Province of British Columbia
Ministry of the Environment
WATER INVESTIGATIONS BRANCH

MEMORANDUM

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Groundwater Section
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Date: June 26, 1979

File: 92 G/1

Re: Fraser Valley Trout Hatchery
- Production Well Performance and Data Analysis

INTRODUCTION

In a memorandum dated May 16, 1979, to Mr. R.A.H. Sparrow, of the Fish and Wildlife Branch, Mr. H.I. Hunter, Chief of the Hydrology Division, Water Investigations Branch indicated that the Groundwater Section would prepare a report regarding the present performance and status of the Hatchery wells. The following report is a summary and analysis of all the available pumping and monitoring data relating to the performance of the Hatchery production wells.

AVAILABLE DATA

The following data has been compiled as a summary of pertinent information regarding the Hatchery wells.

1. Surficial Geology

Figure 1 shows the distribution of unconsolidated surficial materials in the Abbotsford Upland area, which includes the site of the Fraser Valley Trout Hatchery. Figure 2 is a cross-sectional view showing the subsurface relationships of the materials that underlie the region in the vicinity of the Hatchery.

2. Groundwater Recharge and Discharge

In 1974, E. Tradewell of the Groundwater Section, prepared a water level contour map of the upland area, from water level data collected in the field. Figure 3 has been adapted from the contour map to show the approximate area of the aquifer, contributing groundwater flow towards the eastern toe of the Abbotsford Upland; and the inferred direction of groundwater flow. According to Callan (1971b), the major recharge zone lies in the region of Abbotsford Airport. The primary source of this groundwater recharge is precipitation in the form of rain or snowmelt. Groundwater moves both west and east of the Airport area, discharging naturally through Fishtrap Creek to the west and

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through springs along the eastern flank of the Abbotsford Upland, at the Hatchery site. It is at this eastern end of the groundwater flow system that the Hatchery production wells are located.

3. Groundwater Recovery

Figure 4 has been prepared from the Groundwater Section well location map of the area and shows the location of the known major producing wells in the upland area that are each withdrawing in excess of 100 USgpm from the aquifer. Among the major producers that are located within the groundwater reservoir are the following:

User	No. of Wells	Estimated Present Withdrawal Rate	Estimated Potential Total Use
Fraser Valley Trout Hatchery	3	1800 USgpm	2500 USgpm
District of Abbotsford	4	1640 USgpm	3500 USgpm
District of Matsqui	3	1000 USgpm	3000 USgpm
Individuals	12	3000 USgpm	5000 USgpm

4. Precipitation and Water Level Data

Figure 5 shows the relationship between the precipitation recorded at Abbotsford Airport and the water level fluctuations at four Groundwater Section observation wells (for location, see Figure 4). Also on Figure 5 is the yearly variation of precipitation from the mean of 60 inches (based on precipitation data 1949-1978); and, the cumulative precipitation departure curve (from Table 1) which shows the trend in the cumulative precipitation pattern from the monthly average.

5. Fraser Valley Trout Hatchery Production Wells

Figure 6 is a schematic cross-section of the Hatchery wells, showing the present location of the pump intakes and screen locations in each production well. The relative thickness of the aquifer, which thickens toward the south is also indicated.

Figure 7 is a summary of the available production well pumping data and the corresponding water levels in the respective wells. The pumping rates are measured by means of "Measurell" discharge elbow type flow meters and continuous records of the rates are printed automatically at the Hatchery.

From available data, the following is a summary of pertinent information regarding each production well.

a) Production Well #1 (Hatchery Well #8)

Fraser Valley Trout Hatchery Well #8 (now referred to as Production Well #1) is a 16-inch diameter well, drilled and constructed in 1969 to a depth of 216 feet. The depth to the top of the screen assembly is approximately 116 feet below ground level, and at the time of construction, the non-pumping water level was measured at approximately 24 feet below ground level. This indicates that at that time the well had approximately 92 feet of available drawdown. Between 1971 and 1977, the well was equipped with a temporary pump and pumped continuously at an average rate of 400 USgpm (see Figure 7). In early 1977, a large capacity pump was installed with the intake set at approximately 70 feet below ground level. The setting of the intake to this depth has effectively reduced the potential available drawdown to an actual available drawdown of approximately 46 feet.

This well has been pump tested several times since its construction. Table 2 gives a summary of the results from those tests.

b) Production Well #2 (Hatchery Well #7)

Fraser Valley Trout Hatchery Well #7 (now referred to as Production Well #2) is a 16-inch diameter well, drilled and constructed in 1969 to a depth of 161 feet. The depth to the top of the screen assembly is approximately 82 feet below the ground level, and at the time of construction, the non-pumping water level was measured at approximately 26 feet below ground level. This indicates that at that time, the well had approximately 56 feet of available drawdown. Since completion, the well was left idle until 1977, when a large capacity pump was installed. The intake was set at approximately 70 feet below ground level. At this pump setting, the resulting available drawdown was effectively reduced to 44 feet.

This well has been pump tested several times since its construction. Table 2 shows a summary of the results from those tests.

c) Production Well #3 (Hatchery Well #1)

Fraser Valley Trout Hatchery Well #1 (now referred to as Production Well #3) is an 8-inch diameter well drilled and constructed for testing purposes in 1967 to a depth of 137 feet below ground level. The depth to the top of the screen assembly is approximately 95 feet, and at the time of construction, the non-pumping water level was measured at approximately 23 feet below ground level. This resulted in approximately 72 feet of available drawdown. Since completion, the well has not been in use on a continuous basis until 1978. Only one pump test was performed on this well, the results of which are summarized in Table 2.

6. Other Production Wells

Production and water level monitoring data regarding other large producers in the Hatchery area are not available at this time. According to available information, the District of Abbotsford presently pumps approximately 1700 USgpm from three wells located within one mile of the Hatchery wells. A fourth well, located at Farmer Road and approximately 3000 feet south of the Hatchery wells was recently constructed and has a potential yield of 2000 USgpm. However, as of yet, this well has not been in use.

