COMMUNAL WATER SUPPLY

FROM GROUNDWATER SOURCES

ST. PASCAL DE BAYLON

PREPARED FOR:

THE TOWNSHIP OF CLARENCE
AND
MCNEELY ENGINEERING LIMITED

PREPARED BY:

WATER AND EARTH SCIENCE ASSOCIATES LTD.
BOX 430, CARP, ONTARIO, CANADA. K0A 1L0

July 1987

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

Water and Earth Science Associates Ltd.(W.E.S.A.) was contracted by the Township of Clarence to conduct a water supply investigation in the hamlet of St. Pascal de Baylon, Ontario. The present water supply of this community is of limited quantity and is chemically poor. The purpose of the present work is to augment previous well drilling done in 1986 to locate an improved water supply for St. Pascal utilizing groundwater sources (WESA, 1986).

St. Pascal is located about 50 km east of Ottawa, in Clarence Township, Russell County. Figure 1 is the location for the St. Pascal area. All work described in this report was done in the Site 2 area. Figure 2 shows the location of new wells D9 and D10 with respect to previous well locations at Site 2.

2.0 BACKGROUND INFORMATION

The Hamlet of St. Pascal de Baylon has a total population of approximately 250 people. The community is made up of about seventy homes, a nursing home and a school.

The existing communal water supply is a combined surface water-groundwater system which was constructed over 30 years ago. The water source is a pond in a Champlain Sea deltaic sand deposit which is located east of the hamlet. Domestic water shortages and poor water quality are continuous problems within St. Pascal.

Early groundwater studies in the region carried out by the Groundwater Development section of the Ministry of the Environment in 1976 indicated that a single source well for supplying the desired quantities was an unlikely prospect and several linked wells would likely be the only feasible alternative.

A study of the existing water supply system by McNeely Engineering Ltd. (1982) indicated that almost total rebuilding of the existing pumping, piping, storage and filtering systems would be necessary in order to improve the system and alleviate quality and quantity problems.

A hydrogeologic study of the existing St. Pascal reservoir by WESA (1982) concluded that the recharge capacity was insufficient for existing needs and poor water quality made this reservoir undesirable as a water source for the hamlet. An alternative water source was deemed necessary. Due to water quality problems inherent to surface water supplies, a groundwater source is the most desirable in this area.

A report prepared by W.E.S.A. in December 1986 for the Township of Clarence detailed the results of the first phase of

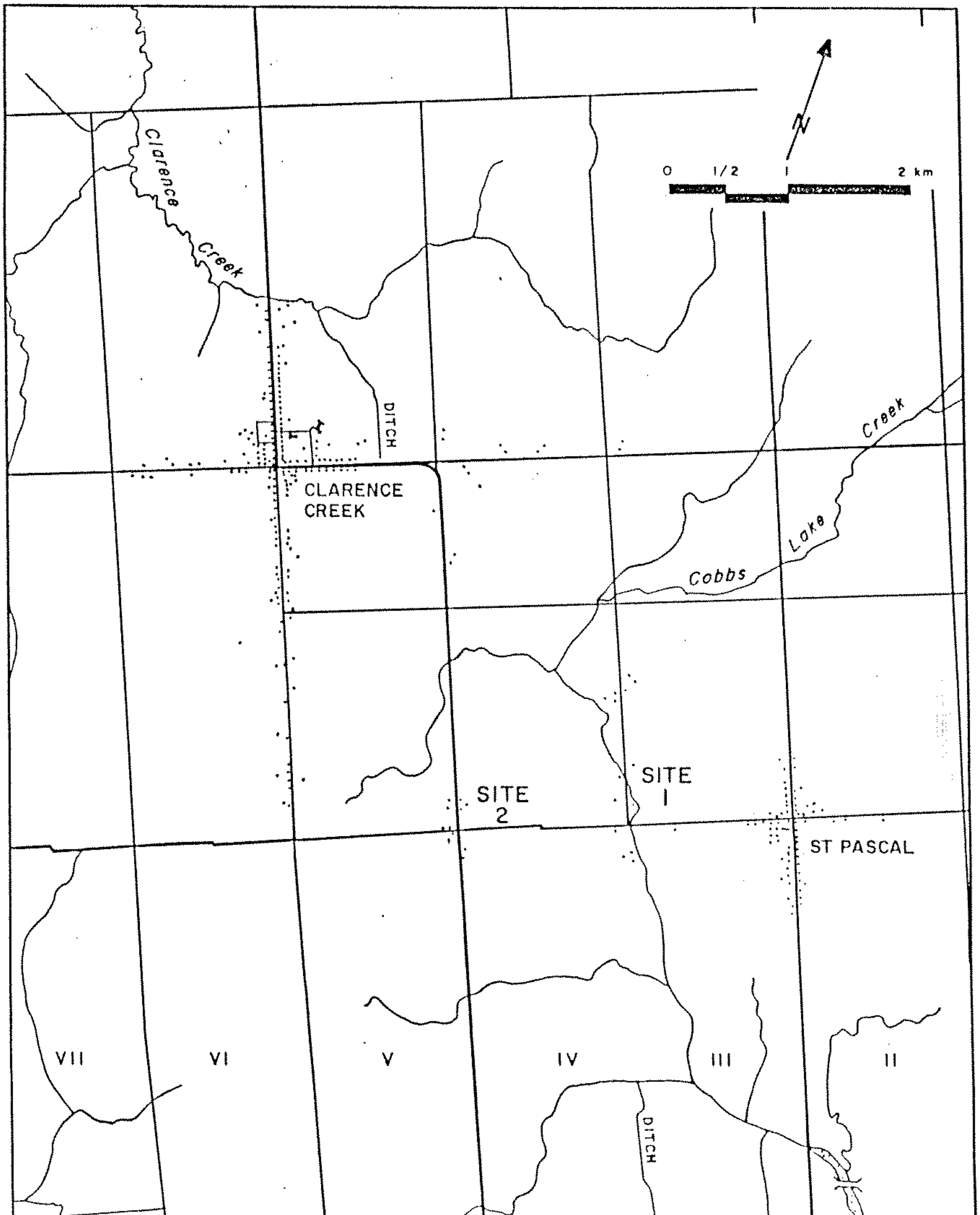


FIGURE I

LOCATION MAP

ST. PASCAL, ONTARIO

WATER AND EARTH SCIENCE ASSOCIATES LTD.

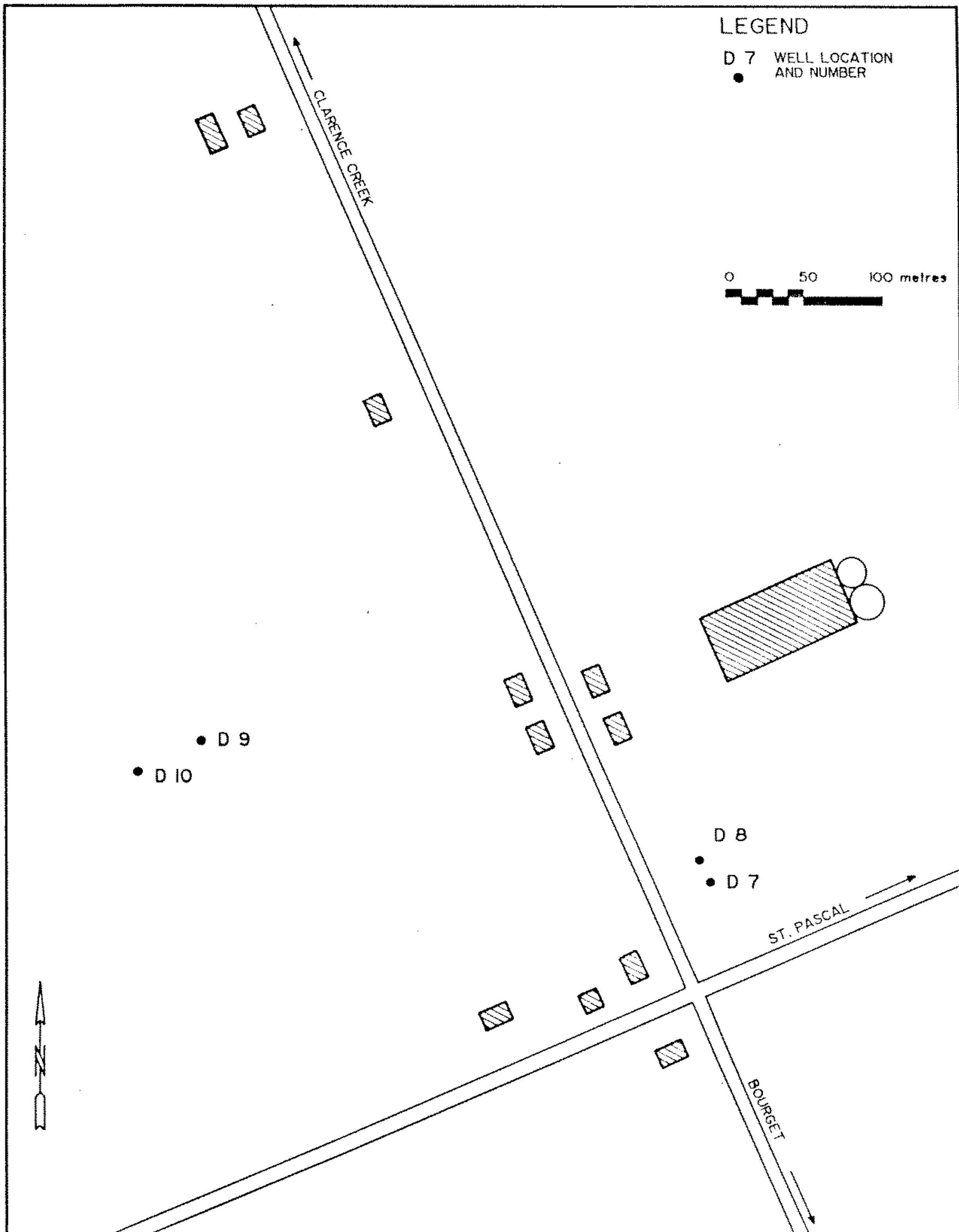


FIGURE 2

LOCATION MAP - SITE 2

ST. PASCAL, ONTARIO.

WATER AND EARTH SCIENCE ASSOCIATES LTD.

drilling and pump testing. Of the two areas under investigation, Site 1, located just over a kilometre west of St. Pascal was found to have a gravel aquifer, oriented along the axis of the Cobbs Creek valley and stratigraphically bounded by Champlain Sea marine clay. A long term safe yield of about 2.27 l/sec (30 IGPM) was calculated. Site 2, located two and three-quarter kilometres west of St. Pascal was found to have a bedrock aquifer calculated to sustain a long term safe yield of 3.48 l/sec (46 IGPM). No hydraulic connection had been proven to exist between Site 1 and 2 up to that point in time.

Although Site 2 was capable of pumping more water than Site 1, the capacity was still under the required yield of 6.33 l/sec (83.5 IGPM) (McNeely Engineering, 1982).

The 1987 field program was designed investigate more fully the production potential of Site 2 and if possible revise upward the established yield at the site of 3.48 l/sec (46 IGPM). This was to be done by drilling an additional pumping well and associated observation well within a 500 m radius of well D7. The well was to be pumped and tested for well efficiency, independent well yield, well yield when pumping was occurring at D7 over a 72 hour period, recovery and water quality. Water quality analyses were to encompass the complete list of MOE water quality objectives for communal drinking water supplies. Sampling was expanded to include some analysis of water from well D7 in order that a complete analysis would be available for this well. This testing was designed to provide enough data to refined the interpretation of mutual well interference from a multi-well communal water system.

3.0 METHOD OF STUDY

3.1 Terms of Reference

The Terms of Reference for this study follow the guidelines established by the Ministry of the Environment Water Supply Branch. The work program was designed to fulfill the following objectives:

- Define the stratigraphy of aquifer(s) present

- Provide detailed quantitative information regarding the aquifer parameters of transmissivity, storativity, and safe perennial yield, maximum yield and potential interference effects.

- Provide detailed chemical analysis including bacteria, major ions, metals, trace organics, radionuclides and pesticides.

3.2 Test Well Drilling

Based on geological and aquifer information obtained from previously drilled water wells, a 20.3 cm (8 inch) diameter observation well with a 150 mm (6 inch) diameter casing, D9, was tricone drilled using bentonite mud as a circulation fluid, within a 500 metre radius of well D7. Based on the encouraging results of D9, a test well, D10, was tricone drilled using mud, 46 metres from the D9 location. Both holes used air percussion methods to drill into the upper few metres of the weathered bedrock.

The geology encountered in D9 and D10 is quite similar to that found in wells D7 and D8. Immediately below ground surface a 1.4 to 3.6 metre thick, red-brown-grey clay overlies a brown-grey silt unit, which averages 8 metres thick. Below this silt, and extending almost to bedrock is soft thixotropic grey clay with local massive stiff grey clay lenses. Just above the weathered bedrock surface is a silty, fine grained gravel which might have a till origin. This unit averages 2 metres thick. Bedrock in both D9 and D10 comprises black shaley limestone/-dolomite, the upper metre of which is highly fractured. D9 was drilled 1.22 metres and D10 3.66 metres into bedrock. Drilling logs and completion techniques for the two new wells are illustrated in Figures 3 and 4, respectively.

3.3 Test Well Design

Observation well D9 was completed with 4 lengths of 6.69 metre (168.3 mm OD x 4.8 mm) casing welded together and set into bedrock, with a casing shoe. Two rubber shale traps were set around the casing approximately one third and two thirds down the hole. The well was developed for four hours by stop-start compressed air surging until the water was clear. No screening was necessary. The upper 6 metres of the hole was cemented with Type 30 Portland cement. A locking well cap covers the well.

Well D10 was completed with 4 lengths of casing of the same type used in D9. A single rubber shale trap was set approximately halfway down the hole. Several hours of well development using stop-start compressed air surging indicated the need to screen the hole. A 1.23 m length of telescoping #50 slot size Johnson stainless steel well screen, 143.5 mm OD was fitted above 3.4 metres of steel casing of the same diameter. The assembly above the screen comprised 1.7 metres of steel casing (143.5 mm OD). The screen and extension pipe were fitted with a figure K packer for installation in the casing. The entire assembly was lowered inside the well casing and pushed to the bottom of the hole, so that the screen would be situated within the fractured upper part of the bedrock. Total well development took close to 20 hours before sand free conditions were achieved. The upper 10 metres of the annular space between the well casing and 200 mm

FIGURE 3	RECORD OF TEST HOLE	DESIGNATION	COMPLETION DATE
		D9	22-5-87

PROJECT: Water Supply - St. Pascal De Baylon
PROJECT NO.: 1120B

DRILLING METHODS: Tricone - Water Jet
SUPERVISOR: T. Keil
DRILLING CONTRACTOR: Stanton Drilling

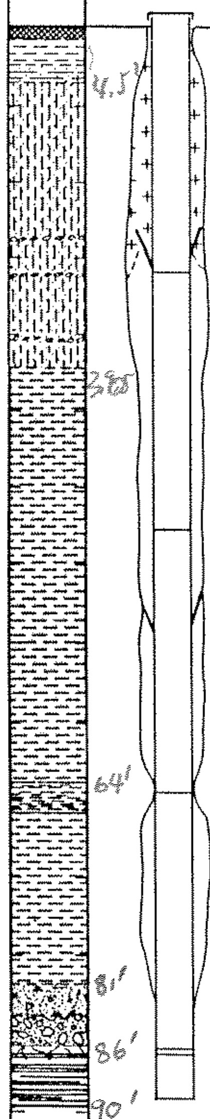
DEPTH METRES: 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38

ELEVATION METRES: (blank)

STRATIGRAPHY & HYDROSTRATIGRAPHY

0-0.3 m	Light to Medium Brown Loam with abundant Brown Clay
0.3-0.9 m	Sticky Red-Brown-Grey Clay (Dry) Mottled with some crude banding
0.9-1.37 m	Softer Brown-Grey Clay, Some Silt
1.37-~9.75 m	Fg Brown-Grey Silt, Some Sand. More Grey color with depth. Occasional small clast.
At 5.5 m	Small Gravel layer
At 6.4 m	Small Gravel layer
At 6.7 m	Some Clay (balls), quartz chips
At 8.2 m	Small Gravel layer. Occasional small amount Grey Clay (balls). Increasing Clay at 8.53 m
9.75-24.7 m	Soft Grey Clay (balls). Locally texture is firm
19.51-20.27 m	Stiff, massive Grey Clay
24.7-25.3 m	Grey Till, Shale, Limestone some Quartz clasts
25.3-26.2 m	Very fine Shale Gravel (Till?) Probably lots of Silt
26.2-27.75 m	Bedrock, Dark Grey Black Shale

LOG / INSTRUMENTATION



Locking Well Cap

Upper 6.1 m cemented with Type 30 Portland Cement

Rubber Shale Trap at 6.1 m

6.69 m casing length 168.3x4.8 mm OD

Rubber Shale Trap between 13 and 20 m

Casing Shoe Set into Shale Bedrock

SAMPLING

TYPE	INTERVAL	N VALUE
Grab	~0 m	
Mud grab	~1.5 m	
Mud grab	~5.5 m	
Mud grab	~6.5 m	
Mud grab	~7.5 m	
Mud grab	~11 m	
Mud grab	~13.5 m	
Mud grab	~17 m	
Mud grab	~20 m	
Mud grab	~22.5 m	
Mud grab	~25 m	
Chips	~27.5 m	

WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE 4

RECORD OF TEST HOLE

DESIGNATION	COMPLETION DATE
D10	27-5-87

PROJECT: Water Supply - St. Pascal De Baylon
PROJECT NO.: 1120B

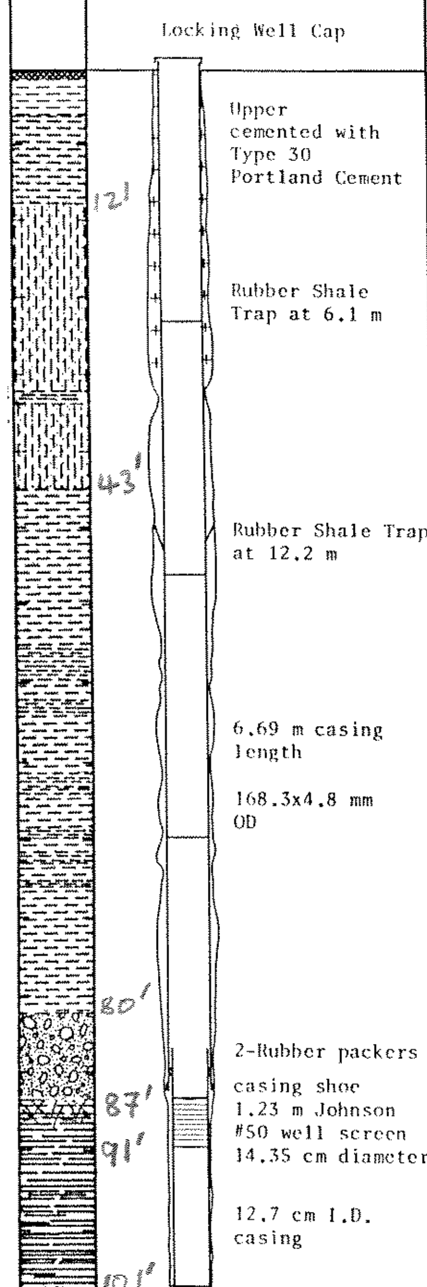
DRILLING METHODS: Tricone - Water Jet
SUPERVISOR: T. Keil
DRILLING CONTRACTOR: Stanton Drilling

DEPTH METRES | ELEVATION METRES | STRATIGRAPHY & HYDROSTRATIGRAPHY | LOG | INSTRUMENTATION | SAMPLING (TYPE, INTERVAL, N VALUE)

Depth scale (metres): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38

Stratigraphy & Hydrostratigraphy

0-1.22 m Silty Loam intermixed with Red-Brown Clay
1.22-~3.6 m Predominantly Grey Clay, also locally Red-Brown Clay
~3.6-11 m Light to Medium Brown Silt
At 8.5 m 0.3 m thick Sticky Grey Clay
11-11.6 m Transition zone Grey Clay and Brown Silt
11.6-24.4 m Soft, Sticky, Grey Clay (return not abundant)
15.24-16.76 m Sold Thick Sticky, Grey Clay (Occurs as lenses)
18.3-18.9 m Solid Thick Sticky, Grey Clay (Occurs as lenses)
19.8-21.9 m Solid Thick Sticky, Grey Clay (Occurs as lenses)
23.2-24.4 m Tough drilling, no Gravel
24.4-26.5 m Gravel (Till unit?) Extensive mud loss, very little return Lots of Silt
26.5-31.4 m Bedrock, Black Shale weathered surface to 27.4 m



Sampling

Type	Approx. depth (m)
mud grab	~1.5
mud grab	~3.5
mud grab	~13.5
grab	~27

WATER AND EARTH SCIENCE ASSOCIATES LTD.

hole was cemented with Type 30 Portland cement. A locking well cap covers the well.

3.4 Aquifer and Well Testing

The first aquifer test, carried out on May 28, 1987 on well D10 was a five part step test. A 5 hp submersible turbine pump was installed 21 metres below the top of casing. Each of the 5 steps had a duration of 30 minutes. Incremental pump discharge rates of 1.52 l/sec (20 IGPM), 3.03 l/sec (40 IGPM), 3.79 l/sec (50 IGPM), 4.55 l/sec (60 IGPM), and finally, 5.3 l/sec (70 IGPM) were used. Discharge rates were measured in a barrel.

Following a two and a half day recovery period, well D10 was pumped at a constant rate of 4.92 l/sec (65 IGPM) for a duration of 13 hours followed by recovery measurements. Discharge was measured using the bucket system, as well as orifice weir and manometer. Pumped discharge for the D10 site was into a nearby drainage ditch which rapidly diverted the water from the pumping location. The multiple clay strata overlying the aquifer hydraulically isolated pump discharge from the aquifer. All water level measurements in the wells were made using an electric tape. Wells D7, D8 and D9 were used as observations wells. Pump setup was the same as for the step test. Pumping was completed on June 1, 1987.

The final aquifer test comprised a 72 hour constant discharge test pumping both wells D10 and D7 simultaneously. Well D10 was pumped at a rate of 4.55 l/sec (60 IGPM) utilizing the same pump and setup as the previous tests at site D10. Well D7 was pumped at the rate of 3.41 l/sec (45 IGPM) using both a 1.5 and 2 hp submersible turbine pump. The 1.5 hp pump was placed 18 metres below the top of the casing and the 2 hp pump 21 metres below the top of the casing. Discharge from both D7 pumps was into the nearby road ditch where pumping rate was measured by the bucket method. The thick overlying clay strata at site D7 and rapid dispersal of the pumped water made the possibility of recharge to the confined aquifer negligible. The 72 hour pump test started on June 2, 1987 16 hours after the end of the 13 hour test. Twenty-four hours of recovery data was obtained from both pumping wells after pumping had ended. Wells D8 and D9 were used as observations wells for this test.

Water samples for chemical analysis were collected from pumping well D10 at regular intervals during the test together with a complete suite after 24 and 72 hours. Due to analytical cost considerations, a complete and detailed analysis carried out on the 72 hour sample. Other analyses were conducted to determine any trends in the data. Samples were collected from well D7 for analysis of those parameters not previously determined.

4.0 RESULTS

4.1 Geology and Hydrogeology

The upper bedrock shale unit found in wells D9 and D10 appears to be a continuation of the shaley limestone unit found in wells D7 and D8. The groundwater survey done by the Ministry of the Environment in 1976 for Clarence Township, Hamlet St. Pascal de Baylon, identifies these shales as belonging to the Billings Formation. The area adjacent and west of St. Pascal has experienced considerable faulting since deposition which resulted in complex bedrock patterns of the Billings Formation and the older limestones of the Ottawa and Eastview Formations. Dip angles are commonly less than 30°. The silt and fine gravel sediments found above bedrock at wells D9 and D10 were not observed at wells D7, D8.

4.2 Aquifer Test Results

Initial observations made during well development and confirmed during the step and 13 hour pumping tests indicates that well D10 has a water production capacity greater than well D7.

The five part step test done in D10 indicated continuing drawdown after 30 minutes of pumping at rates above 4.54 l/sec (60 IGPM). Data and calculations are shown in Appendix A. The calculation of well screen efficiency by the method after Rorabaugh (1953) appears inadequate. An alternative method based on a comparison of the theoretical and observed drawdown in the pumping well was used. This method calculated the theoretical drawdown from a transmissivity and storativity derived from the observation well. Drawdowns in observation wells are not affected by well losses and thereby give a true appraisal of the aquifer parameters. This calculation yielded a pumping well efficiency of 56 percent.

Measurements taken in wells D7, D8 and D9 during the 13 hour constant discharge pump test of well D10 indicate that the wells are hydraulically connected. Data and calculations are shown in Appendix B.

The Jacob method was used to evaluate the aquifer parameters at the pumping well D10 and the observation well D9 during the 13 hour constant discharge test. A transmissivity value of 54.07 m^2/day was obtained for the pumping well and 108.15 m^2/day for the observation well. A storativity of 4.56×10^{-3} was calculated for the observation well.

With both wells D10 and D7 pumping simultaneously, at constant discharge rates early drawdown data, ($t = <1000$ minutes) an observed transmissivity of 24.62 m^2/day was calculated for D10 and 135.4 m^2/day for D9. These values are not true transmissivities and were calculated for comparative purposes only. Well interference effects lower the calculated value substantially.

After 61 hours of the 72 hour test the water level in D10 showed a sudden and unexpected decline, which necessitated changing the pumping rate from 4.54 l/sec (60 IGPM) to 3.79 l/sec (50 IGPM) for the remainder of the test time. No corresponding sudden decrease in water levels were observed for the observation well D9 close to the pumping well or any other of the observation points or pumping well D7. A probable cause of this drawdown surge is a variation in well inefficiency caused by a shift in the flow conditions through the top of screen (turbulent flow with the higher head losses associated with this flow regime). If a real negative boundary had been encountered by the drawdown cone the boundary would have been reflected in increased drawdown in D7 as well as the observation wells. The average pumping rate for D10 over 72 hours was 4.45 l/sec (58.77 IGPM).

Other minor changes in the slope of the Jacob plot can be interpreted as influences of positive or negative boundaries or variations in the configuration of the aquifer from an infinite ,equal thickness homogeneous isotropic unit. The influence of other groundwater users in the area such as farms could also produce these variations.

Recovery data obtained after pumping was stopped showed relatively immediate early recovery followed by slower decay of residual drawdown. After the 13 hour pump test ended, well D10 had recovered 92.5% of its drawdown in the first hour. After the 72 hour pump test ended well D10 had recovered 90% of its drawdown in the first hour.

Analysis of late time ($t/t' < 15$) recovery data for well D10 indicates a transmissivity of 125.72 m^2/day. Similar calculations for well D9 show a transmissivity of 132.6 m^2/day.

A summary of transmissivity values for wells D10 and D9 is given in Table 1.

Table 1: Calculated Transmissivity Values (m^2/day)

	13 Hour Test	72 Hour Test (t <1000 minutes)	Recovery (t/t´ <15)
D10	54.07	24.62	125.72
D9	108.15	135.4	132.6

Notes: 1. All units are in M2/day

2. The effects of interference are not corrected for in wells.

These transmissivity values would therefore yield highly conservative estimates of yield under multiple pumping well conditions. Details of these calculations are shown with the individual type curves in Appendix C.

4.3 Well Efficiency

Attempts to calculate a well efficiency for D10 using Rorabaugh's (1953) method gave values so low as to be unrealistic. A test calculation using a pumping rate of 0.38 l/sec (5 IGPM) indicated a well efficiency of only 8.65% (Appendix A). A method utilizing data obtained from the 13 hour pump test of well D10 and observation well data obtained from well D9 yielded a more realistic well efficiency of 56 %. This value would be considered low for a well developed into a relatively homogeneous sand and gravel aquifer completely penetrated by a well screen. The aquifer at D10 is not homogeneous and water is yielded from a fractured bedrock or weathered bedrock interface. Screen was installed to control interstitial sand and gravel found between the broken bedrock clasts.

Well efficiency may be improved significantly at a production scale if a large diameter gravel packed design is used. Any improvements in well efficiency may be translated into increased available drawdown and consequently increased well yield.

4.4 Water Quality Results

Bacteriological analysis carried out on water samples collected from pumping wells D10 and D7 after 24 and 72 hours showed an absence of faecal coliform and faecal strept bacteria. In all samples, total coliform were 0 col/100 ml. The total bacteriological count in Well D10 at 11 col/ml is within safe levels. Microbial data are outline on Table 2.

TABLE 2: MICROBIAL MONITORING SUMMARY

	D10 24 hrs	D10 72 hrs	D7 24 hrs	D7 72 hrs
Total Count	11 col/ml	11 col/ml	1 col/ml	2 col/ml
Total Coliform	0 col/ml	0 col/ml	0 col/ml	0 col/100 ml
Fecal Coliform	Absent	Absent	Absent	Absent
Fecal Strept	Absent	Absent	Absent	Absent

A summary of the water chemistry is given in Table 3.

TABLE 3. WATER CHEMISTRY RESULTS

Metals		D10 24 hrs.	D10 72 hrs.	D7 72 hrs.	MOE Objectives
Arsenic (As)	ppm		<0.01	<0.001*	<0.05
Barium (Ba)	ppm		0.9	0.1	<1
Boron (B)	ppm		0.89	0.88	<5
Cadmium (Cd)	ppm		<0.005	<0.002*	<0.005
Chromium (Cr)	ppm		<0.01	<0.02*	<0.05
Copper	ppm		<0.01	<0.02*	<1
Cyanide (CN)	ppm		<0.10	<0.1	<0.2
Iron (Fe)	ppm	<0.05	<0.02	<0.05	<0.3
Lead (Pb)	ppm		0.01	<0.02*	<0.05
Manganese (MN)	ppm	<0.05	<0.01	<0.05	<0.05
Mercury (Mg)	ppb		<0.1		<1
Selenium (Se)	ppm		<0.01	<0.001*	<0.01
Silver (Ag)	ppm		<0.01	<0.01	<0.05
Sodium (Na)	ppm	221	208	216	<270
Uranium (U)	ppm		<0.01		<0.02
Zinc (Zn)	ppm		0.01	<0.02*	<5

<u>Non Metals</u>

Hydrogen Sulphide (H_2S) ppm	0.16	0.12	<0.1	<0.05 (guideline
Chloride (Cl) ppm	104	84-86	79	<250
Flouride (F) ppm		1	1	~~<1.5~~ 2.4

Table 3 continued

Ammonia Nitrogen ($N-NH_3$) ppm		0.61-0.99	.98*	<0.5	
Nitrate Nitrogen ($N-NO_3$) ppm	<0.1	<0.1	<.002*	<10	
Nitrite Nitrogen ($N-NO_3$) ppm	<0.1	<0.1	<0.1	<1	
Sulphate (SO_4) ppm		3	3*	<500	

<u>Other Parameters</u>

Colour UNT		36.0		~~<15~~ <5	Check
pH		8.1		6.5-8.5	
TDS	764	752	662	< 500	
Turbidity JCU	<1.0	<1.		<5	

<u>Radionuclides</u>

Cs_{137}	BQ/L	<1.0		<50
I_{131}	BQ/L	<1.0	@ 6/16/87	<10
Ra_{226}	BQ/L	0.1		<1
H_3	BQ/L	<100		<40000
Sr_{90}	BQ/L	<1.0		<10

<u>Organic Parameters</u>

Phenols ppb	<2	ND*	<2
Nitrilotriacetic acid ppm	<0.02		<0.05
Trihalomethanes	ND	ND*	<0.35
PCB	ND	ND*	<0.003

<u>Pesticides</u> Not detected (See Appendix D for detail)

Note: Data marked * from WESA (1986)

All metals in water analyses are within the safe limits for drinking water. Sodium, an element without a well defined provincial water quality objective occurs at a relatively high concentration on the order of 200 mg/l at both production sites. This is also consistent with the previously tested site closer to St. Pascal (WESA, 1986). Traces of hydrogen sulphide were detected during well development. Well D10 showed a maximum value of 0.16 ppm H_2S after 24 hours of pumping. The value of ammonia nitrogen after 72 hours of pumping D10 is slightly in excess of the water quality objective. In both wells D10 and D7 the level of total dissolved solids (TDS) is over the recommended limit of 500 ppm. Well D10 shows a maximum of 764 ppm at 24 hours.

The colour value in well D10 after 72 hours is 36 UNT. This is equivalent to 36 TCU and is slightly more than twice the recommended limit of 15 TCU.

Radionuclides, pesticides, phenols and nitrilotriacetic acid are all within the provincial water quality objectives for drinking water supply.

Those parameters showing values above recommended limits, hydrogen sulphide, ammonia, TDS and colour are all related to aesthetic quality. Water treatment technology exists to reduce concentrations of all the parameters, however, the economic feasibility of doing so may be a constraint in the case of St. Pascal.

Chlorination of the water supply may be expected to reduce the hydrogen sulphide concentrations. Other effects may be better appraised in a treatability study.

5.0 INTERPRETATION OF RESULTS

5.1 Physical Hydrogeology

The aquifer at Site 2 forms a fairly uniform, continuous aquifer that is confined by overlying clay layers. The overlying aquitard provides a significant measure of security to the underlying water producing zones from surface derived contaminants. The aquifer appears to very extensive although what could be interpreted as hydraulic boundaries do appear in the aquifer response testing. Recharge to the aquifer occurs at a significant distance from the site. The most likely recharge areas are to the north west and south. In these areas till ridges are evident and the thick low permeability Champlain Sea clays and silts thin and allow infiltration into either the basal sands and gravels. These more permeable deposits are hydraulically connected to the shallow bedrock.

Evaluation of a confined aquifer using the Jacob method is based on the following assumptions.

- The aquifer has a seemingly infinite areal extent.
- The aquifer is homogeneous, isotropic and of uniform thickness over the area influenced by the pumping test.
- Prior to pumping, the piezometric surface is nearly horizontal over the area influenced by the pumping test.
- The aquifer is pumped at a constant rate.

- The pumped well penetrates the entire aquifer and receives water from the entire thickness of the aquifer by horizontal flow.

- The radius of the well (r) is small and time (t) is large.

These assumptions appear to be largely valid at Site 2. A notable exception is the irregular nature of the bedrock fractures which severely compromises the second assumption. Large regional faults and changes in bedrock lithology are known to occur near the site, however, any boundary conditions resulting from these changes were not readily apparent in the analytical plots.

The use of a transmissivity of 40 m^2/day used in many calculations were done as `worst case´ scenario. Actual transmissivity of the aquifer at the D10-D9 location is likely to be three times as great and in the range of values shown for D9 in Table 1. The maximum 24 hour pumping rate in D10 is calculated at about 7.2 l/sec (95 IGPM) at a transmissivity of 40 m^2/day and 20.1 l/sec (266 IGPM) at a transmissivity of 120 m/day. In general there appears to be significant variability in the transmissivity of the aquifer likely a combined effect of both variable thickness and hydraulic conductivity. This variability is observable between the different well sites and within calculated transmissivities around individual sites. There is also significant evidence that the aquifer is anisotropic. These factors tend to complicate simulation for purposes of well interference, mutual interference of pumping wells and calculation of long term safe yield.

The use of transmissivity values calculated during combined pumping of wells D10 and D7 provide for some measure of security. Transmissivities calculated in this manner already incorporate a measure of mutual pumping well interference in them already. They may be therefore used as upper limits to the aquifer parameters in interference calculations.

Calculation of the 10 and 20 year safe yield, shown in Table 4 for well D10 uses transmissivities of 40 m^2/day and 120 m^2/day. These were done incorporating a maximum available drawdown of 18 metres into the equation, based on present static levels. No interference effects from other pumping wells were included in these calculations.

