is encountered at a depth of about 105 metres (325 feet) well number 22 (Figure). It is not known whether this deeper aquifer extends along the Nicola Valley or into the Guichon Valley. Test drilling should be conducted to determine continuity of this aquifer into either valley as the well within this aquifer occurs near the mouth of Guichon Valley.

A third shallow but discontinuous aquifer unit E, commonly occurs at depths less than 16 metres (50 feet) below ground level near Nicola and Canford. Locally, as at Merritt, this aquifer may extend to depths of 50 metres (150 feet) or more where well yields of up to 75 L/s (1000 gpm) may be obtained in the vicinity of the confluence of Lower Coldwater Creek with the Nicola River.

The only area where the occurrence and yield of groundwater is mapped, and quite well understood is in the Highland Valley. In this valley the main developed aquifer averages about 30 metres (100 feet) thick occurring at a depth of about 75 metres (250 feet) and extends throughout much of the valley. Wells yielding over 38 L/s (500 Igpm) have been developed from this aquifer.

Elsewhere it is appropriate only to mention localities of present high well yields. There are 4 other such localities: Douglas Lake, Logan Lake, Lower Moore Creek and Monck Park campsite near the centre on the north side of Nicola Lake.

Groundwater Quality

Information on groundwater quality in the basin is severely limited. On most of the available drillers' reports for the basin, very little water chemistry information is supplied. Several reports include only a measurement of pH or the general observation that the water is "hard." Some drillers' reports exist for abandoned wells. When the reason for abandonment is "poor quality (domestic) water," an indication of water quality in the immediate area of the abandoned well can be obtained. In the Nicola watershed, however, not enough information of this kind is available to support even general statements on the occurrence of poor quality domestic water.

The only wells for which detailed chemical analyses have been undertaken are the Ministry of Environment observation well at Stump Lake, the Logan Lake municipal supply wells, and the dewatering and mill supply wells of the three mining companies in the Highland Valley, Appendix B. From work by Brown, Erdman and Associates Ltd. (1980), the groundwater of the surficial aquifers of the Highland Valley can be classified as moderately hard calcium bicarbonate water with low total dissolved solids 320 mg/L (milligrams per litre). The groundwater contained within bedrock aquifers may exhibit similar characteristics. The Brown Erdman report concludes that the water is potable and suitable for domestic and industrial use. The groundwater samples from Logan Lake, total dissolved solids 416 mg/L and Stump Lake, total dissolved solids 250 mg/L, (Appendix B) show that the water meets nearly all recommended standards for the Province of British Columbia (1969) for drinking water and industrial use except for two parameters: (1) the pH at the Stump Lake well is 9.3, which exceeds most recommended limits for drinking water and industrial use; and (2) the "total hardness" measured at Logan Lake is 208 mg/L, which is classified as "hard." The recommended upper limit for hardness in drinking water is 180 mg/L calcium carbonate. In conclusion, however, the limited number of adverse comments on groundwater quality that have been reported show no evidence of any widespread occurrence of unsuitable groundwater serious enough to restrict exploration for groundwater supplies for domestic and industrial use in any area of the Nicola watershed.

Recommendations for Further Data Collection

Collection of Additional Water Well Data

An allowance of approximately 6 weeks is made for a field inventory program to collect additional information on some wells and also on wells for which records are not available on Groundwater Section files. The type of data to be collected would include well depth, water level, well log, well yield and comments on water quality. Field work is to include taking conductivity readings and field tests of chemical quality of water well samples and a very limited number of groundwater samples for laboratory chemical analysis. It is suggested such work is assigned to technical staff and approximate costs have been estimated as follows:

1.	Salaries	$ 2,300
2.	Field Expenses	2,250
3.	Laboratory Chemical Analyses	2,700
		$ 7,250

Following upon an office review of additional water well data collected from a field inventory program consideration can be given to selecting possible sites for test drilling and pump testing programs.