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ANALYSIS OF DATA

1. Precipitation and Hydrograph Data

For the past three years (1976-1979), the amount of precipitation recorded at Abbotsford Airport has declined relative to the average yearly precipitation of 60 inches (based upon 30 years data). This is graphically illustrated in Figure 5. Also in Figure 5, the cumulative precipitation departure curve reflects a similar declining trend in precipitation for the period of 1976-1979.

Since precipitation, in the form of rain or snow-melt, is the primary source of recharge to the Abbotsford Upland aquifer, then changes in normal precipitation pattern will cause a corresponding change in the groundwater levels.

A comparison between the hydrograph of observation well WR-4-62 and the cumulative precipitation departure curve (Figure 5) indicates a similarity in the two curves with a coincidence of annual depressions and peaks. This coincidence suggests that the water level in the well responds directly to precipitation with an average lag of 2 to 3 weeks (i.e. the time for the groundwater level to respond to precipitation infiltration). Another coincidence occurs in the declining trends of the two curves for the period 1976-1979. A relative decrease in the amount of precipitation during this period (i.e. decrease in the amount of recharge to the aquifer), is reflected in a corresponding decrease in the average groundwater level at this site by approximately 10 feet; the greatest decrease having occurred between 1976-1977.

A comparison between the cumulative precipitation departure curve and the hydrograph of observation well WR-13-62 indicates a similar relationship as in the previous case. There is a coincidence of annual depressions and peaks and the average lag between precipitation infiltration and groundwater level response is approximately 1 to 2 months. This lag is longer than in the previous case because of the well's greater distance from the recharge area (just east of the airport). The declining trends in the two graphs during the period 1976-1979 are somewhat similar, except for the fact that the lowered water level during 1977 and 1978 appears to have stabilized and is not declining at the same rate as observation well WR-4-62. This observation suggests that even though the relative amount of recharge to the aquifer has decreased during 1976-1979, the amount of discharge (withdrawal from the aquifer in this area) is approximately equal to the present amount of recharge to the aquifer. Thus it appears that the water levels in the vicinity of the Hatchery are approaching new equilibrium conditions. This observation further implies that at observation well WR-4-62, the declining water level trend may be due to a combination of below average recharge <u>and</u> the effects of groundwater withdrawals. To what extent each contribute to the decline is not determinable at this time.

A comparison between the water levels in observation wells F.V.T.H. #3 and #5 and the cumulative precipitation departure curve also shows a similarity in the coincidence of annual depressions and peaks, but not as well defined as in the previous two cases. The declining trends in the groundwater levels at these two sites are consistent with the trend of the cumulative precipitation departure curve for the period 1976-1979; with the greatest amount of decline of approximately 13 feet occurring in 1977. Since then, groundwater levels at the Hatchery well sites declined at an average rate of 3.5 feet per year. The apparent reasons for the decline is due to a combination of below average recharge and interference effects from the Hatchery production wells.

2. Hatchery Production Well Pumping Data

To analyse the performances of the production wells, and any changes with time, the use of specific capacity values, determined from pumping tests, is made. The specific capacity of a well is its yield per unit of drawdown, and in the following analyses is expressed as USgpm per foot of drawdown.

a) Production Well #1

Based on the short term tests (less than 5 hours duration) and pumping rates between 1500 and 2000 USgpm, the available data (Table 2), indicates that the specific capacity of Production Well #1 has decreased from 96.2 USgpm/ft. in 1970 (Callan, 1971a), to 80.8 USgpm/ft. in 1977 (Kohut, 1977a) and 66.1 USgpm/ft. in 1979 (Zubel, 1979). This decrease represents a decline in the relative performance of the well by approximately 30%. The cause(s) of this decline in performance is not definitely known at this time, but may be due to iron encrustation of the well screen, and/or aquifer around the screen, or movement of fine-grained aquifer materials around the well screen, thereby, effectively reducing the open area of the screen and/or permeability of the aquifer adjacent to the screen.

b) Production Well #2

Based on the results of the short term pumping tests of 1969, and 1977 and pumping rates between 400 and 500 USgpm, the available data indicates that the specific capcity of Production Well #2 has remained relatively constant at approximately 42.5 USgpm/ft. of drawdown. By referring to the present pumping rate and corresponding water level data, an estimate of the present performance of Production Well #2 can be made. Accordingly, at an average rate of 500 USgpm, the water level dropped approximately 12.5 feet from a "static" water level of approximately 40 feet. From this data, the specific capacity is 40.0 USgpm/ft. of drawdown; which compares favourably with previous results.

c) Production Well #3

According to available data, Production Well #3 has been pump tested only once, in July 1967. Since no subsequent pump test data is available for comparison, it is difficult to accurately determine the present performance of the well. However, using the present pumping rate data and corresponding water levels in the well, an estimate of the performance can be made. Before

Production Well #3 began operating in May, 1978, the depth to the water level was approximately 44 feet below ground level. Continuous pumping at an average rate of 480 USgpm has caused a long term drawdown of approximately 11 feet. From this data, the specific capacity over a one year period appears to be approximately 43.7 USgpm/ft.; which is comparable to the specific capacity of 54.7 USgpm/ft. determined in 1967 for a short term test.

3. Other Production Wells

The District of Abbotsford presently utilizes three of five wells that are located within a potential interference range of the Hatchery wells(see Figure 4 for locations). According to Callan (1971a), an aquifer boundary exists between the location of the two Abbotsford wells (north of the Hatchery wells) and the Hatchery production wells. From pump test results, it was found that there are no interference effects from pumping activities between the Abbotsford and Hatchery wells.

The remaining well is located off Farmer Road, approximately 3000 feet south of the Hatchery wells, and is presently pumping at a rate of approximately 1000 USgpm. Based upon a transmissivity of 1.9×10^5 USgpd/ft., and a storage coefficient of 0.1, the theoretical drawdown of the water levels at the Hatchery wells, caused by the Farmer Road well, after one year of pumping at an average rate of 1000 USgpm would be approximately 2 feet.

At present, there does not appear to be any other wells of significant yields (i.e. 500+ USgpm) within the interference range of the Hatchery wells.