TABLE 4: LONG TERM SAFE YIELD - WELL D10

Time	**Transmissivity (m^2/day)**	
	40	**120**
10 years	4.61 l/sec(60.9 IGPM)	13.2 l/sec(174.3 IGPM)
20 years	4.47 l/sec(58.97 IGPM)	12.83 l/sec(169.3 IGPM)

These calculations are conservative considering that no leakage from overlying clays and no vertical recharge or recharge from positive boundaries were incorporated into the equation. The T values were calculated from the observed slope of the drawdown curve and do not take into account any flattening of the curve normally associated with relatively extensive aquifers of this type.

A notable result of the pumping tests, especially the step test, is the increased drawdown at increased pumping rates in the pumping well. This is a product of the discharge and time dependant nature of well efficiency. Additional unquantifiable losses occur as water moves from the aquifer through the well screen, from aquifer fractures.

5.2 Well Interference

The mutual and additive drawdown effects are of great concern in evaluating the potential of a groundwater aquifer that may be ultimately exploited by more than one production well. They are also a concern in evaluating the impact of a concentrated pumping source on existing domestic, commercial and agricultural water supplies in the area.

Initial calculations were done considering well D10 as the sole pumping well. Figures 5 and 6 show the calculated drawdowns at various surrounding locations when D10 is pumping at 4.54 l/sec (60 IGPM). Aquifer transmissivities of 40 m^2/day and 120 m^2/day were used, respectively. Figure 7 shows local drawdown when D10 is pumping at 6.82 l/sec (90 IGPM) and the aquifer is simulated with a transmissivity of 80 m^2/day.

It was demonstrated by WESA (1986) that the theoretical long term safe yield of well D7 is insufficient to meet ultimate design requirement of St. Pascal. The following evaluates the response of the aquifer to combined pumping of wells D10 and D7 at various rates. Aquifer data for well D7 was taken from WESA (1986). The transmissivity of the aquifer at D7 was calculated

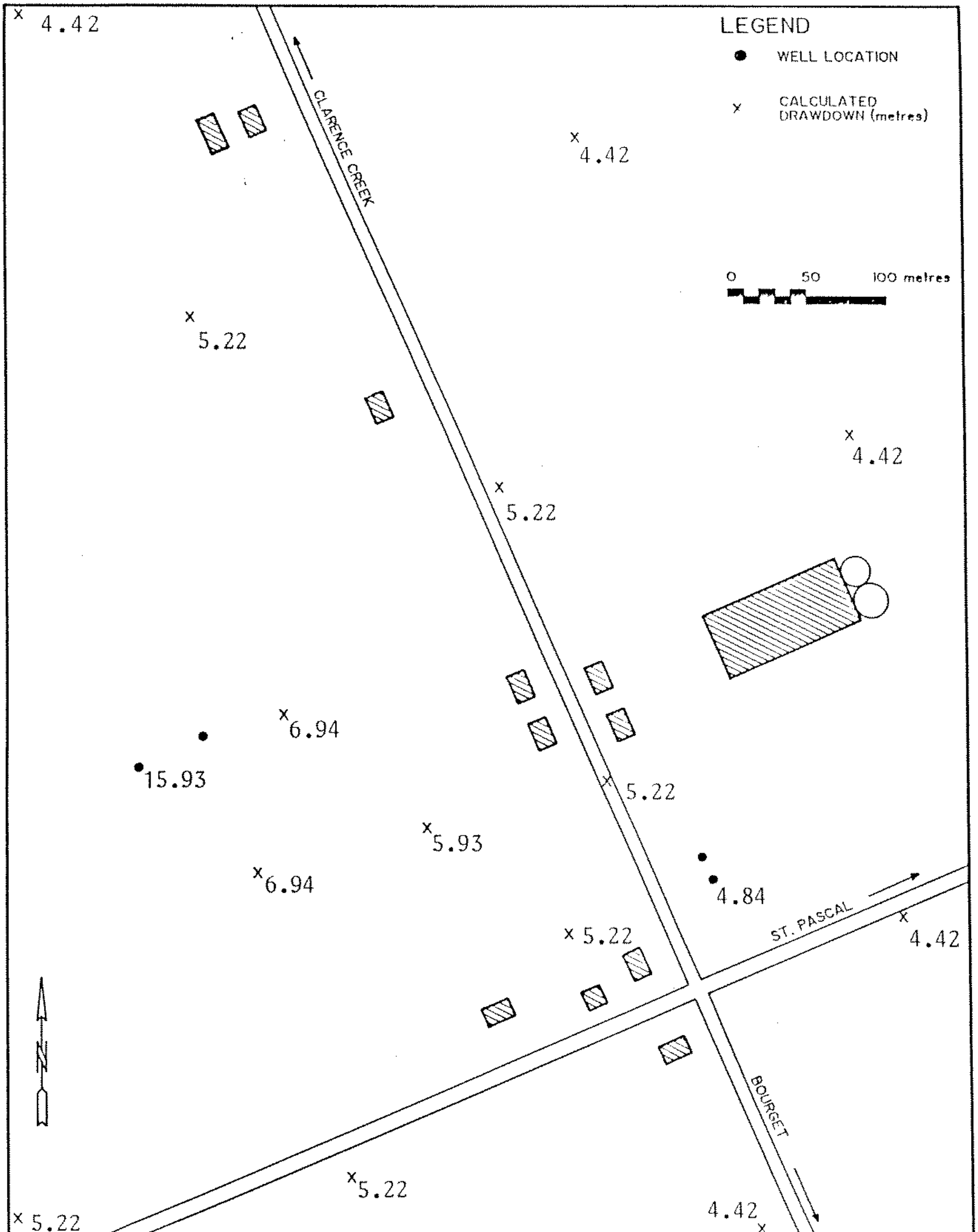


FIGURE 5

Calculated Drawdown at 4.55 L/sec.(60 IGPM) ($T = 40m^2$ / day) Well D10

ST. PASCAL, ONTARIO.

WATER AND EARTH SCIENCE ASSOCIATES LTD.

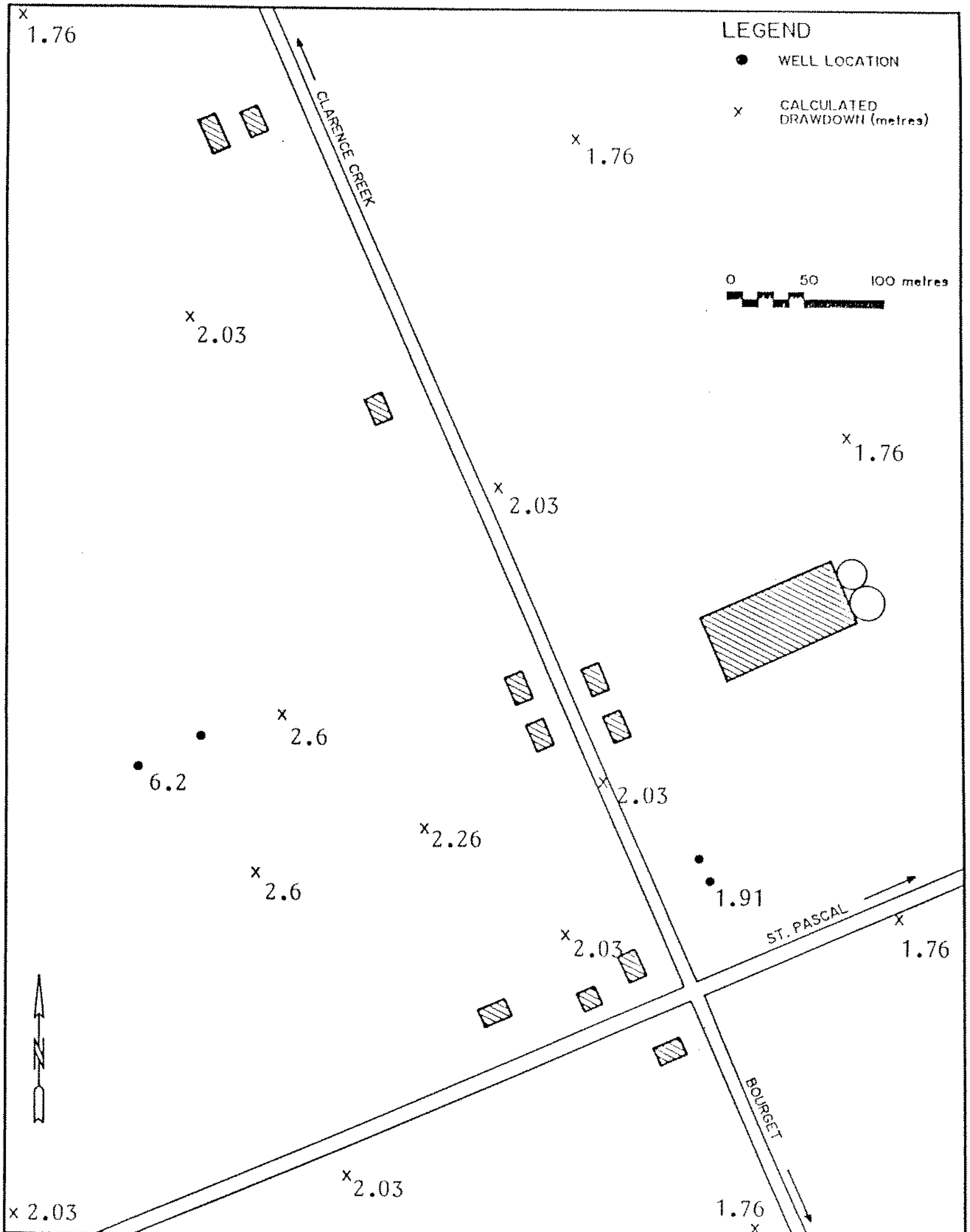


FIGURE 6

Calculated Drawdown at 4.55 L/sec.(60 IGPM) (T = 120m^2 / day) Well D10

ST. PASCAL, ONTARIO.

WATER AND EARTH SCIENCE ASSOCIATES LTD.

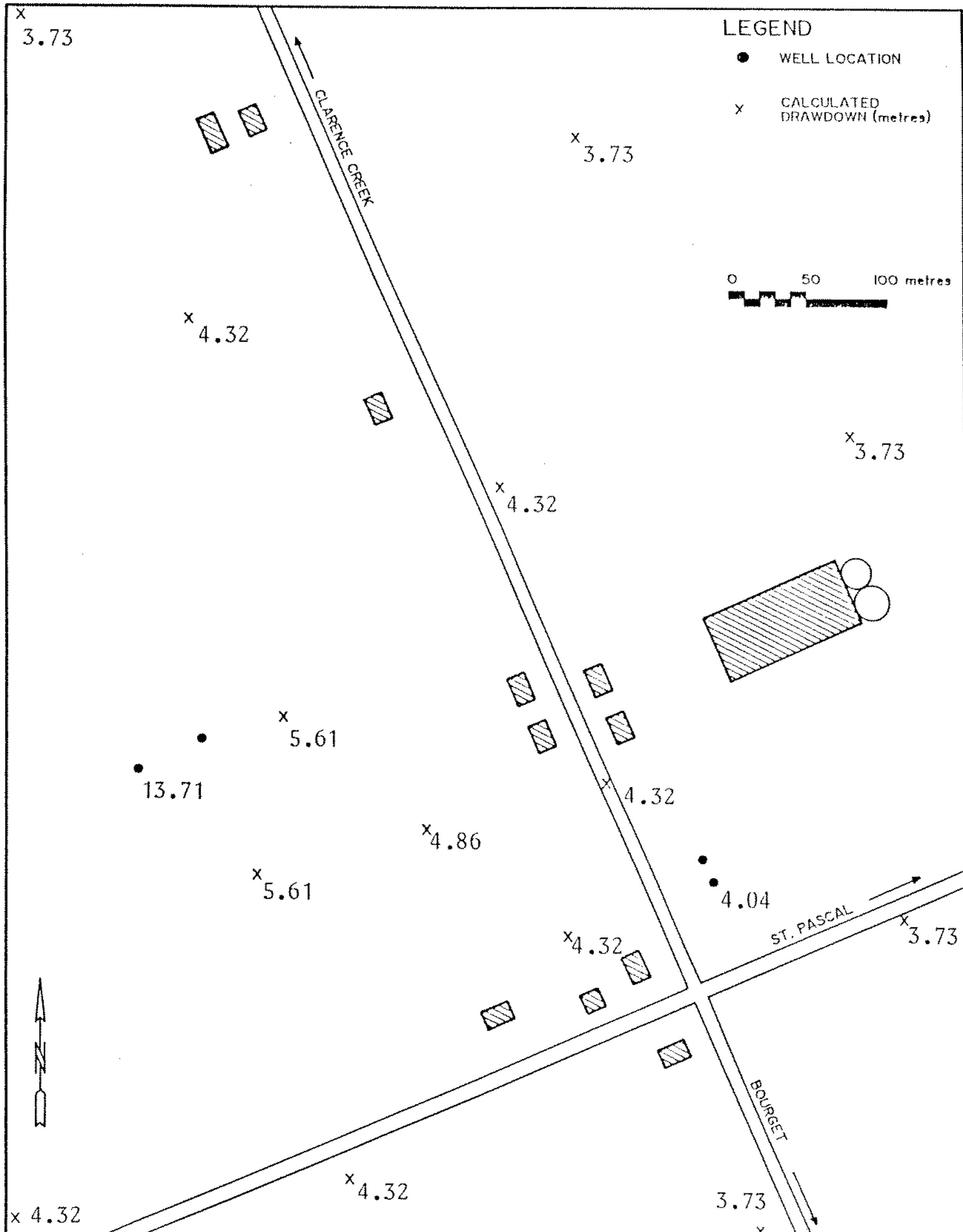


FIGURE 7

Calculated Drawdown at 6.82 L/sec.(90 IGPM) (T = 80m^2 / day) Well D10

ST. PASCAL, ONTARIO.

WATER AND EARTH SCIENCE ASSOCIATES LTD.

to be 36.14 m^2/day. The twenty year safe yield was calculated to be 3.48 l/sec (46 IGPM).

Figure 8 shows calculated drawdowns at various locations when D10 was pumping at 4.55 l/sec (60 IGPM) and D7 at 2.27 l/sec (30 IGPM) at aquifer transmissivities of 120 m^2/day and 36.14 m^2/day, respectively.

Figure 9 shows calculated drawdowns at the same locations when D10 is pumping at 6.06 l/sec (80 IGPM) and D7 at 1.52 l/sec (20 IGPM). Aquifer transmissivities are unchanged.

An additional calculation, the results of which are contained on Table 5, was done to see if there would be serious problems in a dual well pumping system. The calculation assumed a conservative aquifer transmissivity of 80 m^2/day for the area as a whole.

Table 5 Combined Drawdown at Pumping Wells D10, D7 (metres)

	D10 Q (IGPM)		
Well	**60**	**80**	**90**
D7	12.09	12.98	13.43
D10	11.40	14.44	15.97

Note: D7 pumping at 30 IGPM in all instances

The calculated drawdown is acceptable, although when D10 is pumping at 6.82 l/sec (90 IGPM) and D7 at 2.27 l/sec (30 IGPM), the combined drawdown at D7 is close to the allowable maximum 14 metres.

The above calculations show how different pumping rates combine to give different drawdowns. The transmissivity at well D10 is greater than at well D7 and the optimum combined pumping setup would be one in which well D10 is producing several times the quantity of D7. Interference on wells close to the pumping wells may best be minimized however by reducing the individual pumping rates of the wells or balancing the yields. Such a strategy however will have little impact on regional well

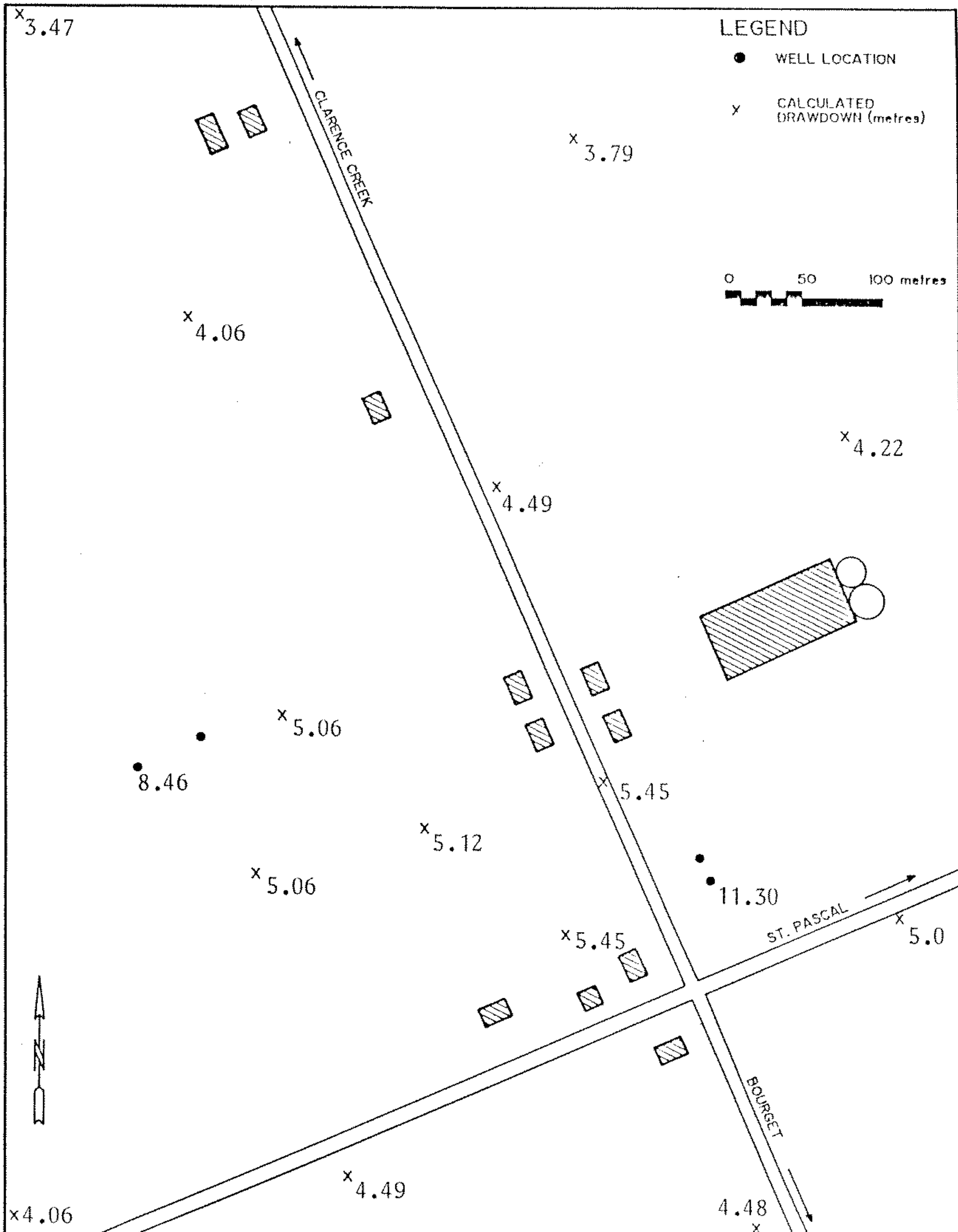


FIGURE 8

Combined Drawdown at 4.55 L/sec.(60 IGPM) (T = 120m² / day) D10
2.27 L/sec.(30 IGPM) (T = 36.14m²/day) D7

ST. PASCAL, ONTARIO.