Groundwater Exploration Programs

Cost estimates for example purposes have been prepared for test drilling in the surficial deposits for 8-inch diameter wells to be completed to depths of about 30 metres (100 feet) and 90 metres (300 feet), (Appendix C). These cost estimates have been prepared for drilling by the cable-tool method or by rotary drilling with a driven casing. Costs total about $11,200 and just over $22,000 to depths of 30 metres (100 feet) and 90 metres (300 feet) respectively. Drilling to greater depths, to about 500 feet or more, could require special drilling techniques and careful supervision. Costs given here are for contract costs only and do not include engineering supervisory costs.

The foregoing estimates have been provided as a guide to the costs of groundwater exploration in aquifers known to occur at depths approximately 30 metres (100 feet) and 90 metres (300 feet) as is the case in the Nicola River Valley.

The mud rotary test hole method may be more economical for an initial determination of the occurrence or absence of deep aquifers at about 500 feet or more. It is also suggested that with careful supervision, this method could be used to determine the possible continuity within Guichon Valley of the deepest aquifer in the well near the mouth of the valley (Well No.22) shown on the cross-section (Figure 2).

The foregoing cost estimates are also offered as a guide to the cost of groundwater exploration elsewhere in the surficial deposits in river valleys within the basin.

References

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Summary

In general, the movement of groundwater occurs from the upland areas towards the valley bottoms. The deep glacial sediments in the major valleys may contain several aquifers. Because of the limited amount of available data, the delineation of the depth and areal extent of the aquifers in the watershed is not possible except in the Highland Valley, and to some extent for the Nicola Valley.

There are seven known areas in which wells are capable of producing in excess of 7.5 L/s (100 Igpm): Highland Valley, Logan Lake, Douglas Lake, near Pennask Lake, Lower Moore Creek, at the confluence of Guichon Creek with the Nicola River and at the confluence of the Lower Coldwater River with the Nicola River. These areas may have the potential to support future demands for water supply from groundwater. In all areas, however, exploration drilling programs will be required to establish the availability of water to satisfy future demands. The areas of highest probability of successful development are the major valley bottoms particularly the areas near the mouths of major tributaries such as the Guichon and Lower Coldwater. Except for general comments on the quality of some well waters at a very few scattered locations, data on groundwater quality is available only for the Ministry of Environment observation well at Stump Lake (WR-67-18) and the wells in Highland Valley and Logan Lake. Water quality analyses from these wells indicate that the groundwater of the surficial aquifers is moderately hard, calcium and magnesium bicarbonate type low in Total Dissolved Solids ranging from 250 to 400 mg/L but potable and of sufficient quality for many domestic and industrial uses.

It is estimated that it will cost about $7,250 for a field inventory program to obtain some additional water well data and for laboratory chemical analyses of groundwater samples.

Only unit cost estimates have been calculated for this report for wells drilled to depths of 30 metres (100 feet) and 90 metres (300 feet) together with costs for a 24-hour pumping test for each well. Respective costs for these wells are estimated to be approximately $11,000 and $22,000. However cost estimates for groundwater exploration programs and well yield calculations have not been supplied. When the strategic basin planning process has identified areas where water shortages do or may occur and it appears that groundwater may be the only or more economical source of water supply, then cost estimates will be provided for groundwater exploration and pumping test programs.