DISCUSSION AND RECOMMENDATIONS

As was outlined in the analyses of Production Wells #2 and #3, the performances of these wells appear to be normal at this time. Of concern is Production Well #1. As was revealed in the May, 1979 pumping test, the specific capacity under a short term has decreased by approximately 30%. This indicates that in maintaining a pumping rate of 1000 USgpm, the water level in the well would presently be drawn down by approximately 15 feet as compared to approximately 11 feet when the specific capacity was 96.2 USgpm/ft. of drawdown. This decrease in the available drawdown, compounded by presently decreasing water levels regionally, has caused a decrease in the potential production capacity of the well. According to the May 1979 pumping test results, it was found that at a pumping rate of between 1400 to 1600 USgpm, the remaining available drawdown in the well to the pump intake was less than 5 feet. This represents a serious restriction to the future production capacity of this well.

To overcome the problem of decreasing available drawdown, other than natural recharge to the aquifer by increased precipitation, it is recommended that the pump intake in Production Well #1 should be lowered to its maximum depth. According to the well construction data, the pump intake in Production Well #1 is presently located at a depth of approximately 70 feet below ground level. The maximum depth to which the intake can theoretically be lowered is approximately 115 feet, or 1 foot above the top of the screen assembly. This will effectively increase the available drawdown from a present 30 feet to approximately 75 feet. The lowering of the intake may necessitate redesign of the pump by way of additional pump stages to increase the pumping head or, refitting the entire pump and motor assembly.

With regards to the other two production wells, it is also recommended that the pump intakes be lowered to their maximum depths (approximately 1 foot above their screen assemblies), thereby providing a greater safety factor in case of continued decrease in the regional water level.

Another serious consideration in the overall production capacity of the Hatchery wells is the possibility of pump breakdown in Production Well #1. Since the combined capacities of Production Wells #2 and #3 cannot meet the Hatchery water requirements even at low demands, then any breakdown of Production Well #1 pumping equipment could seriously affect the operation of the Trout Hatchery. In fact, from the latest pumping test results (Zubel, 1979), it was found that under present Hatchery operating conditions, the Trout Hatchery could not sustain a shut-down of Production Well #1 for more than 15 minutes, even with Production Wells #2 and #3 operating at near maximum capacity. In light of this potential problem, it is recommended that a stand-by well of similar capacity as Production Well #1 be drilled. The following is a summary of the cost estimate (less supervisory costs) to drill, construct and pump test a 20-inch diameter, 250 foot deep well, to be located approximately 50 feet south of Production Well #1:

Item	Unit Price	Estimated Cost
1. Mobilization and Demobilization	Lump Sum	$ 500.
2. Drill and case 250' x 20" diameter	$ 85/ft.	$ 21,250.
3. Drive shoe (20" diameter)	Lump Sum	$ 1,150.
4. Screen 50' x 12" diameter	$200/ft.	$ 10,000.
5. Hourly work: Development, etc. (80 hrs.)	$ 70/hr.	$ 5,600.
6. Pump test (35 hours)	$ 45/hr.	$ 1,575.
7. Pump equipment, mobilization, set-up, etc.	Lump Sum	$ 1,250.
8. Discharge pipe (2000 ft.)	$ 1/ft.	$ 2,000.
	TOTAL	$ 43,325.
	+ 15% CONTINGENCIES	$ 6,500.
	TOTAL ESTIMATED COST	$ 49,825.

It is also recommended that prior to the lowering of the pump intake in Production Well #1, that the pump column be removed and inspected for iron deposits. Also, the well screen should be inspected by means of a downhole

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television monitor, for signs of iron encrustation and/or other signs of well screen deterioration. If the well screen is encrusted, then it should be cleaned and the well should be redeveloped prior to the re-installation of the pump column. If no encrustation is apparent, the well should nevertheless be redeveloped.

Further, it is recommended that all three production wells be equipped with in-line mechanical flow meters so that more accurate determinations of the actual flow rate can be measured. Monitoring the production rate and water level in each production well should continue as at present.

Marc Zubel

Marc Zubel
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Groundwater Section

MZZ/dmc

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2. Callan, D.M. (1971a) "Results of an Eight-Day Field Pumping Test of Two Production Wells at the Fraser Valley Trout Hatchery near Abbotsford, Sept. 1970", Water Investigations Branch, File 0239016, January 22.

3. Callan, D.M. (1971b) "Recommendations for Development of a Groundwater Aquifer at the Fraser Valley Trout Hatchery near Abbotsford", Water Investigations Branch, File 0239016, January 22.

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7. Kohut, A.P. (1977b) "Abbotsford Trout Hatchery Production Well Retests, Well 7(2)", Water Investigations Branch, File 0239016 (NTS 92G/1), February 4.