WATER AND EARTH SCIENCE ASSOCIATES LTD.

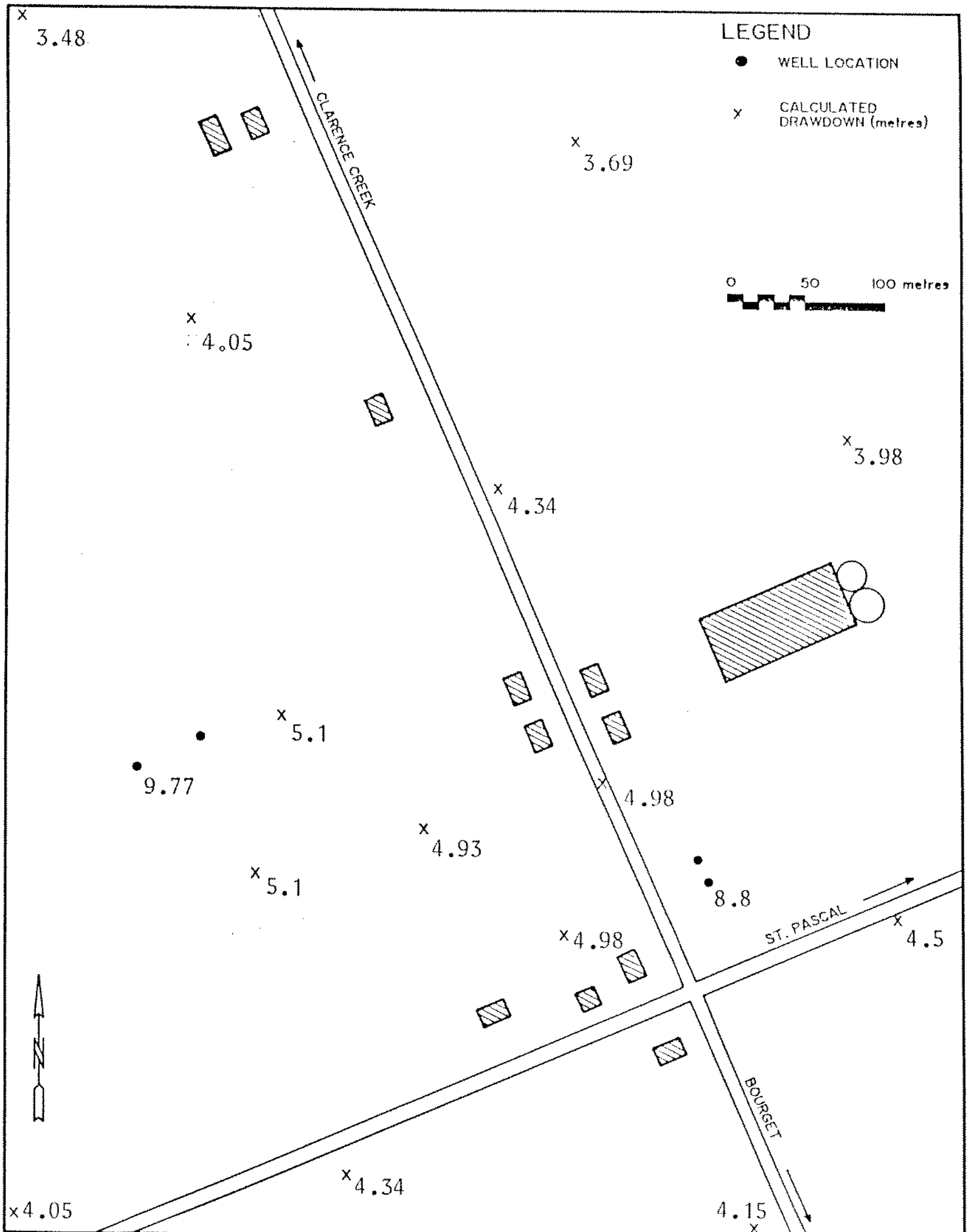


FIGURE 9

Combined Drawdown at 6.06 L/sec.(80 IGPM) (T = 120 m^2 / day) D10

1.52 L/sec.(20 IGPM) (T = 36.14m^2/day) D7

ST. PASCAL, ONTARIO.

WATER AND EARTH SCIENCE ASSOCIATES LTD.

interference on a wider scale. Pumping rates on the order of 4.545 l/sec (60 IGPM) and 2.0 l/sec (25 IGPM) for sites 3 and 2 are recommended at this time. This split may be revised with data produced during the installation of production wells.

During the 72 hour pump test, some local well interference was noted. This occurred at the Roberts/Smart house 420 metres north of pumping well D10. In this case, well interference and water supply interruption had been previously reported during summer dry periods. The well was being pumped by a shallow lift pump which when the static water level dropped during the summer or due to interference such as that which occurred during the testing program the water supply was interrupted. The well is completed into the same aquifer and has substantial available drawdown. Although this individual problem was solved in the short term by trucking in water and has since been permanently corrected through replacement of the shallow well pump with a deep well submersible pump.

This is not a unique problem and does not represent a major disadvantage. Many of the pumps and wells in the area are poorly constructed and are presently equipped with pumps which are incapable of operating in a aquifer where piezometric levels are fluctuating more than a metre on a seasonal basis. Significant available drawdown is available in these domestic wells however a number of households will require conversion to deep well pumps. It is estimated that on the order of 10 well installations should be surveyed in the immediate vicinity of the proposed well field. Pump replacement costs on the order of $2,000. per installation have been estimated, including landscaping.

5.3 Production Well Design

The production well design recommendations of this report are identical with those outlined in the previous report (WESA, 1986). In summary they are as follows.

1. A screened gravel-packed production well should be investigated to reduce the potential for sand production, increase the effective radius of the well especially in the weathered bedrock interface aquifer. This type of design will allow a maximum well efficiency.

2. A 400X200 mm design is recommended. Gravel pack and screen slot size must be sized according to the formation intersected at the production site.

3. A wire wrap stainless steel screen should be used in the well to facilitate maintenance.

4. Installation of the well by cable tool techniques is preferred unless it can be demonstrated that other tech-

niques may provide similar diameters and will not introduce unnecessarily large quantities of drilling fluid into the aquifer during drilling. Hole stability in this type of bouldery weathered bedrock formation is usually a problem in uncased drilling methods.

5. The borehole annulus should be pressure cement grouted in such a manner as to prevent the vertical migration of contaminants. The well head should be completed as to allow inclusion of the well in a pump house or connection to the pump house by a pitless adapter and service conduit.

6.0 CONCLUSIONS

The following conclusions have been produced based on work conducted in this study. They do not contradict conclusions of the previous WESA (1986) study and are designed to be evaluated in conjunction with previous statements.

1. Well D10, drilled to augment well D7, penetrates the upper fractured zone of a bedrock shale aquifer. The bedrock at D10 is similar to that at D7 and the aquifers are hydraulically connected. The aquifers are confined by overlying layers of grey marine clay.

2. The measured transmissivity of D10 is greater than that of D7 and should produce a larger safe yield. A conservative long term or safe perennial yield of 4.55 l/sec (60 IGPM) has been calculated.

3. Due to moderately low well efficiencies and mutual well interference associated with pumping the aquifers, long term pumping rates should average a maximum of 6.44 l/sec (85 IGPM). Pump intakes should be set as deep as possible to maximize available drawdown. Intakes should not however be set inside the well screen.

4. Some well interference with the local homeowners was observed during the pump tests. This interference is largely a function of substandard or marginally adequate existing pumping equipment in the homes and farms. These systems will require assessment and possibly adjustment or replacement if identified as substandard or vulnerable to interference.

5. The water quality has been assessed to be generally acceptable based on Ontario Ministry of the Environment objectives for public water supply related to health. The parameters that were seen to exceed the MOE objectives are ammonia, hydrogen sulphide, TDS, and colour. These constituents are largely related to aesthetic water quality criteria. In the case of ammonia the concentrations do not appear to be associated with other substantial contamination. The water quality in the aquifer is far better than that presently available to St. Pascal from the reservoir site both from a quality and quantity perspective. The water is generally used without complaint by local farming operations, dairy and market garden as well as a number of residences without complaint.

7.0 RECOMMENDATIONS

The following is recommended in light of the results of this investigation.

1. Field studies to date indicate that a total yield of 6.4 l/sec (85 IGPM) may be obtained from two pumping centres at Site 2 and Site 3. Recommended pumping rates for the two sites are 2.0 l/sec and 4.5 l/sec respectively.

2. To maximize available drawdown and therefore yields, pump intakes should be set as deep as possible in the wells above the screen. Large diameter 400 X 200 mm gravel packed production wells should be employed to minimize well efficiency and sand production.

3. Treatment of the water to improve its aesthetic qualities might be desirable in the long term. A treatability analysis is recommended.

4. An inventory of domestic and farm wells should be undertaken prior to any development of the communal system. On the order of 10 potential interference sites have been identified. Problems do not relate to the magnitude of the interference but more to the marginal condition and design of the pumping equipment in the homes and farms. This inventory may then be used to assess the validity of any potential future claims against the municipality and may also be used to identify substandard water systems on behalf of the owners. A contingency allowance for the upgrading of wells and pumping systems in the affected area should be considered in the overall project costs.

Respectfully submitted,

Tom Keil B.Sc.
Hydrogeologist

Roger M. Woeller M.Sc.
Hydrogeologist

8.0 REFERENCES

Driscoll, F.G., 1986, Groundwater and Wells, 2nd Ed., Johnson Division, St. Paul MN.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater Prentice Hall, N.J.

Kruseman, G.P., and De Ridder, N.A., 1983, Analysis and Evaluation of Pumping Test Data, 3rd Ed., ILRA, Netherlands.

Rorabaugh, M.I., 1953, Graphical and Theoretical Analysis of Step-Drawdown Test of an Artesian Well, Proc. of ASCE, Separate No. 362, pp 1-23.

Steltner, I.R., 1976, Groundwater Survey Clarence Township, Hamlet of St. Pascal de Baylon, Ontario Ministry of the Environment.

W.E.S.A. Ltd., December, 1984, Interim Report, St. Pascal Water Supply, unpublished report.

W.E.S.A. Ltd., June, 1986, Water Supply Investigation, Hamlet of St. Pascal de Baylon, unpublished report.

W.E.S.A. Ltd., December, 1986, Water Supply Investigation, Hamlet of St. Pascal de Baylon. Final report, unpublished report.

APPENDIX A

STEP-DRAWDOWN DATA AND CALCULATIONS

AQUIFER TEST DATA JOB#1120B WELL#: D10

Type of aquifer test: STEP DRAWDOWN Well type: PUMPING
How Q Measured: ORIFICE WEIR Data type: PUMPING
Distance from pumping well:0 m Depth pump: 19.81 m
Meas. point for w. l.'s: 0.30 m Pump on: 29-05-87 17:55:00
Elevation of Measuring Pt.: Pump off: 29-05-87 20:25:00
Static Water Level (m): 6.85 Discharge rate: 20,40,50,60,70 IGPM

Time minutes for each step	Time minutes total	Water Level Data w.l. (m)	Residual Drawdown	Discharge rate IGPM
1.0	1.0	7.160	0.310	20.00
2.0	2.0	7.240	0.390	
3.0	3.0	7.260	0.410	
4.0	4.0	7.260	0.410	
5.0	5.0	7.260	0.410	
6.0	6.0	7.270	0.420	
7.0	7.0	7.280	0.430	
8.0	8.0	7.285	0.435	
9.0	9.0	7.290	0.440	
10.0	10.0	7.295	0.445	
12.0	12.0	7.295	0.445	
14.0	14.0	7.300	0.450	
16.0	16.0	7.300	0.450	
18.0	18.0	7.305	0.455	
20.0	20.0	7.310	0.460	
22.0	22.0	7.310	0.460	
24.0	24.0	7.315	0.465	
26.0	26.0	7.315	0.465	
28.0	28.0	7.315	0.465	
30.0	30.0	7.315	0.465	
1.0	31.0	7.810	0.960	40.00
2.0	32.0	7.840	0.990	
3.0	33.0	7.855	1.005	
4.0	34.0	7.870	1.020	
5.0	35.0	7.880	1.030	
6.0	36.0	7.885	1.035	
7.0	37.0	7.890	1.040	
8.0	38.0	7.895	1.045	
9.0	39.0	7.900	1.050	
10.0	40.0	7.905	1.055	
12.0	42.0	7.910	1.060	
14.0	44.0	7.915	1.065	
16.0	46.0	7.920	1.070	
18.0	48.0	7.920	1.070	
20.0	50.0	7.925	1.075	
22.0	52.0	7.930	1.080	
24.0	54.0	7.935	1.085	
26.0	56.0	7.940	1.090	
28.0	58.0	7.950	1.100	
30.0	60.0	7.960	1.110	
1.0	61.0	8.710	1.860	50.00
4.0	64.0	8.900	2.050	

AQUIFER TEST DATA JOB#1120B WELL#: D10

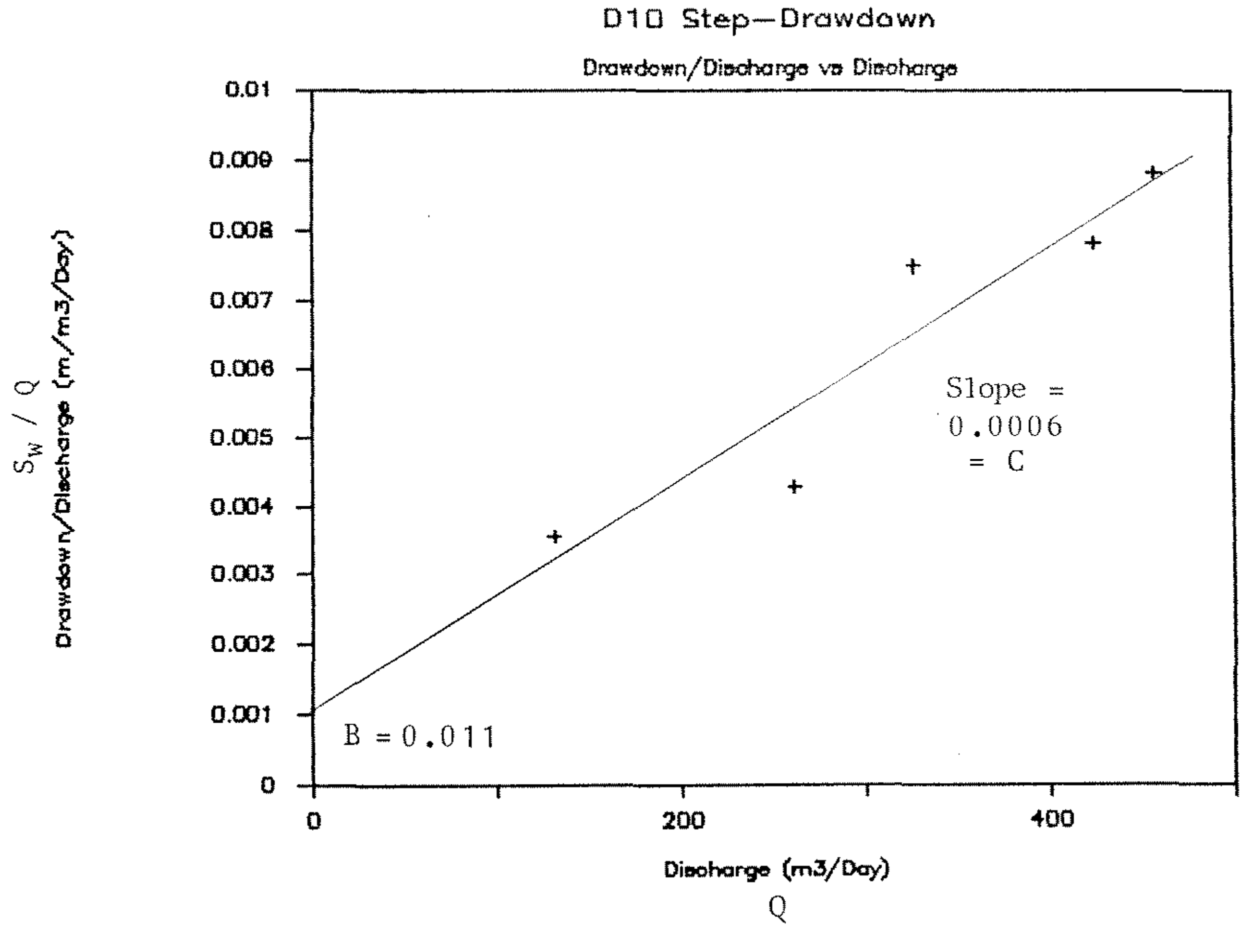
Type of aquifer test: STEP DRAWDOWN Well type: PUMPING
How Q Measured: ORIFICE WEIR Data type: PUMPING
Distance from pumping well:0 m Depth pump: 19.81 m
Meas. point for w. l.'s: 0.30 m Pump on: 29-05-87 17:55:00
Elevation of Measuring Pt.: Pump off: 29-05-87 20:25:00
Static Water Level (m): 6.85 Discharge rate: 20,40,50,60,70 IGPM