APPENDIX B

Groundwater Quality at Selected Sites

Physical Tests		Stump Lake Observation Well WR-18-67 - 1975	Bethlehem[1] BW5 - 1977	Logan Lake[1] Well - 1970
pH		9.3	7.7	8.00
Conductivity (μmhos/cm)		431	346	N/A
Turbidity (JTU)		N/A	0.3	2.0
Colour (Pt-Co)		N/A	<5	1.0
Total Dissolved Solids (mg/L)		250	320	416
Dissolved Anions (mg/L)				
Alkalinity				
Bicarbonate	HCO_3	109	241	282
Carbonate	CO_3	45	-	-
Chloride	Cl	10.5	0.5	4.0
Sulfate	SO_4	56.1	2.0	12.8
Nitrate & Nitrite	N	N/A	<0.01	N/A
Nitrogen (Kjeldahl)		0.02	N/A	N/A
Phosphorous (Total)		<0.003	N/A	N/A
Phosphate	PO_4	N/A	0.09	N/A
Fluoride	F	N/A	0.11	N/A
Silica	SiO_2	N/A	N/A	21.2
Dissolved Cations (mg/L)				
Total Hardness	$CaCO_3$	96.5	146.7	208
Calcium	Ca	1.9	43.6	49.5
Magnesium	Mg	22.3	9.2	20.4
Sodium	Na	44.6	16.4	21.5
Potassium	K	22.7	1.9	3.4
Iron	Fe	N/A	<0.03	0.05
Manganese	Mn	N/A	0.079	Trace
Cadmium	Cd	N/A	N/A	N/A
Copper	Cu	N/A	0.002	0.02
Lead	Pb	N/A	<0.001	<0.01
Zinc	Zn	N/A	0.012	0.02
Others (mg/L)				
Total Iron	Fe	N/A	0.073	0.22
Total Manganese	Mn	N/A	0.084	N/A

mg/L = milligrams per litre; N/A = not analyzed for.

[1] From Brown, Erdman and Associates Ltd. (1980).

APPENDIX C

Test Production Well Costs

Estimates of Itemized Costs for an 8" Diameter, 100 Feet Deep, Test Well in Overburden Using Cable-Tool Method or Rotary Drilling with a Driven Casing

	ITEM	COST
1.	Mobilization and Demobilization (lump sum)	$ 500.
2.	10-inch drive shoe (each)	300.
3.	20 feet of 10" cased drilling ($48/ft.)	960.
4.	8-inch drive shoe (each)	185.
5.	20 feet of 8-inch overlap ($16.25/ft.)	325.
6.	80 feet of 8-inch cased drilling ($38/ft.)	3,040.
7.	10 feet of 8-inch screen and fittings (lump sum)	1,000.
8.	Hourly work (set screen, bail test, well development, etc., calculated at $80/hour)	1,600.
9.	Standby Time ($60/hr.)	480.
10.	Mobilization and Demobilization of pump and equipment (lump sum)	200.
11.	Install and remove pump and discharge pipe (lump sum)	200.
12.	24-hour pumping test ($50/hr.)	1,200.
13.	Pumping crew standby ($40/hr.)	120.
	Sub-total	$10,110.
	+ 10% contingencies	1,011.
	Total	$11,121.

Plus

Cost of 2 laboratory chemical analyses of groundwater samples at $180 each	360.
	$11,481.

Estimates of Itemized Costs for an 8" Diameter, 300 Feet Deep Test-Well in Overburden Using Cable-Tool or Rotary Drilling with a Driven Casing

	ITEM	COST
1.	Mobilization and Demobilization (lump sum)	$ 500.
2.	10-inch drive shoe (each)	300.
3.	100 feet of 10-inch cased drilling ($48/ft.)	4,800.
4.	8-inch drive shoe (each)	185.
5.	100 feet of 8-inch overlap ($16.25/ft.)	1,625.
6.	200 feet of 8-inch cased drilling ($38/ft.)	7,600.
7.	10 feet of 8-inch screen and fittings (lump sum)	1,000.
8.	Hourly work (set screen, bail test, well development, etc., calculated at $80/hr.)	1,840.
9.	Standby time ($60/hr.)	480.
10.	Mobilization and Demobilization of pump and equipment (lump sum)	200.
11.	Install and remove pump and discharge pipe (lump sum)	200.
12.	24-hour pumping test ($50/hr.)	1,200.
13.	Pumping crew standby ($40/hr.)	120.
	Sub-total	$ 20,050.
	+ 10% contingencies	2,005.
	Total	$ 22,055.

Plus

Cost of 2 laboratory chemical analyses of groundwater samples at $180 each	360.
	$ 22,415.