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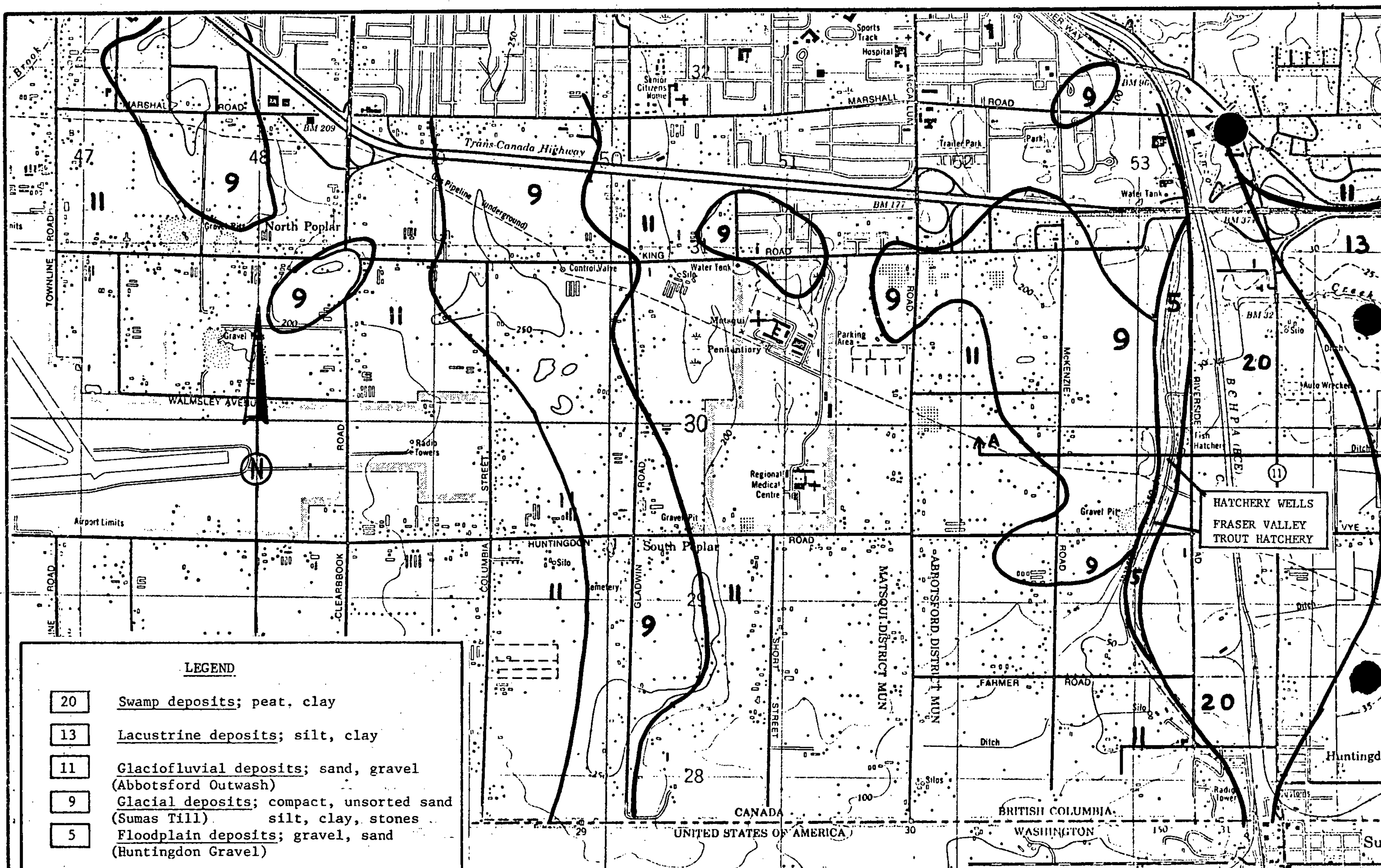
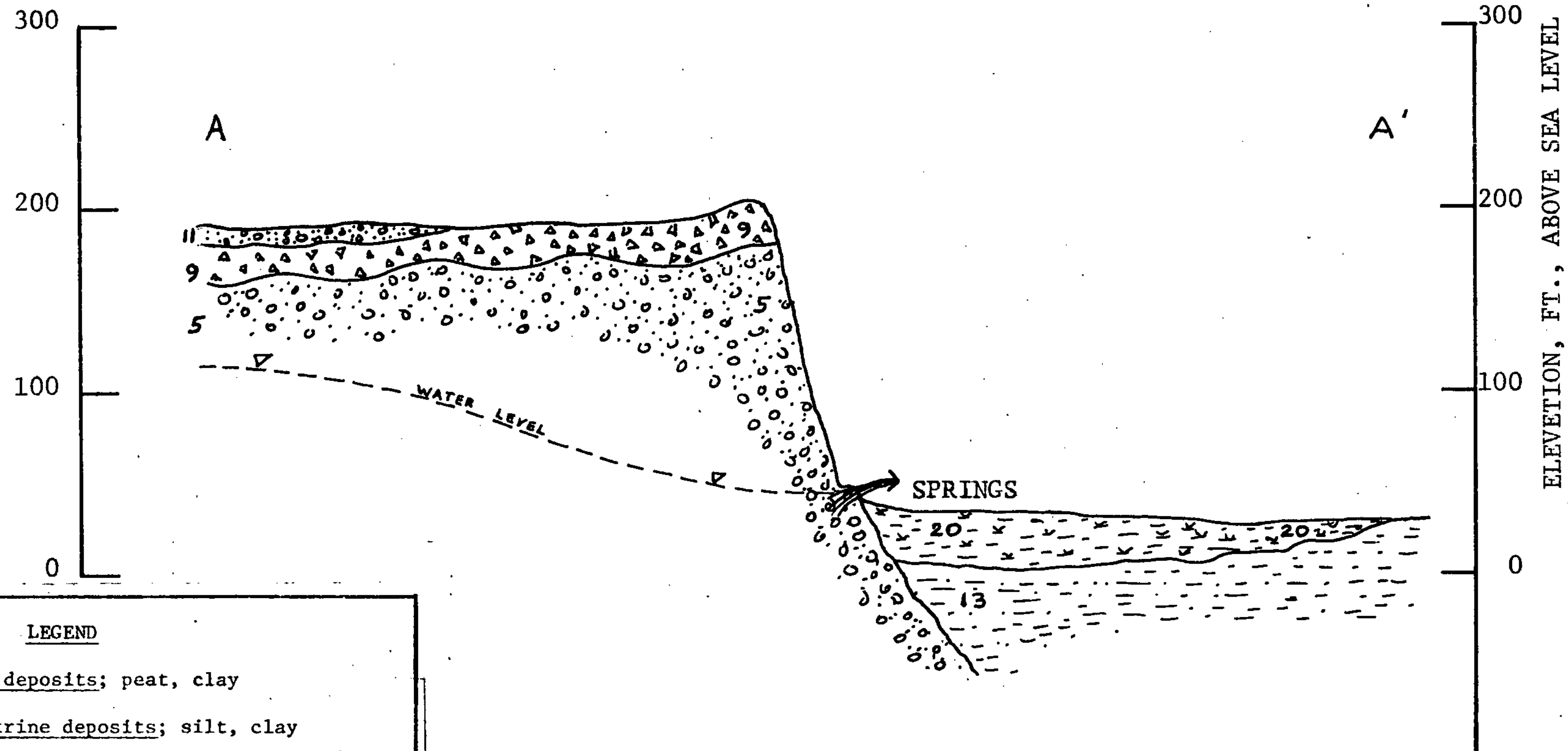