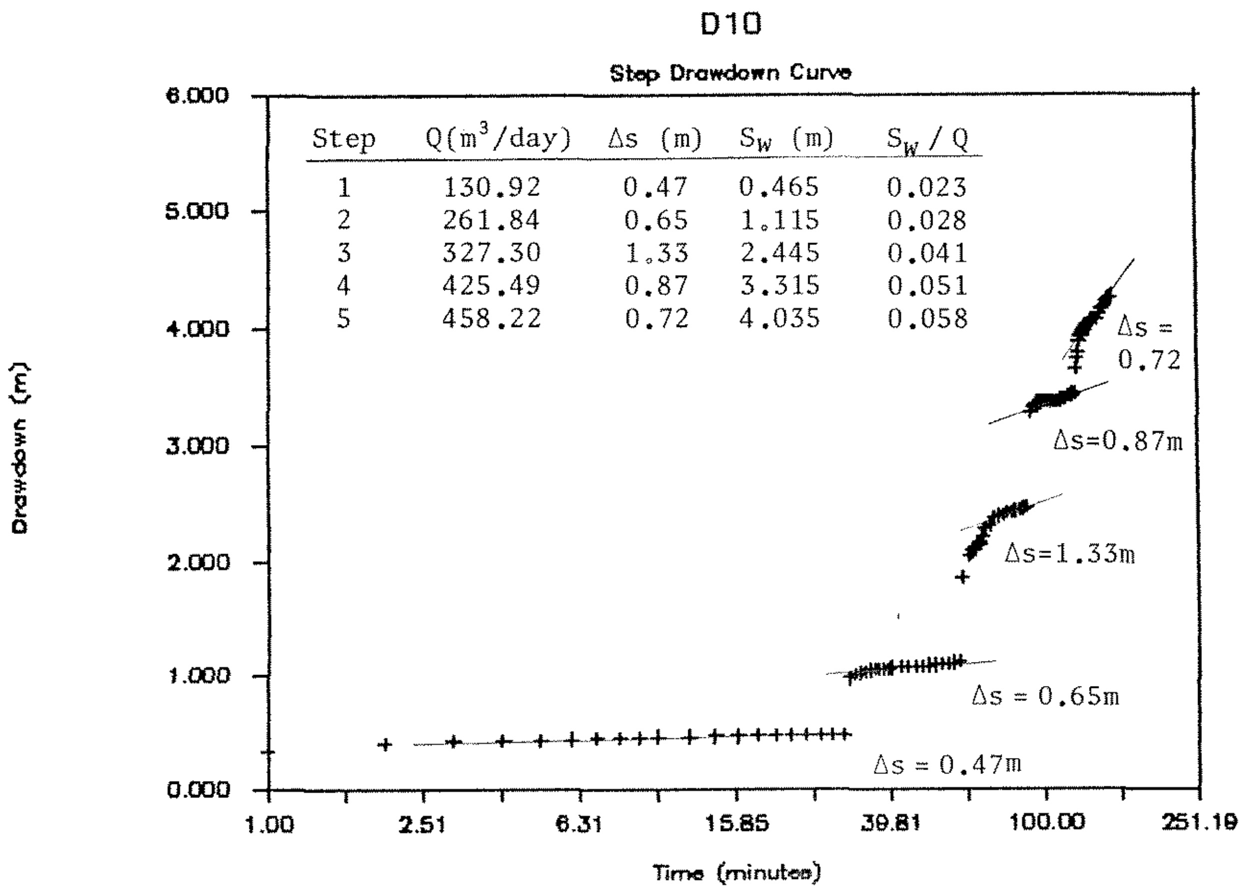
Time minutes for each step	Time minutes total	Water Level Data w.l. (m)	Residual Drawdown	Discharge rate IGPM
5.0	65.0	8.930	2.080	
6.0	66.0	8.960	2.110	
7.0	67.0	8.990	2.140	
8.0	68.0	9.000	2.150	
9.0	69.0	9.050	2.200	
10.0	70.0	9.120	2.270	
12.0	72.0	9.160	2.310	
14.0	74.0	9.210	2.360	
16.0	76.0	9.230	2.380	
18.0	78.0	9.250	2.400	
20.0	80.0	9.260	2.410	
22.0	82.0	9.270	2.420	
24.0	84.0	9.280	2.430	
26.0	86.0	9.290	2.440	
28.0	88.0	9.300	2.450	
30.0	90.0	9.310	2.460	
2.0	92.0	10.130	3.280	60.00
4.0	94.0	10.180	3.330	
5.0	95.0	10.200	3.350	
6.0	96.0	10.210	3.360	
7.0	97.0	10.210	3.360	
8.0	98.0	10.215	3.365	
9.0	99.0	10.220	3.370	
10.0	100.0	10.220	3.370	
12.0	102.0	10.225	3.375	
14.0	104.0	10.225	3.375	
16.0	106.0	10.230	3.380	
18.0	108.0	10.230	3.380	
20.0	110.0	10.235	3.385	
22.0	112.0	10.240	3.390	
24.0	114.0	10.250	3.400	
26.0	116.0	10.270	3.420	
28.0	118.0	10.280	3.430	
30.0	120.0	10.290	3.440	
1.0	121.0	10.500	3.650	70.00
2.0	122.0	10.600	3.750	
3.0	123.0	10.640	3.790	
4.0	124.0	10.730	3.880	
5.0	125.0	10.780	3.930	
6.0	126.0	10.800	3.950	
7.0	127.0	10.820	3.970	
8.0	128.0	10.830	3.980	

AQUIFER TEST DATA   JOB#1120B   WELL#: D10

Type of aquifer test: STEP DRAWDOWN Well type: PUMPING
How Q Measured: ORIFICE WEIR Data type: PUMPING
Distance from pumping well:0 m Depth pump: 19.81 m
Meas. point for w. l.'s: 0.30 m Pump on: 29-05-87 17:55:00
Elevation of Measuring Pt.: Pump off: 29-05-87 20:25:00
Static Water Level (m): 6.85 Discharge rate: 20,40,50,60,70 IGPM

Time minutes for each step	Time minutes total	Water Level Data w.l. (m)	Residual Drawdown	Discharge rate IGPM
9.0	129.0	10.850	4.000	
10.0	130.0	10.870	4.020	
12.0	132.0	10.900	4.050	
14.0	134.0	10.920	4.070	
16.0	136.0	10.925	4.075	
18.0	138.0	10.930	4.080	
20.0	140.0	10.970	4.120	
22.0	142.0	11.010	4.160	
24.0	144.0	11.040	4.190	
26.0	146.0	11.080	4.230	
28.0	148.0	11.100	4.250	
30.0	150.0	11.120	4.270	





Step	$Q(m^3/day)$	Δs (m)	S_W (m)	S_W / Q
1	130.92	0.47	0.465	0.023
2	261.84	0.65	1.115	0.028
3	327.30	1.33	2.445	0.041
4	425.49	0.87	3.315	0.051
5	458.22	0.72	4.035	0.058

Well Efficiency - D10

$$WE = \frac{Sw\ theoretical}{Sw\ actual}$$

from Rorabaugh (1953)

$$= \frac{BQ}{BQ + CQ^n}$$

B = 0.011
C = 0.0006
n = 2.5

Assume pumping rate 32.73 m^3/day (5 IGPM)

$$= \frac{(0.011)32.73}{(0.011)32.73 + (0.0006)32.73^{(2.5)}}$$

= 8.65 %

APPENDIX B

13 HOUR AQUIFER TEST DATA AND CALCULATIONS

AQUIFER TEST DATA JOB#1120B WELL#: D10

Type of aquifer test: 13HR CONST.Q
How Q Measured: ORIFICE WEIR
Distance from pumping well:0 m
Meas. point for w. l.'s: 0.30 m
Elevation of Measuring Pt.:
Static Water Level (m): 6.75

Well type: OBSERV.
Data type: PUMPING
Depth pump: 19.81 m
Pump on: 01-06-87 8:00:00
Pump off: 01-06-87 21:00:00
Discharge rate: 65 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
3	10.47	3.72
5	10.68	3.93
7	10.88	4.13
8	10.93	4.18
10	11.03	4.28
12	11.06	4.31
14	11.12	4.37
16	11.16	4.41
18	11.21	4.46
20	11.24	4.49
25	11.30	4.55
30	11.37	4.62
35	11.16	4.41
40	11.23	4.48
45	11.29	4.54
50	11.31	4.56
55	11.37	4.62
60	11.39	4.64
70	11.46	4.71
85	11.58	4.83
90	11.62	4.87
100	11.66	4.91
110	11.70	4.95
120	11.71	4.96
150	11.78	5.03
180	11.82	5.07
210	11.94	5.19
240	12.01	5.26
270	12.07	5.32
300	12.18	5.43
330	12.27	5.52
360	12.32	5.57
390	12.36	5.61
420	12.40	5.65
450	12.42	5.67
480	12.47	5.72
510	12.50	5.75
540	12.52	5.77
580	12.53	5.78
600	12.61	5.86
630	12.66	5.91
660	12.69	5.94
690	12.75	6.00

AQUIFER TEST DATA JOB#1120B WELL#: D10

Type of aquifer test:	13HR CONST.Q	Well type:	OBSERV.
How Q Measured:	ORIFICE WEIR	Data type:	PUMPING
Distance from pumping well:	0 m	Depth pump:	19.81 m
Meas. point for w. l.'s:	0.30 m	Pump on:	01-06-87 8:00:00
Elevation of Measuring Pt.:		Pump off:	01-06-87 21:00:00
Static Water Level (m):	6.75	Discharge rate:	65 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
775	12.85	6.10
780	12.86	6.11

AQUIFER TEST DATA   JOB#1120B   WELL#: D9

Type of aquifer test: 13HR CONST.Q   Well type: OBSERV.
How Q Measured: ORIFICE WEIR   Data type: PUMPING
Distance from pumping well: 46.2 m   Depth pump: 19.81 m
Meas. point for w. l.'s: 0.25 m   Pump on: 01-06-87 8:00:00
Elevation of Measuring Pt.:   Pump off: 01-06-87 21:00:00
Static Water Level (m): 6.74   Discharge rate: 65 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
11	7.50	0.76
17	7.54	0.80
26	7.58	0.84
42	7.62	0.88
56	7.66	0.92
76	7.69	0.95
148	7.77	1.03
181	7.79	1.05
211	7.82	1.08
241	7.84	1.10
272	7.86	1.12
317	7.89	1.15
362	7.91	1.17
408	7.94	1.19
435	7.94	1.20
482	7.97	1.22
513	7.98	1.23
543	7.99	1.25
573	8.00	1.26
603	8.01	1.27
633	8.05	1.31
663	8.07	1.33
693	8.08	1.34
770	8.09	1.35

AQUIFER TEST DATA   JOB#1120B   WELL#: D8

Type of aquifer test: 13HR CONST.Q   Well type: OBSERV.
How Q Measured: ORIFICE WEIR   Data type: PUMPING
Distance from pumping well:372 m   Depth pump: 19.4 m
Meas. point for w. l.'s: 0.55 m   Pump on: 01-06-87 8:00:00
Elevation of Measuring Pt.:   Pump off: 01-06-87 21:00:00
Static Water Level (m): 6.53   Discharge rate: 65 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
77	6.53	0.00
157	6.54	0.01
217	6.54	0.01
277	6.54	0.01
372	6.55	0.01
461	6.54	0.01
582	6.59	0.06
702	6.62	0.09

AQUIFER TEST DATA JOB#1120B WELL#: D7

Type of aquifer test: 13HR CONST.Q
How Q Measured: ORIFICE WEIR
Distance from pumping well:380 m
Meas. point for w. l.'s: 0.55 m
Elevation of Measuring Pt.:
Static Water Level (m): 6.55

Well type: OBSERV.
Data type: PUMPING
Depth pump: 19.4 m
Pump on: 01-06-87 8:00:00
Pump off: 01-06-87 21:00:00
Discharge rate: 65 IGPM

Time	Water Level Data	
minutes	w.l. (m)	Drawdown
75	6.55	0.00
155	6.55	0.00
215	6.55	0.00
275	6.55	0.00
376	6.56	0.01
465	6.55	0.00
584	6.60	0.05
704	6.62	0.07

AQUIFER TEST DATA WELL#: D10

Type of aquifer test: 13HR CONST Q. Well type: PUMPING
How Q Measured: ORIFICE WEIR Data type: RECOVERY
Distance from pumping well:0 m Depth pump: 19.81 m
Meas. point for w. l.'s: 0.30 m Pump on: 03-06-87 8:00:00
Elevation of Measuring Pt.: Pump off: 05-06-87 21:00:00
Static Water Level (m): 6.75 Discharge rate: 65 IGPM

At t' = 0, t = Time minutes	780.00 t/t'	Water Level Data w.l. (m)	Residual Drawdown
1.0	781.0	7.680	0.930
2.0	391.0	7.530	0.780
3.0	261.0	7.470	0.720
4.0	196.0	7.440	0.690
5.0	157.0	7.410	0.660
9.0	87.7	7.350	0.600
10.0	79.0	7.340	0.590
12.0	66.0	7.325	0.575
15.0	53.0	7.300	0.550
20.0	40.0	7.290	0.540
25.0	32.2	7.260	0.510
30.0	27.0	7.245	0.495
45.0	18.3	7.230	0.480
60.0	14.0	7.205	0.455
660.0	2.2	6.950	0.200

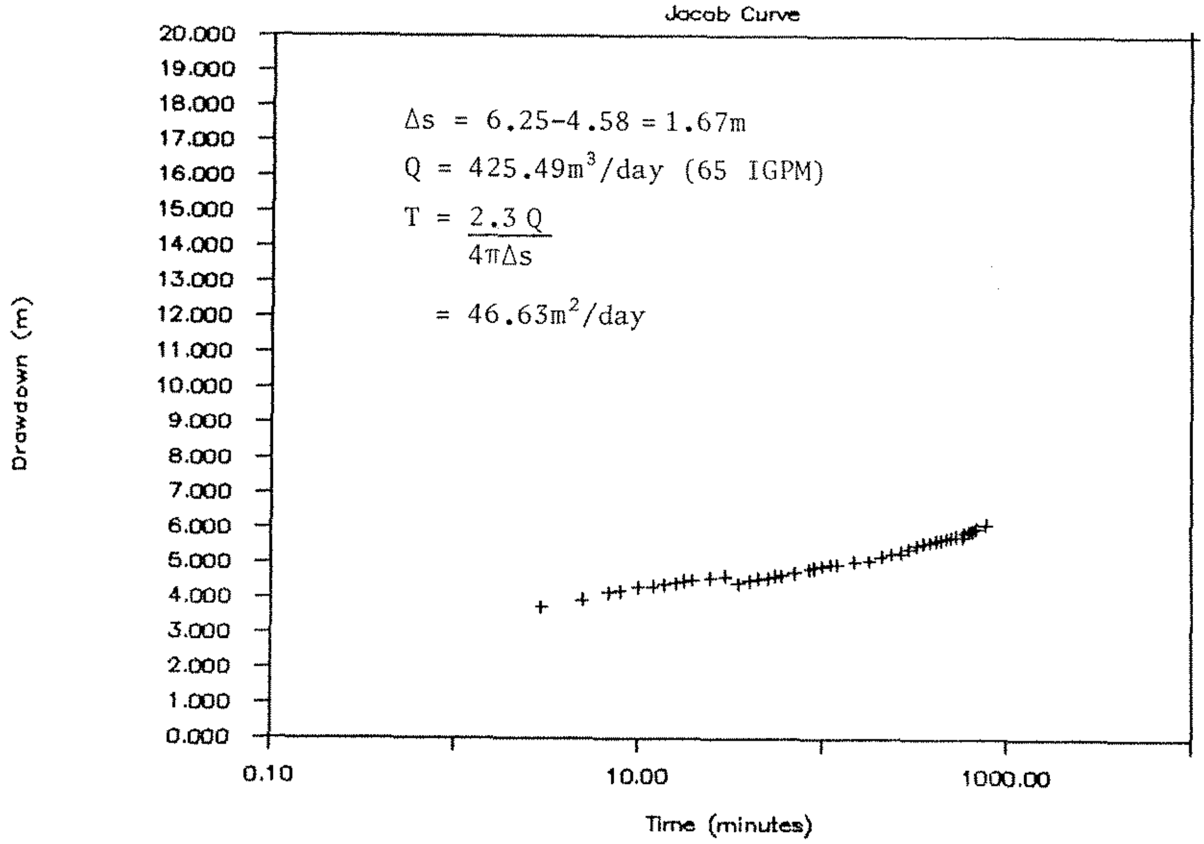
AQUIFER TEST DATA WELL#: D9

Type of aquifer test: 13HR CONST Q. Well type: OBSERV.
How Q Measured: ORIFICE WEIR Data type: RECOVERY
Distance from pumping well:46.2 m Depth pump: 19.81 m
Meas. point for w. l.'s: 0.25 m Pump on: 01-06-87 8:00:00
Elevation of Measuring Pt.: Pump off: 01-06-87 21:00:00
Static Water Level (m): 6.74 Discharge rate: 65 IGPM