Province of British Columbia Ministry of the Environment ENVIRONMENTAL AND ENGINEERING SERVICE WATER INVESTIGATIONS BRANCH	Abbotsford Uplands Area Surficial Geology after: Armstrong, J.E. (1960)	SCALE: VERT. HOR. 1" = 1800' M. Zubel ENGINEER FILE No. 92 G/1 DWG. No. Figure 1	DATE June, 1979

bcil 6661 wrs



LEGEND

20	Swamp deposits; peat, clay
13	Lacustrine deposits; silt, clay
11	Glaciofluvial deposits; sand, gravel (Abbotsford Outwash)
9	Glacial deposits; compact, unsorted sand silt, clay, stones (Sumas Till)
5	Floodplain deposits; gravel, sand (Huntingdon Gravel)

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Fraser Valley Trout Hatchery Area
Section A-A'

SCALE: VERT. 1" = 100'
HOR. 1" = 1000' (approx)

DATE June, 1979

M. Zubel ENGINEER

FILE No. 92 G/1 DWG. No. Figure 2

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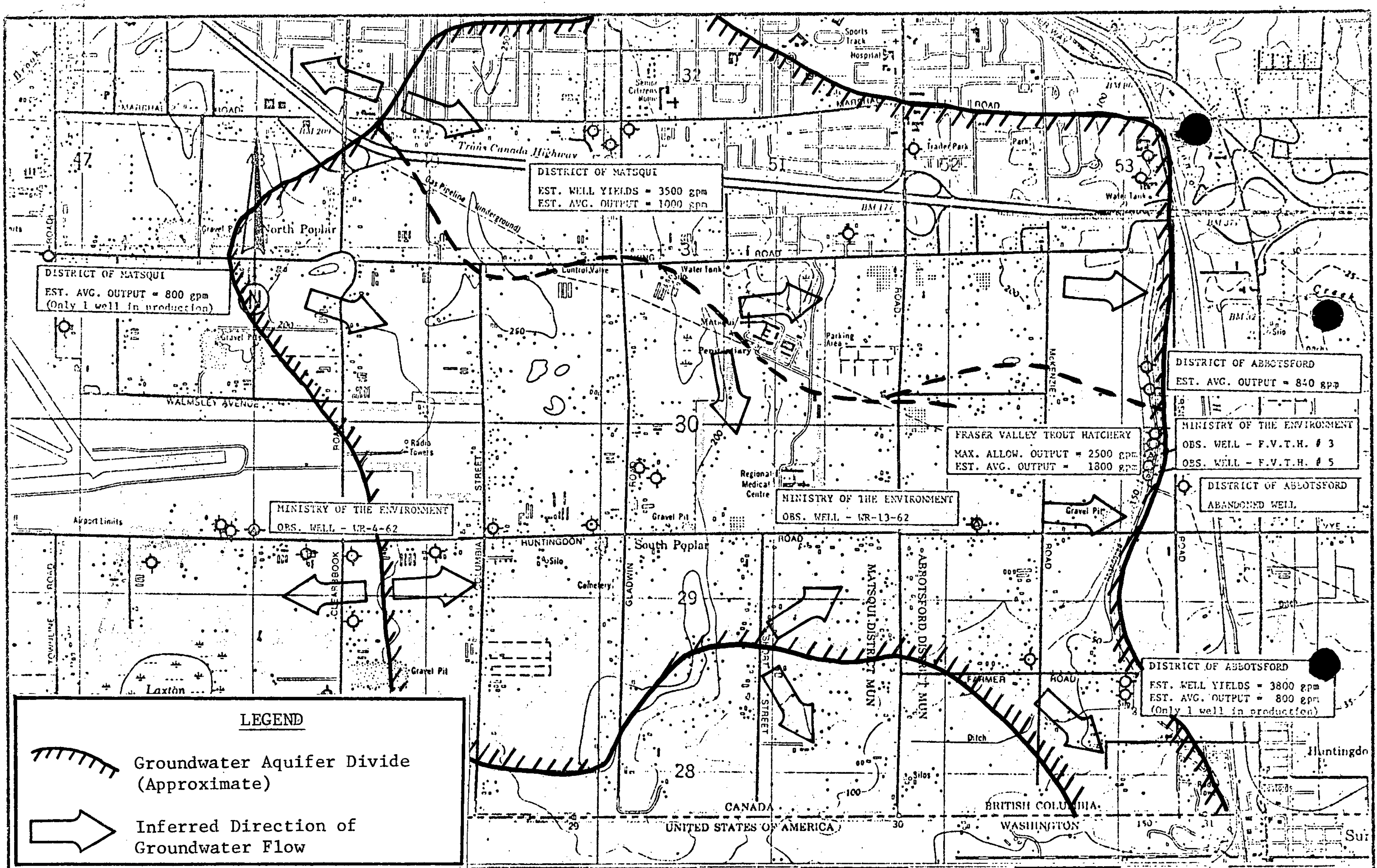

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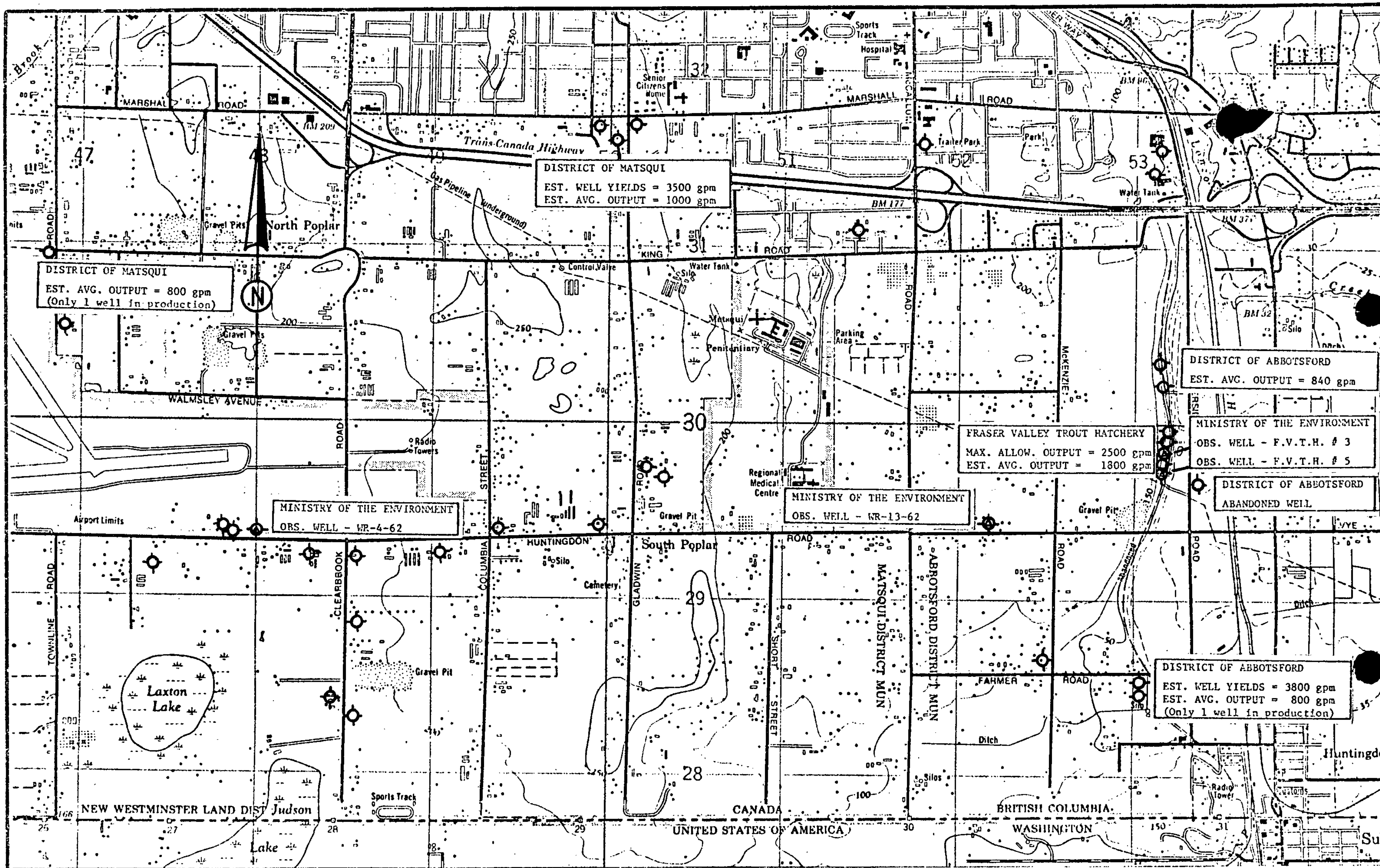
Abbotsford Upland Area
Outline of Groundwater Reservoir
(After Tradewell, 1974)

SCALE: VERT. / HOR. 1" = 1800' (approx)	DATE June, 1979
M. Zubel ENGINEER	
FILE No. 92 G/1	DWG. No. Figure 3



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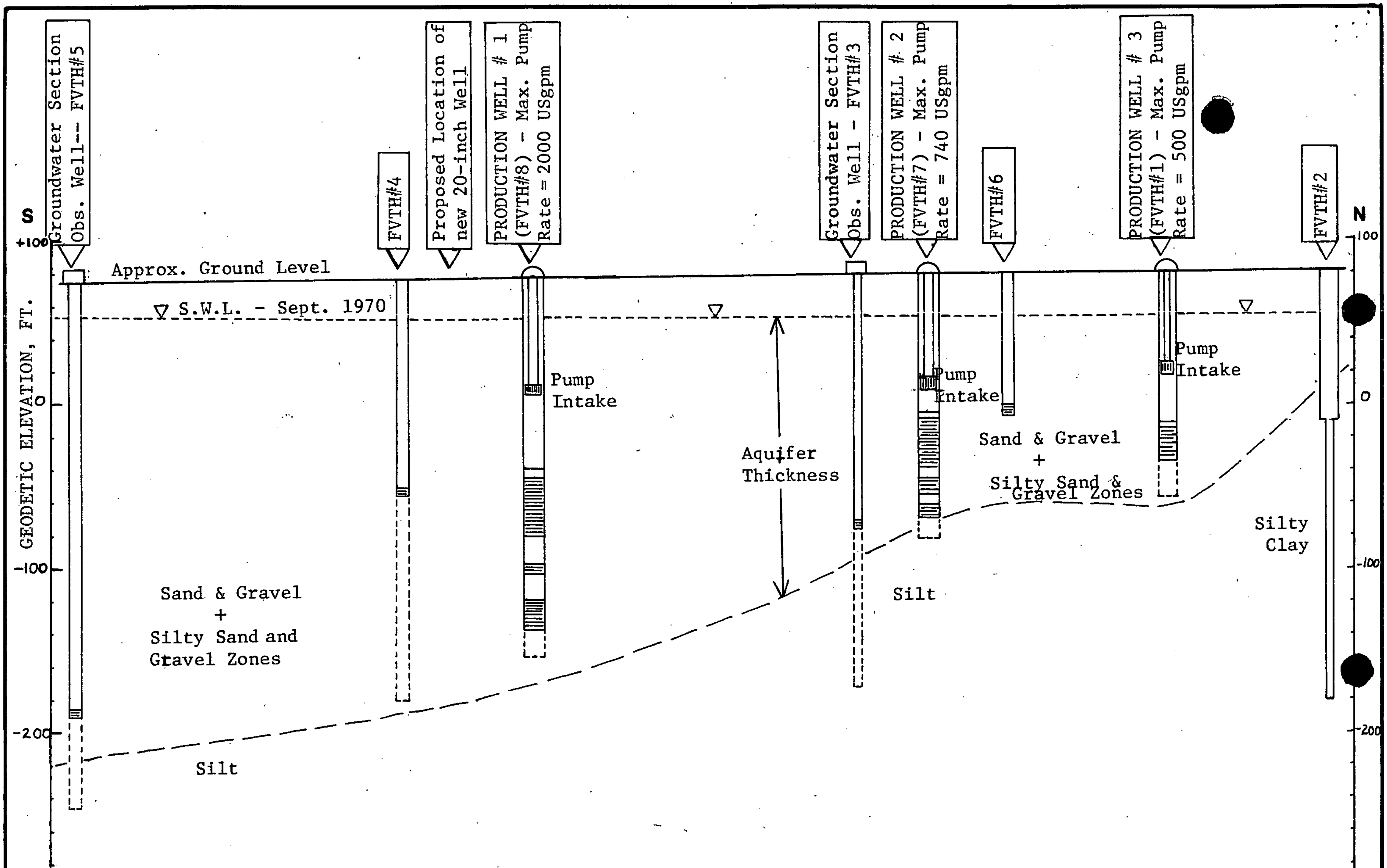
Abbotsford Upland Area