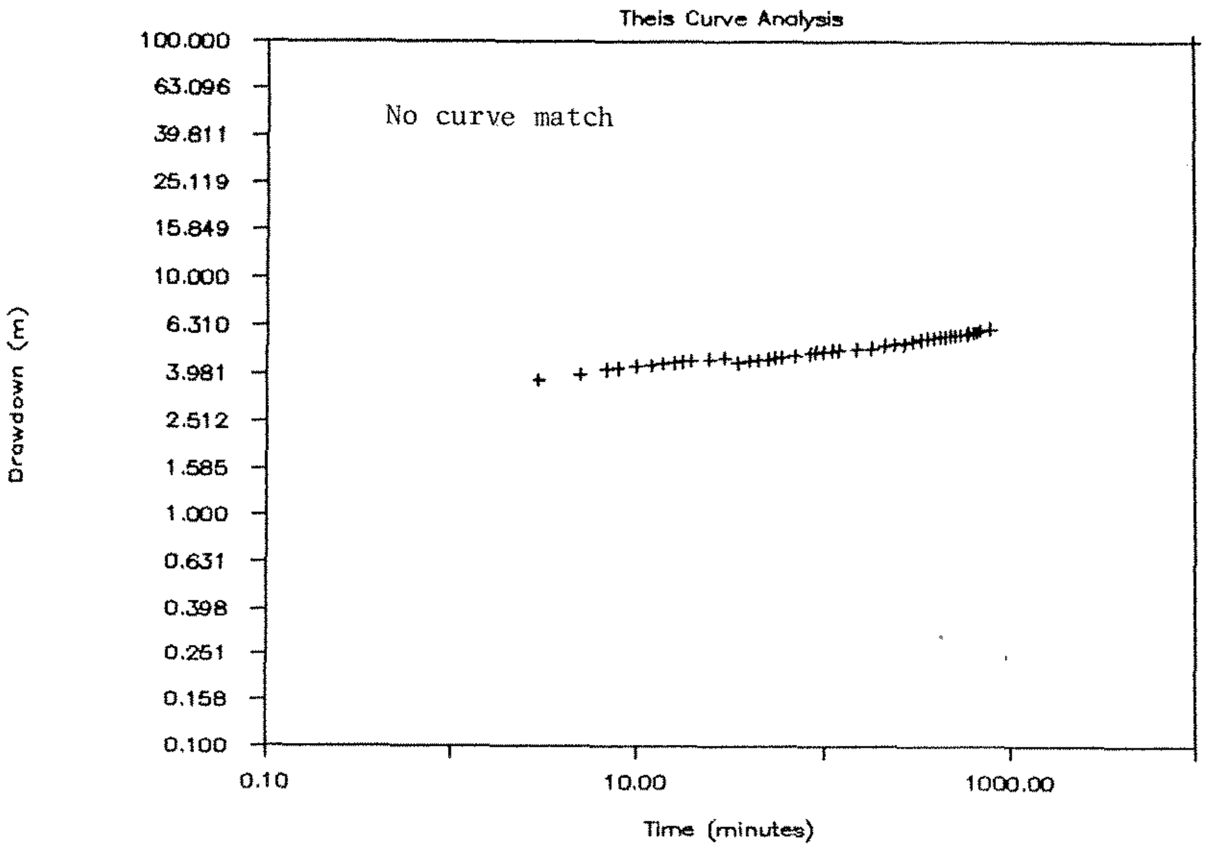
At t' = 0, t = 780.00

Time minutes	t/t'	Water Level Data w.l. (m)	Residual Drawdown
6.0	131.0	7.370	0.630
16.0	49.8	7.280	0.540
23.0	34.9	7.250	0.510
44.0	18.7	7.220	0.480
61.0	13.8	7.190	0.450
660.0	2.2	6.940	0.200

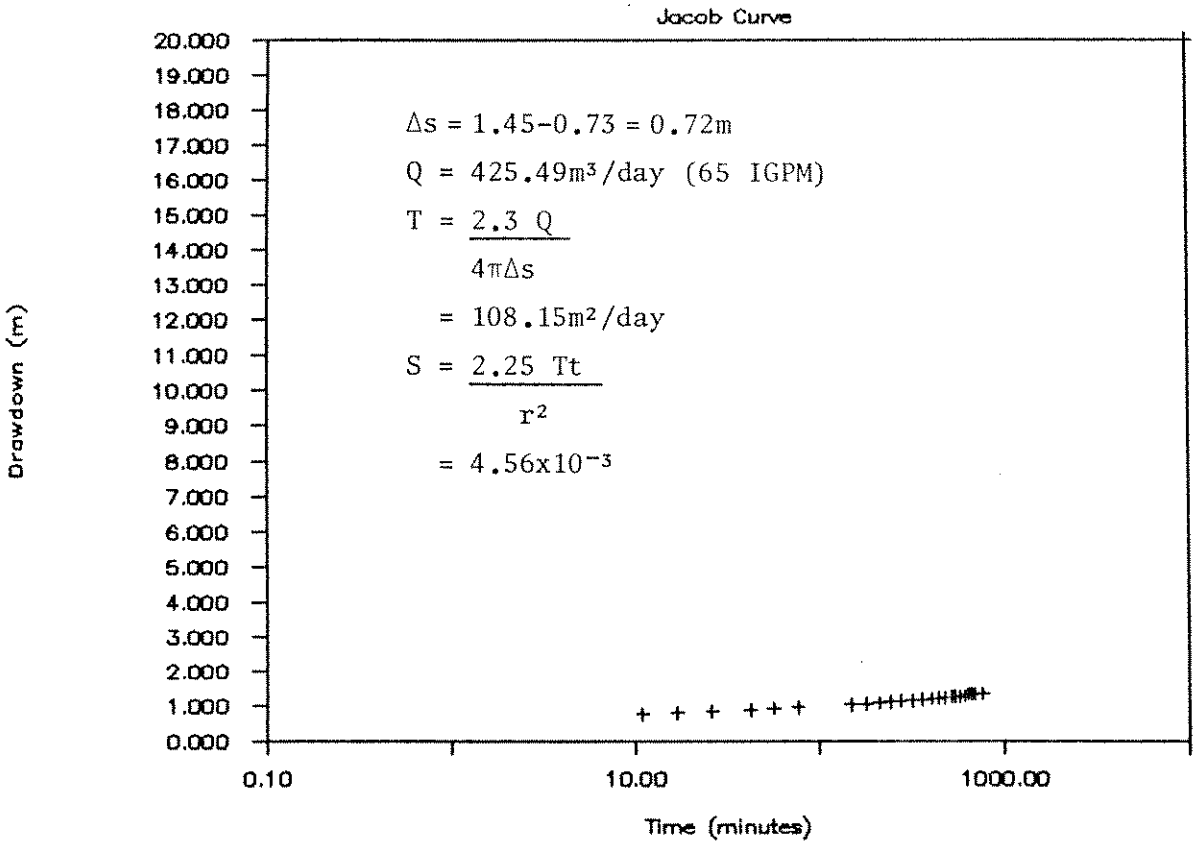
D10 - 13 HR TEST



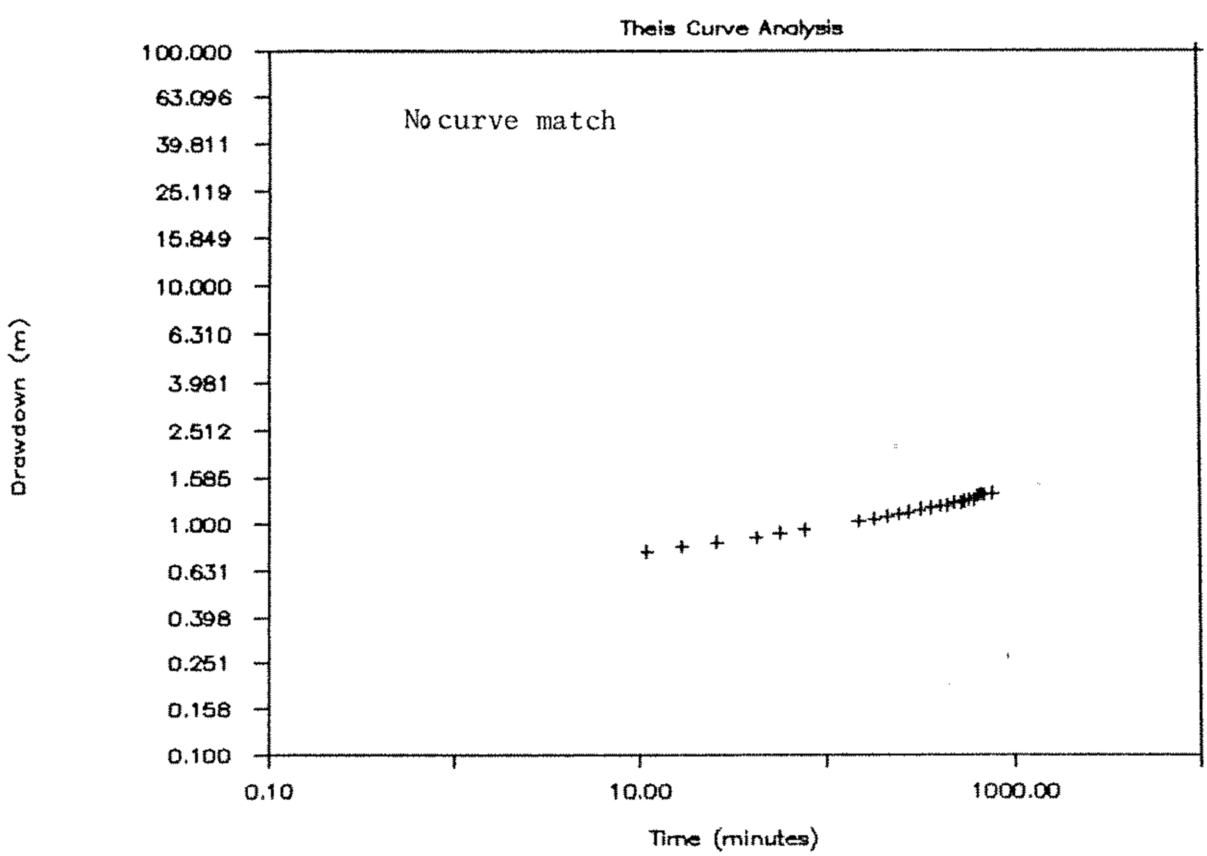
D10 - 13 HR TEST



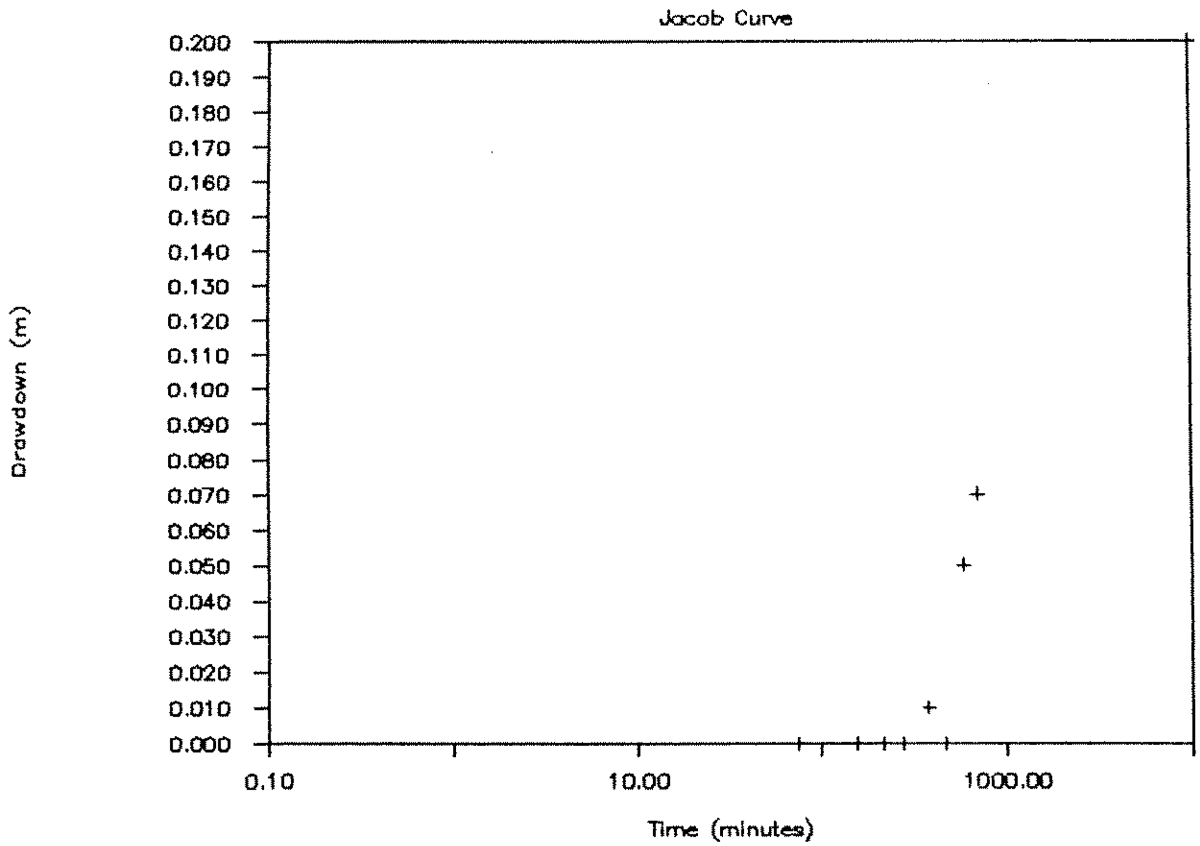
D9 - 13 HR TEST



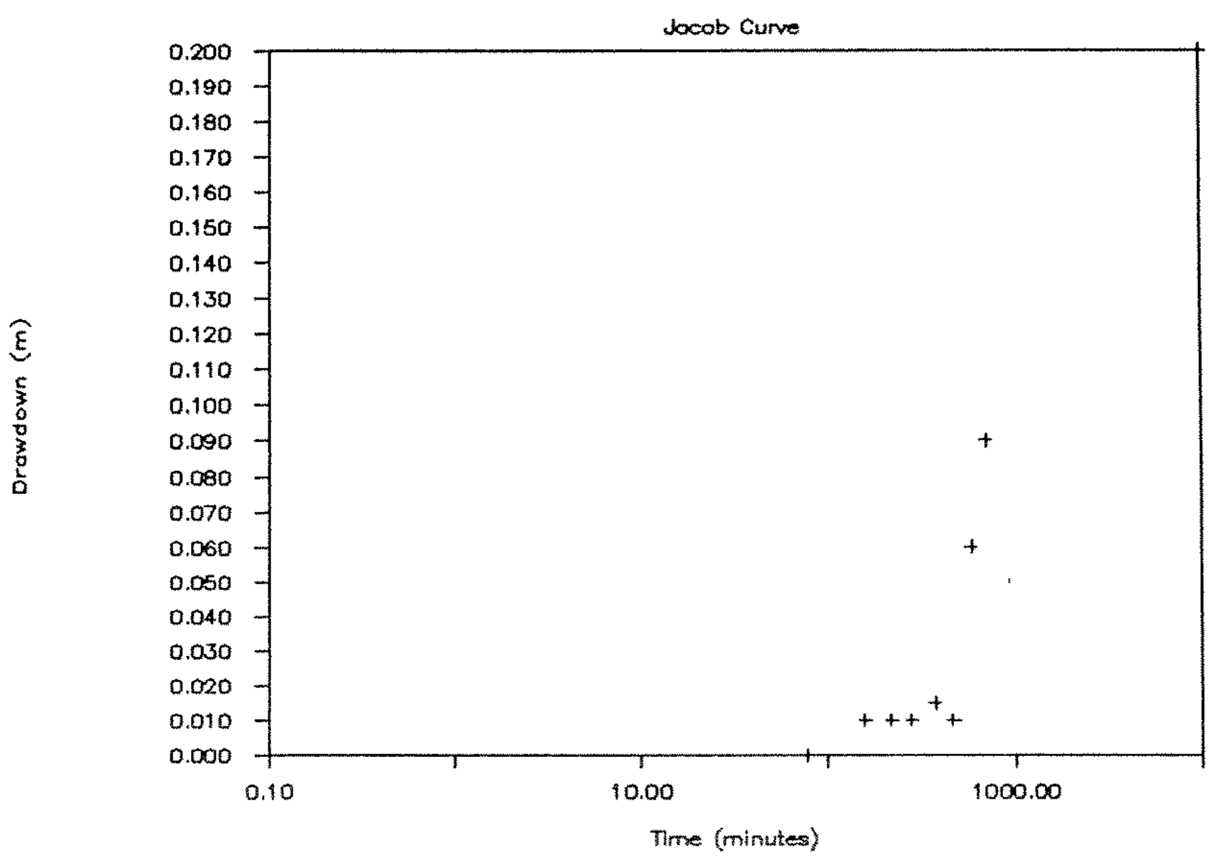
D9 - 13 HR TEST



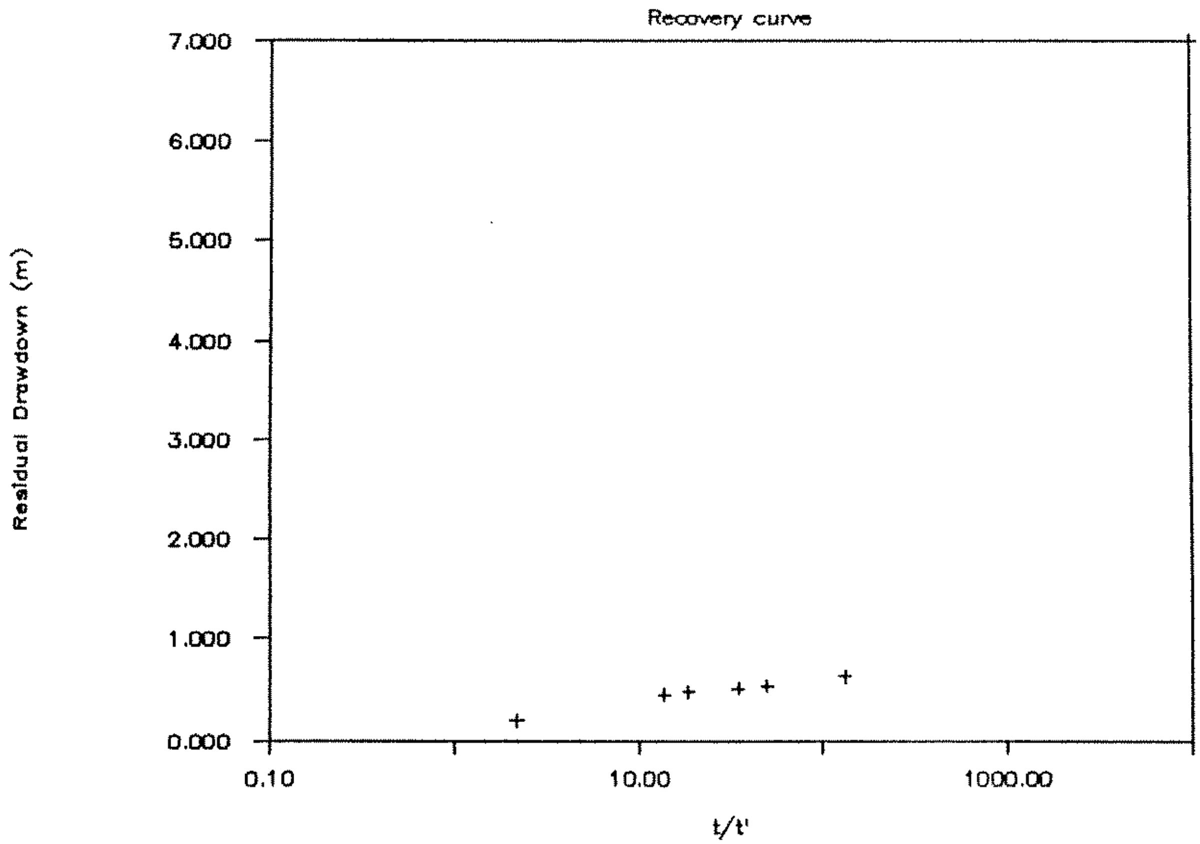
D7 - 13 HR TEST



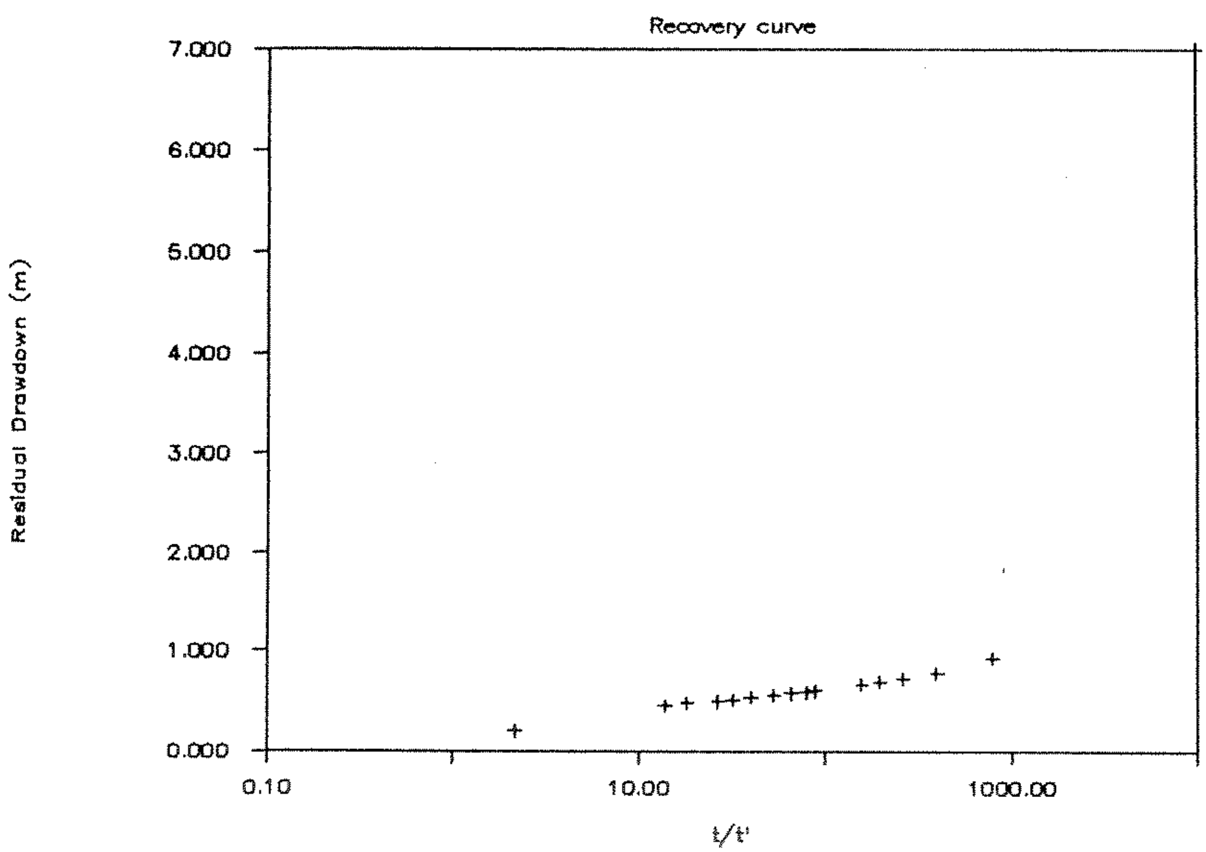
D8 - 13 HR TEST



D9 - 13 HR TEST



D10 - 13 HR TEST



APPENDIX C

71 HOUR AQUIFER TEST DATA AND CALCULATIONS

AQUIFER TEST DATA JOB#1120B WELL#: D7

Type of aquifer test:	CONST.Q	Well type:	PUMPING
How Q Measured:	BUCKET	Data type:	PUMPING
Distance from pumping well:	0 m	Depth pump:	18 m and 21 m
Meas. point for w. l.'s:	0.55 m	Pump on:	03-06-87 13:00:00
Elevation of Measuring Pt.:		Pump off:	05-06-87 13:00:00
Static Water Level (m):	6.66	Discharge rate:	45 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
2	7.16	0.50
3	7.21	0.55
4	7.23	0.57
5	7.25	0.59
6	7.26	0.60
7	7.27	0.61
8	7.28	0.62
9	7.29	0.63
10	7.30	0.64
12	7.32	0.66
14	7.34	0.68
16	7.35	0.69
18	7.36	0.70
20	7.38	0.72
25	7.40	0.74
30	7.43	0.77
35	7.45	0.79
40	7.48	0.82
45	7.50	0.84
50	7.52	0.86
55	7.55	0.89
60	7.58	0.92
70	7.60	0.94
80	7.65	0.99
90	7.68	1.02
100	7.71	1.05
110	7.77	1.11
120	7.81	1.15
150	7.89	1.23
180	7.97	1.31
210	8.14	1.47
240	8.19	1.53
270	8.26	1.60
299	8.33	1.67
330	8.43	1.77
360	8.48	1.82
390	8.53	1.87
420	8.61	1.95
450	8.65	1.99
510	8.77	2.11
540	8.83	2.16
570	8.86	2.20
630	8.98	2.32

AQUIFER TEST DATA JOB#1120B WELL#: D7

Type of aquifer test:	CONST.Q	Well type:	PUMPING
How Q Measured:	BUCKET	Data type:	PUMPING
Distance from pumping well:	0 m	Depth pump:	18 m and 21 m
Meas. point for w. l.'s:	0.55 m	Pump on:	03-06-87 13:00:00
Elevation of Measuring Pt.:		Pump off:	05-06-87 13:00:00
Static Water Level (m):	6.66	Discharge rate:	45 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
690	9.06	2.40
750	9.14	2.48
815	9.23	2.57
872	9.29	2.63
930	9.37	2.71
990	9.44	2.78
1050	9.55	2.89
1110	9.61	2.95
1169	9.71	3.05
1231	9.77	3.11
1288	9.81	3.15
1351	9.89	3.23
1408	9.91	3.25
1478	9.97	3.31
1539	10.02	3.36
1589	10.05	3.39
1651	10.20	3.54
1710	10.19	3.53
1773	10.24	3.57
1832	10.27	3.61
1901	10.31	3.65
1951	10.36	3.70
2012	10.40	3.74
2071	10.45	3.79
2131	10.46	3.80
2191	10.50	3.83
2252	10.53	3.87
2310	10.55	3.89
2370	10.58	3.91
2430	10.61	3.95
2491	10.67	4.01
2551	10.69	4.03
2612	10.77	4.11
2670	10.79	4.13
2728	10.83	4.16
2789	10.84	4.18
2851	10.86	4.20
2910	10.88	4.22
2970	10.89	4.23
3033	10.91	4.25
3089	10.99	4.33
3131	11.00	4.33
3182	11.00	4.34

AQUIFER TEST DATA JOB#1120B WELL#: D7

Type of aquifer test:	CONST.Q	Well type:	PUMPING
How Q Measured:	BUCKET	Data type:	PUMPING
Distance from pumping well:	0 m	Depth pump:	18 m and 21 m
Meas. point for w. l.'s:	0.55 m	Pump on:	03-06-87 13:00:00
Elevation of Measuring Pt.:		Pump off:	05-06-87 13:00:00
Static Water Level (m):	6.66	Discharge rate:	45 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
3242	11.04	4.38
3300	11.05	4.39
3368	11.06	4.40
3420	11.10	4.44
3477	11.11	4.45
3540	11.11	4.45
3600	11.12	4.46
3660	11.13	4.47
3720	11.14	4.48
3780	11.17	4.51
3840	11.18	4.52
3900	11.21	4.55
3960	11.25	4.58
4020	11.33	4.67
4087	11.31	4.65
4141	11.33	4.67
4200	11.35	4.69
4260	11.34	4.68
4316	11.36	4.70

AQUIFER TEST DATA JOB#1120B WELL#: D8

Type of aquifer test:	CONST.Q	Well type:	OBSERV.
How Q Measured:	BUCKET	Data type:	PUMPING
Distance from pumping well:	15 m	Depth pump:	18 m and 21 m
Meas. point for w. l.'s:	0.28 m	Pump on:	03-06-87 13:00:00
Elevation of Measuring Pt.:		Pump off:	05-06-87 13:00:00
Static Water Level (m):	6.65	Discharge rate:	45 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
15	7.10	0.45
22	7.14	0.49
32	7.19	0.54
42	7.25	0.60
52	7.29	0.64
62	7.34	0.69
82	7.40	0.75
102	7.48	0.83
122	7.56	0.91
153	7.65	1.00
182	7.73	1.08
211	7.89	1.24
241	7.97	1.31
269	8.03	1.38
301	8.12	1.47
339	8.20	1.55
362	8.27	1.62
387	8.30	1.65
417	8.36	1.71
445	8.42	1.77
512	8.54	1.89
536	8.59	1.94
572	8.65	2.00
627	8.75	2.10
692	8.82	2.17
748	8.89	2.24
814	9.00	2.35
869	9.06	2.40
933	9.13	2.47
989	9.20	2.55
1052	9.31	2.65
1109	9.37	2.72
1171	9.48	2.82
1229	9.54	2.89
1290	9.58	2.92
1348	9.64	2.99
1410	9.68	3.03
1475	9.73	3.08
1541	9.78	3.13
1587	9.82	3.17
1648	9.96	3.31
1708	9.96	3.31
1771	10.01	3.36

AQUIFER TEST DATA JOB#1120B WELL#: D8

Type of aquifer test: CONST.Q
How Q Measured: BUCKET
Distance from pumping well: 15 m
Meas. point for w. l.'s: 0.28 m
Elevation of Measuring Pt.:
Static Water Level (m): 6.65

Well type: OBSERV.
Data type: PUMPING
Depth pump: 18 m and 21 m
Pump on: 03-06-87 13:00:00
Pump off: 05-06-87 13:00:00
Discharge rate: 45 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
1830	10.04	3.39
1899	10.08	3.43
1949	10.12	3.47
2015	10.16	3.50
2068	10.22	3.57
2128	10.23	3.58
2194	10.27	3.62
2249	10.30	3.65
2312	10.33	3.67
2372	10.34	3.69
2428	10.39	3.74
2494	10.43	3.78
2549	10.46	3.81
2609	10.56	3.90
2672	10.57	3.91
2729	10.59	3.94
2791	10.63	3.98
2848	10.63	3.98
2910	10.65	3.99
2972	10.66	4.01
3029	10.69	4.04
3093	10.78	4.13
3128	10.79	4.14
3185	10.79	4.14
3240	10.80	4.15
3303	10.84	4.19
3364	10.84	4.19
3417	10.85	4.20
3480	10.90	4.24
3538	10.90	4.24
3598	10.90	4.24
3657	10.91	4.25
3718	10.92	4.27
3776	10.94	4.29
3835	10.95	4.30
3895	10.99	4.33
3955	11.01	4.36
4023	11.10	4.45
4085	11.07	4.42
4140	11.09	4.44
4197	11.12	4.47
4258	11.11	4.46
4315	11.13	4.48

AQUIFER TEST DATA JOB#1120B WELL#: D9

Type of aquifer test:	CONST.Q	Well type:	OBSERV.
How Q Measured:	ORIFICE	Data type:	PUMPING
Distance from pumping well:	46.2 m	Depth pump:	19.81 m
Meas. point for w. l.'s:	0.25 m	Pump on:	03-06-87 13:00:00
Elevation of Measuring Pt.:		Pump off:	05-06-87 13:00:00
Static Water Level (m):	6.93	Discharge rate:	60 & 50 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
5.5	7.61	0.68
7.5	7.64	0.71
11	7.68	0.75
15	7.71	0.78
21	7.74	0.81
28	7.77	0.84
42	7.80	0.87
52	7.82	0.89
71	7.84	0.91
91	7.87	0.94
121	7.90	0.97
166	7.94	1.01
196	7.96	1.03
226	7.99	1.06
258	8.04	1.11
284	8.06	1.13
317	8.09	1.16
347	8.11	1.18
377	8.12	1.19
403	8.13	1.20
437	8.17	1.24
464	8.18	1.25
527	8.19	1.26
553	8.21	1.28
587	8.22	1.29
643	8.24	1.31
707	8.26	1.33
763	8.27	1.34
827	8.29	1.36
884	8.30	1.37
947	8.31	1.38
1005	8.33	1.39
1067	8.35	1.42
1126	8.38	1.45
1187	8.39	1.46
1245	8.41	1.47
1308	8.42	1.49
1364	8.43	1.50
1424	8.44	1.51
1484	8.45	1.52
1531	8.45	1.52
1609	8.46	1.53
1664	8.47	1.54

AQUIFER TEST DATA JOB#1120B WELL#: D9

Type of aquifer test: CONST.Q Well type: OBSERV.
How Q Measured: ORIFICE Data type: PUMPING
Distance from pumping well: 46.2 m Depth pump: 19.81 m
Meas. point for w. l.'s: 0.25 m Pump on: 03-06-87 13:00:00
Elevation of Measuring Pt.: Pump off: 05-06-87 13:00:00
Static Water Level (m): 6.93 Discharge rate: 60 & 50 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
1727	8.49	1.56
1783	8.51	1.58
1848	8.52	1.59
1907	8.53	1.60
1962	8.54	1.61
2018	8.56	1.63
2079	8.57	1.64
2145	8.59	1.66
2205	8.59	1.66
2268	8.61	1.68
2327	8.62	1.69
2385	8.63	1.70
2447	8.65	1.72
2503	8.66	1.73
2566	8.67	1.74
2624	8.68	1.75
2687	8.69	1.76
2744	8.69	1.76
2808	8.70	1.77
2864	8.71	1.78
2926	8.71	1.78
2988	8.72	1.79
3046	8.72	1.79
3103	8.73	1.80
3138	8.74	1.81
3192	8.74	1.81
3255	8.74	1.81
3317	8.75	1.81
3381	8.76	1.83
3427	8.76	1.83
3492	8.76	1.83
3549	8.77	1.84
3613	8.77	1.84
3669	8.78	1.85
3731	8.77	1.84
3793	8.75	1.81
3853	8.73	1.80
3911	8.73	1.80
3971	8.73	1.80
4031	8.61	1.68
4069	8.59	1.66
4101	8.58	1.65
4127	8.59	1.66

AQUIFER TEST DATA JOB#1120B WELL#: D9

Type of aquifer test:	CONST.Q	Well type:	OBSERV.
How Q Measured:	ORIFICE	Data type:	PUMPING
Distance from pumping well:	46.2 m	Depth pump:	19.81 m
Meas. point for w. l.'s:	0.25 m	Pump on:	03-06-87 13:00:00
Elevation of Measuring Pt.:		Pump off:	05-06-87 13:00:00
Static Water Level (m):	6.93	Discharge rate:	60 & 50 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
4152	8.58	1.65
4187	8.59	1.66
4228	8.59	1.66
4299	8.58	1.65
4319	8.58	1.65

AQUIFER TEST DATA JOB#1120B WELL#: D10

Type of aquifer test: CONST.Q Well type: PUMPING
How Q Measured: ORIFICE Data type: PUMPING
Distance from pumping well: 0 m Depth pump: 19.81 m
Meas. point for w. l.'s: 0.30 m Pump on: 03-06-87 13:00:00
Elevation of Measuring Pt.: Pump off: 05-06-87 13:00:00
Static Water Level (m): 6.94 Discharge rate: 60 & 50 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
0.5	9.40	2.46
1.0	9.79	2.85
1.5	10.02	3.08
2.0	10.14	3.20
2.5	10.20	3.26
3.0	10.27	3.33
3.5	10.27	3.33
4.0	10.28	3.34
4.5	10.31	3.37
5.0	10.34	3.40
6.0	10.40	3.46
7.0	10.45	3.51
8.0	10.50	3.56
9.0	10.54	3.60
10	10.56	3.62
12	10.62	3.68
14	10.60	3.66
16	10.63	3.69
18	10.66	3.72
20	10.69	3.75
23	10.73	3.79
26	10.77	3.83
30	10.80	3.86
35	10.85	3.91
40	10.85	3.91
45	10.87	3.93
50	10.90	3.96
55	10.94	4.00
60	10.97	4.03
70	11.05	4.11
80	11.06	4.12
90	11.13	4.19
105	11.21	4.27
120	11.29	4.35
135	11.40	4.46
165	11.50	4.56
198	11.63	4.69
256	11.76	4.82
285	11.95	5.01
315	12.08	5.14
345	12.20	5.26
375	12.33	5.39
405	12.45	5.51