Well Location Plan of Major Producers (100+ gpm)

SCALE: VERT.	
HOR.	1" = 1800'
DATE	June, 1979
ENGINEER	M. Zubel
FILE No.	92 G/1
DWG. No.	Figure 4



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Fraser Valley Trout Hatchery Wells

Schematic Section

SCALE: VERT. 1" = 80'
HOR. 1" = 100'

DATE June, 1979

M. Zubel ENGINEER

FILE No. 92 G/1 DWG. No. Figure 6

bcil 6661 wrs

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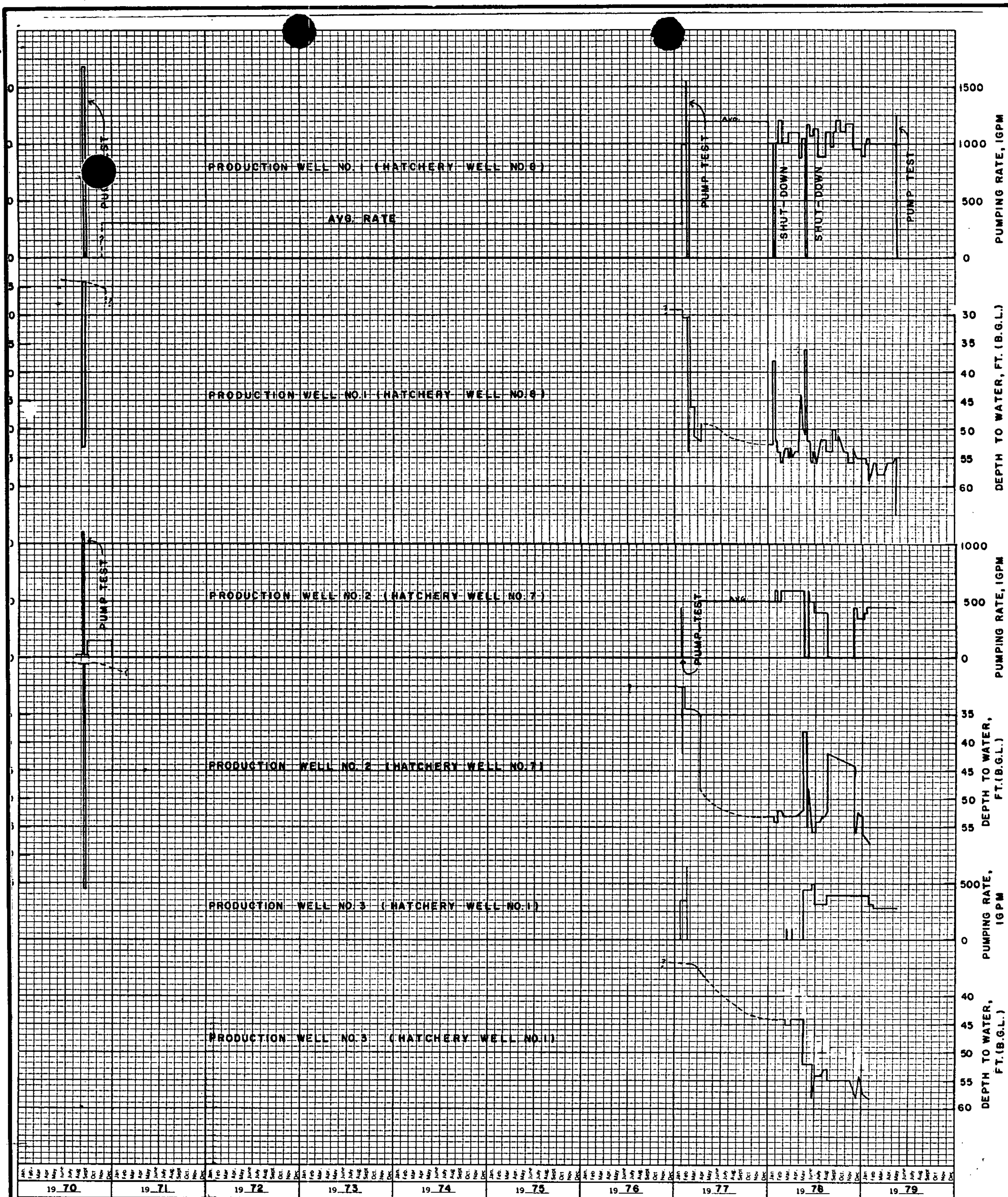
Abbotsford Upland Area
Precipitation (1970 - 1978) & Water
Level Hydrographs

SCALE: VERT. N/A HOR. N/A	DATE June, 1979	M. Zubel ENGINEER FILE No. 92 G/1 DWG. No. Figure 5

bcil 6660 wrs



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Fraser Valley Trout Hatchery
Production Well Data

SCALE: VERT. N/A	DATE	M. Zubel ENGINEER
HOR. N/A	June, 1979	FILE No. 92 G/1 DWG. No. Figure 7

bcil 6660 wrs

TABLE 1

PRECIPITATION DATA

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1970	7.52	3.19	3.46	6.42	1.85	1.36	2.51	0.15	4.41	4.21	7.36	8.05	Precipitation, in.
	+2.52	-1.81	-1.54	+1.42	-3.15	-3.64	-2.49	-4.85	-0.59	-0.79	+2.36	+3.05	Departure from mean
	+2.52	+0.71	-0.83	+0.59	-2.56	-6.20	-8.69	-13.54	-14.13	-14.92	-12.56	-9.51	Cum. Departure
1971	13.58	6.27	7.94	2.65	2.73	5.57	1.26	0.78	4.47	8.19	11.73	11.06	Precipitation, in.
	+8.58	+1.27	+2.94	-2.35	-2.27	+0.57	-3.74	-4.22	-0.53	+3.19	+6.73	+6.06	Departure from mean
	-0.93	0.34	3.28	0.93	-1.34	-0.77	-4.51	-8.73	-9.26	-6.07	0.66	+6.72	Cum. Departure
1972	8.21	11.70	10.67	7.43	2.77	2.82	5.65	2.16	6.14	1.89	4.99	14.37	Precipitation, in.
	+3.21	+6.70	+5.67	+2.43	-2.23	-2.18	+0.65	-2.84	+1.14	-3.11	-0.01	+9.37	Departure from mean
	9.93	16.63	22.3	24.73	22.5	20.32	20.97	18.13	19.27	16.16	16.15	25.52	Cum. Departure
1973	4.74	3.52	3.82	2.21	3.25	2.92	0.71	0.78	1.28	6.76	9.09	9.37	Precipitation, in.
	-0.26	-1.48	-1.18	-2.79	-1.75	-2.08	-4.29	-4.22	-3.72	+1.76	+4.09	+4.37	Departure from mean
	25.26	23.78	22.6	19.81	18.06	15.98	11.69	7.47	3.75	5.51	9.6	13.97	Cum. Departure
1974	11.42	8.68	6.28	4.96	4.27	2.48	2.33	0.13	0.51	2.30	8.18	9.70	Precipitation, in.
	+6.42	+3.68	+1.28	-0.04	-0.73	-2.52	-2.67	-4.87	-4.49	-2.70	+3.18	+4.70	Departure from mean
	20.39	24.07	25.35	25.31	24.58	22.06	19.39	14.52	10.03	7.3	10.51	15.21	Cum. Departure
1975	7.94	6.66	3.56	2.27	2.45	1.46	1.26	5.81	0.41	13.65	9.31	13.50	Precipitation, in.
	+2.94	+1.66	-1.44	-2.73	-2.55	-3.54	-3.74	+0.81	-4.59	+8.65	+4.31	+8.50	Departure from mean
	18.15	19.81	18.37	15.64	13.09	9.55	5.81	6.62	2.03	10.68	14.99	23.49	Cum. Departure
1976	10.74	7.14	4.92	4.62	3.99	2.74	2.55	3.63	2.60	4.75	3.12	5.83	Precipitation, in.
	+5.74	+2.14	-0.08	-0.38	-1.01	-2.26	-2.45	-1.37	-2.40	-0.25	-1.88	+0.83	Departure from mean
	29.23	31.37	31.29	30.91	29.9	27.64	25.19	23.82	21.42	21.17	19.29	20.12	Cum. Departure
1977	5.73	2.71	5.37	3.07	4.49	1.02	1.91	3.91	3.44	4.33	9.17	9.61	Precipitation, in.
	+0.73	-2.29	+0.37	-1.93	-0.51	-3.98	-3.09	-1.09	-1.56	-0.67	+4.17	+4.61	Departure from mean
	20.85	18.56	18.93	17.0	16.49	12.51	9.42	8.33	6.77	6.1	10.27	14.88	Cum. Departure
1978	5.92	3.90	5.01	4.11	4.39	2.12	0.43	5.36	5.97	2.87	6.94	3.91	Precipitation, in.
	+0.92	-1.10	+0.01	-0.89	-0.61	-2.88	-4.57	+0.36	+0.97	-2.13	+1.94	-1.09	Departure from mean
	15.8	14.7	14.71	13.82	13.21	10.33	5.76	6.12	7.09	4.96	6.9	5.81	Cum. Departure
1979	2.97	6.80	3.73	4.13									Precipitation, in.
	-2.03	+1.80	-1.27	-0.87									Departure from mean
	3.78	5.58	4.31	3.44									Cum. Departure

Average yearly precipitation (1949-1978) = 59.95 in.

Average monthly precipitation (1949-1978) = 5.00 in.

TABLE 2

SUMMARY OF PRODUCTION WELL PUMPING TESTS

TEST DATE	RATE (Usgpm)	DURATION OF TEST (hrs.)	DRAWDOWN (ft.)	SPECIFIC CAPACITY (USgpm/ft.)	COMMENTS
(a) Production Well #1 (Hatchery Well #8)					
September 1969 *1	1027	-	10.20	100.7	- Nonpumping static water level = 22.67 ft.
	1572	-	15.60	96.9	
	2010	1	21.23	94.7	
	2010	24	22.63	88.8	
	2010	48	23.30	86.3	
September 1970 *2	2000	1	20.80	96.2	- Nonpumping static water level = 23.57 ft.
	2000	24	23.13	86.5	- Hatchery Well #7 also pumping at 1300 USgpm.
	2000	192	29.31	68.2	
February 1977 *3	1863	5	23.95	77.8	- Hatchery Well #3 also pumping at 600 USgpm.
	1521	1	18.83	80.8	- Pumping water level = 30.42 ft.
	2100	3	25.06	83.8	
May 1979 *4	1140	1	15.54	73.4	- Hatchery Wells #2 & #3 also pumping at 850 USgpm.
	1500	2	22.70	66.1	- Pumping water level = 42.42 ft.
(b) Production Well #2 (Hatchery Well #7)					
June 1969 *5	400	1	9.80	40.7	- Nonpumping static water level = 25.53 ft.
	840	2	19.80	42.4	
	1290	3	30.80	41.8	
September 1970 *2	1300	1	30.87	42.1	- Nonpumping static water level = 26.44 ft.
	1300	24	33.20	39.2	- Hatchery Well #1 also pumping at 2000 USgpm.
	1300	192	40.00	32.5	
January 1977 *6	425	1	10.00	42.5	- Hatchery Wells #1 & #3 also pumping at 720 USgpm.
	513	5	12.00	42.8	
(c) Production Well #3 (Hatchery Well #1)					
July 1967 *7	525 (Avg.)	24	9.66	54.7	

*1 (Hall, 1970)
*2 (Callan, 1971a)
*3 (Kohut, 1977a)
*4 (Zubel, 1979)
*5 (Parry, 1969)
*6 (Kohut, 1977b)
*7 (Foweraker, 1967)