AQUIFER TEST DATA JOB#1120B WELL#: D10

Type of aquifer test: CONST.Q
How Q Measured: ORIFICE
Distance from pumping well: 0 m
Meas. point for w. l.'s: 0.30 m
Elevation of Measuring Pt.:
Static Water Level (m): 6.94

Well type: PUMPING
Data type: PUMPING
Depth pump: 19.81 m
Pump on: 03-06-87 13:00:00
Pump off: 05-06-87 13:00:00
Discharge rate: 60 & 50 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
435	12.57	5.63
465	12.61	5.67
525	12.72	5.78
555	12.81	5.87
585	12.89	5.95
645	12.94	6.00
705	12.98	6.04
765	13.10	6.16
825	13.32	6.38
887	13.38	6.44
945	13.47	6.53
1005	13.78	6.84
1065	13.88	6.94
1125	13.93	6.99
1184	14.01	7.07
1246	14.23	7.29
1305	14.31	7.37
1365	14.49	7.55
1422	14.51	7.57
1486	14.56	7.62
1529	14.60	7.66
1611	14.71	7.77
1662	14.81	7.87
1728	14.86	7.92
1785	14.92	7.97
1845	14.94	8.00
1908	15.01	8.07
1959	15.12	8.18
2021	15.22	8.28
2077	15.31	8.37
2147	15.42	8.48
2206	15.43	8.49
2265	15.44	8.50
2325	15.64	8.70
2387	15.79	8.85
2445	15.89	8.95
2505	15.99	9.05
2564	15.96	9.02
2625	16.05	9.11
2685	16.18	9.24
2746	16.65	9.71
2805	16.33	9.39
2866	16.15	9.21

AQUIFER TEST DATA JOB#1120B WELL#: D10

Type of aquifer test: CONST.Q
How Q Measured: ORIFICE
Distance from pumping well: 0 m
Meas. point for w. l.'s: 0.30 m
Elevation of Measuring Pt.:
Static Water Level (m): 6.94

Well type: PUMPING
Data type: PUMPING
Depth pump: 19.81 m
Pump on: 03-06-87 13:00:00
Pump off: 05-06-87 13:00:00
Discharge rate: 60 & 50 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
2895	16.27	9.33
2910	16.36	9.42
2925	16.42	9.48
2940	16.36	9.42
2985	16.40	9.46
3015	16.46	9.51
3044	16.51	9.57
3106	16.67	9.73
3136	16.60	9.66
3195	16.65	9.71
3252	16.82	9.88
3319	16.90	9.96
3380	16.87	9.93
3430	17.08	10.14
3488	17.27	10.33
3550	17.11	10.17
3610	17.30	10.36
3670	17.61	10.67
3732	19.04	12.10
3790	20.18	13.24
3850	20.17	13.23
4010	16.84	9.90
4032	17.58	10.64
4047	17.61	10.67
4065	17.61	10.67
4101	17.77	10.83
4125	17.51	10.57
4152	17.57	10.63
4185	17.92	10.98
4228	17.97	11.03
4298	18.12	11.18
4320	18.15	11.21

AQUIFER TEST DATA   WELL#: D7

Type of aquifer test: CONST Q. Well type: PUMPING
How Q Measured: ORIF.WEIR Data type: RECOVERY
Distance from pumping well: 0 m   Depth pump: 18 m and 21 m
Meas. point for w. l.'s: 0.55 m   Pump on: 03-06-87 13:00:00
Elevation of Measuring Pt.:   Pump off: 05-06-87 13:00:00
Static Water Level (m): 6.66   Discharge rate: 45 IGPM

At t' = 0, t = 4,320.00		Water Level Data	
Time minutes	t/t'	w.l. (m)	Residual Drawdown
1.0	4321.0	10.890	4.230
2.0	2161.0	10.860	4.200
3.0	1441.0	10.840	4.180
4.0	1081.0	10.820	4.160
5.0	865.0	10.820	4.160
6.0	721.0	10.815	4.155
7.5	577.0	10.805	4.145
8.0	541.0	10.800	4.140
10.0	433.0	10.780	4.120
12.0	361.0	10.755	4.095
14.0	309.6	10.735	4.075
16.0	271.0	10.720	4.060
18.0	241.0	10.705	4.045
25.0	173.8	10.675	4.015
30.0	145.0	10.662	4.002
35.0	124.4	10.640	3.980
40.0	109.0	10.600	3.940
45.0	97.0	10.580	3.920
50.0	87.4	10.560	3.900
60.0	73.0	10.530	3.870
70.0	62.7	10.490	3.830
80.0	55.0	10.455	3.795
90.0	49.0	10.430	3.770
112.0	39.6	10.370	3.710
143.0	31.2	10.270	3.610
193.0	23.4	10.240	3.580
223.0	20.4	10.140	3.480
255.0	17.9	10.040	3.380
312.0	14.8	9.940	3.280
367.0	12.8	9.830	3.170
442.0	10.8	9.700	3.040
542.0	9.0	9.540	2.880
600.0	8.2	9.440	2.780
681.0	7.3	9.320	2.660
722.0	7.0	9.265	2.605
782.0	6.5	9.180	2.520
842.0	6.1	9.105	2.445
897.0	5.8	9.020	2.360
962.0	5.5	8.945	2.285
1021.0	5.2	8.880	2.220
1134.0	4.8	8.790	2.130
1264.0	4.4	8.695	2.035
1395.0	4.1	8.620	1.960

AQUIFER TEST DATA WELL#: D8

Type of aquifer test: CONST Q. Well type: OBSERVATION
How Q Measured: ORIF.WEIRData type: RECOVERY
Distance from pumping well:15 m Depth pump: 18 m and 21 m
Meas. point for w. l.'s: 0.28 m Pump on: 03-06-87 13:00:00
Elevation of Measuring Pt.: Pump off: 05-06-87 13:00:00
Static Water Level (m): 6.65 Discharge rate: 45 IGPM

At t' = 0, t = 4,320.00		Water Level Data	
Time minutes	t/t'	w.l. (m)	Residual Drawdown
7.0	618.1	10.800	4.150
9.0	481.0	10.770	4.120
10.0	433.0	10.765	4.115
12.5	346.6	10.730	4.080
14.5	298.9	10.710	4.060
17.0	255.1	10.700	4.050
18.5	234.5	10.680	4.030
25.5	170.4	10.660	4.010
27.5	158.1	10.650	4.000
32.0	136.0	10.640	3.990
37.0	117.8	10.600	3.950
42.5	102.6	10.575	3.925
52.0	84.1	10.540	3.890
62.0	70.7	10.500	3.850
72.0	61.0	10.480	3.830
82.0	53.7	10.440	3.790
92.0	48.0	10.400	3.750
110.0	40.3	10.340	3.690
145.0	30.8	10.250	3.600
185.0	24.4	10.240	3.590
225.0	20.2	10.120	3.470
257.0	17.8	10.020	3.370
311.0	14.9	9.940	3.290
367.0	12.8	9.820	3.170
442.0	10.8	9.690	3.040
542.0	9.0	9.510	2.860
600.0	8.2	9.430	2.780
678.0	7.4	9.310	2.660
720.0	7.0	9.255	2.605
780.0	6.5	9.170	2.520
839.0	6.1	9.100	2.450
895.0	5.8	9.015	2.365
960.0	5.5	8.940	2.290
1020.0	5.2	8.870	2.220
1130.0	4.8	8.780	2.130
1200.0	4.6	8.690	2.040
1332.0	4.2	8.610	1.960

AQUIFER TEST DATA WELL#: D9

Type of aquifer test: CONST Q. Well type: OBSERVATION
How Q Measured: ORIF.WEIRData type: RECOVERY
Distance from pumping well:46.2 m Depth pump: 19.81 m
Meas. point for w. l.'s: 0.25 m Pump on: 03-06-87 13:00:00
Elevation of Measuring Pt.: Pump off: 05-06-87 13:00:00
Static Water Level (m): 6.93 Discharge rate: 60 & 50 IGPM

At t' = 0, t = 4,320.00		Water Level Data	
Time minutes	t/t'	w.l. (m)	Residual Drawdown
3.0	1441.0	8.100	1.170
4.0	1081.0	8.050	1.120
8.0	541.0	7.980	1.050
10.0	433.0	7.960	1.030
12.0	361.0	7.940	1.010
14.0	309.6	7.930	1.000
16.0	271.0	7.920	0.990
18.0	241.0	7.910	0.980
20.0	217.0	7.900	0.970
26.0	167.2	7.880	0.950
31.0	140.4	7.860	0.930
36.0	121.0	7.850	0.920
41.0	106.4	7.840	0.910
46.0	94.9	7.830	0.900
51.0	85.7	7.820	0.890
56.0	78.1	7.820	0.890
61.0	71.8	7.810	0.880
71.0	61.8	7.800	0.870
81.0	54.3	7.780	0.850
91.0	48.5	7.770	0.840
105.0	42.1	7.750	0.820
125.0	35.6	7.730	0.800
151.0	29.6	7.710	0.780
181.0	24.9	7.700	0.770
229.0	19.9	7.670	0.740
252.0	18.1	7.650	0.720
300.0	15.4	7.620	0.690
372.0	12.6	7.580	0.650
447.0	10.7	7.540	0.610
535.0	9.1	7.510	0.580
605.0	8.1	7.480	0.550
666.0	7.5	7.460	0.530
909.0	5.8	7.385	0.455
1028.0	5.2	7.365	0.435
1144.0	4.8	7.350	0.420
1275.0	4.4	7.335	0.405
1380.0	4.1	7.320	0.390

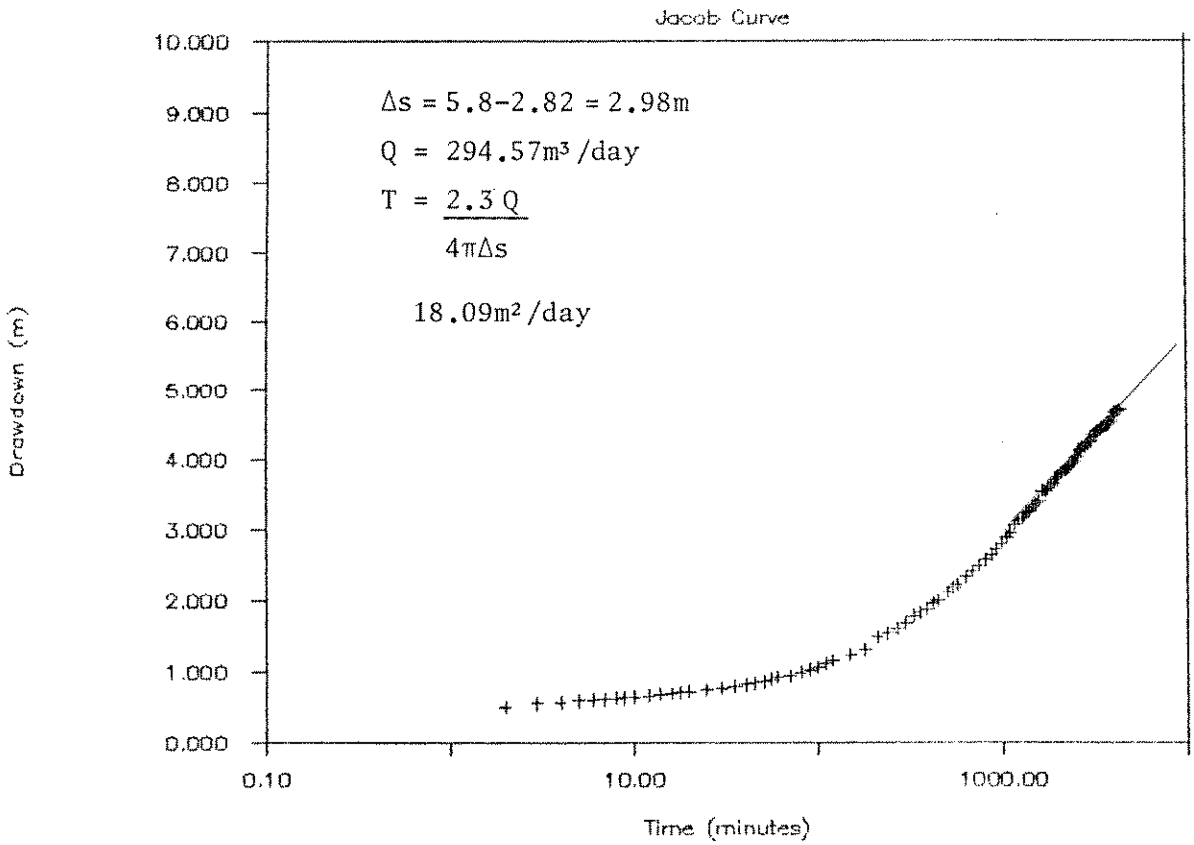
AQUIFER TEST DATA WELL#: D10

Type of aquifer test: CONST Q. Well type: PUMPING
How Q Measured: ORIF.WEIR Data type: RECOVERY
Distance from pumping well: 0 m Depth pump: 19.81 m
Meas. point for w. l.'s: 0.30 m Pump on: 03-06-87 13:00:00
Elevation of Measuring Pt.: Pump off: 05-06-87 13:00:00
Static Water Level (m): 6.94 Discharge rate: 60 & 50 IGPM

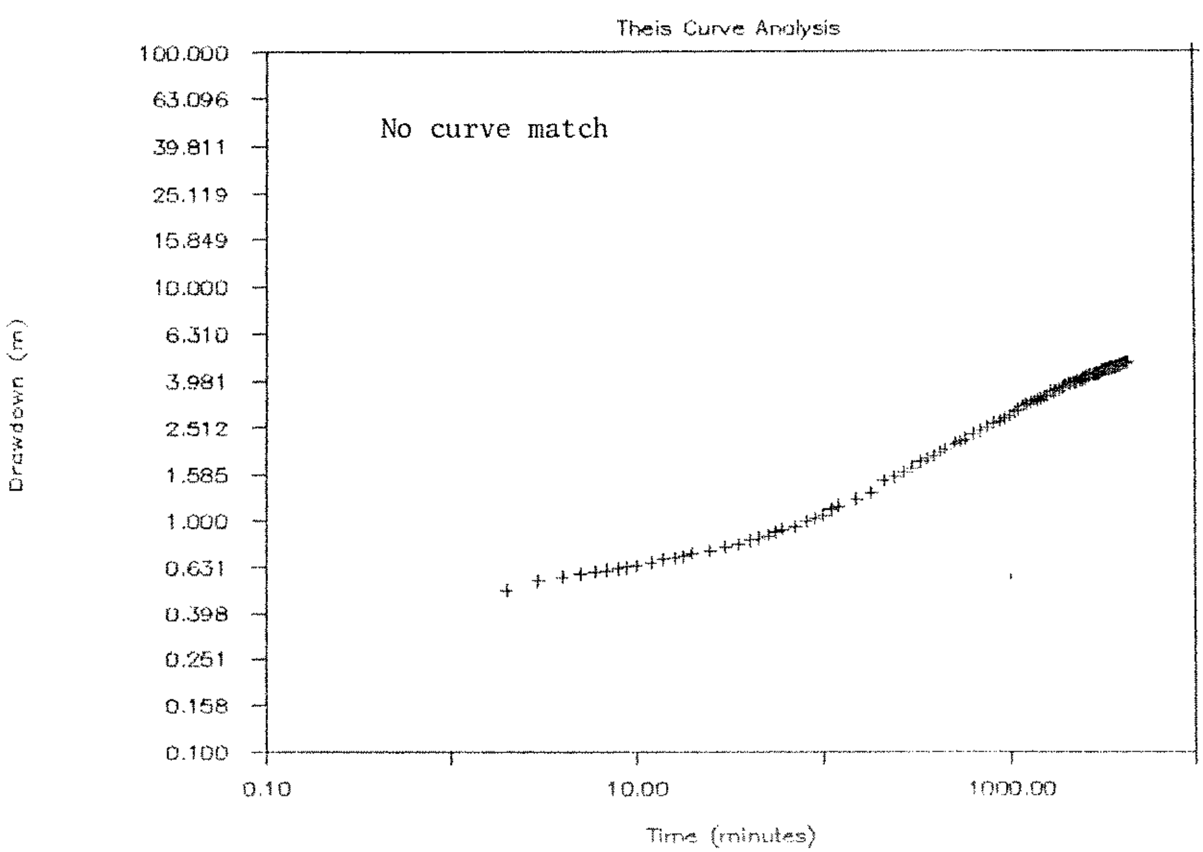
At t' = 0, t = 4,320.00 — Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
0.5	8641.0	12.970	6.030
1.0	4321.0	9.720	2.780
1.5	2881.0	8.370	1.430
2.0	2161.0	8.160	1.220
4.0	1081.0	8.080	1.140
5.0	865.0	8.040	1.100
7.0	618.1	7.990	1.050
9.0	481.0	7.970	1.030
11.0	393.7	7.950	1.010
13.0	333.3	7.940	1.000
15.0	289.0	7.925	0.985
17.0	255.1	7.920	0.980
19.0	228.4	7.910	0.970
25.0	173.8	7.880	0.940
30.0	145.0	7.870	0.930
35.0	124.4	7.860	0.920
40.0	109.0	7.850	0.910
45.0	97.0	7.840	0.900
50.0	87.4	7.830	0.890
55.0	79.5	7.820	0.880
60.0	73.0	7.810	0.870
70.0	62.7	7.800	0.860
80.0	55.0	7.790	0.850
90.0	49.0	7.780	0.840
105.0	42.1	7.760	0.820
125.0	35.6	7.740	0.800
152.0	29.4	7.720	0.780
182.0	24.7	7.700	0.760
228.0	19.9	7.670	0.730
251.0	18.2	7.650	0.710
300.0	15.4	7.630	0.690
372.0	12.6	7.580	0.640
447.0	10.7	7.550	0.610
535.0	9.1	7.520	0.580
605.0	8.1	7.500	0.560
665.0	7.5	7.470	0.530
906.0	5.8	7.400	0.460
1032.0	5.2	7.370	0.430
1140.0	4.8	7.350	0.410
1278.0	4.4	7.330	0.390
1378.0	4.1	7.315	0.375

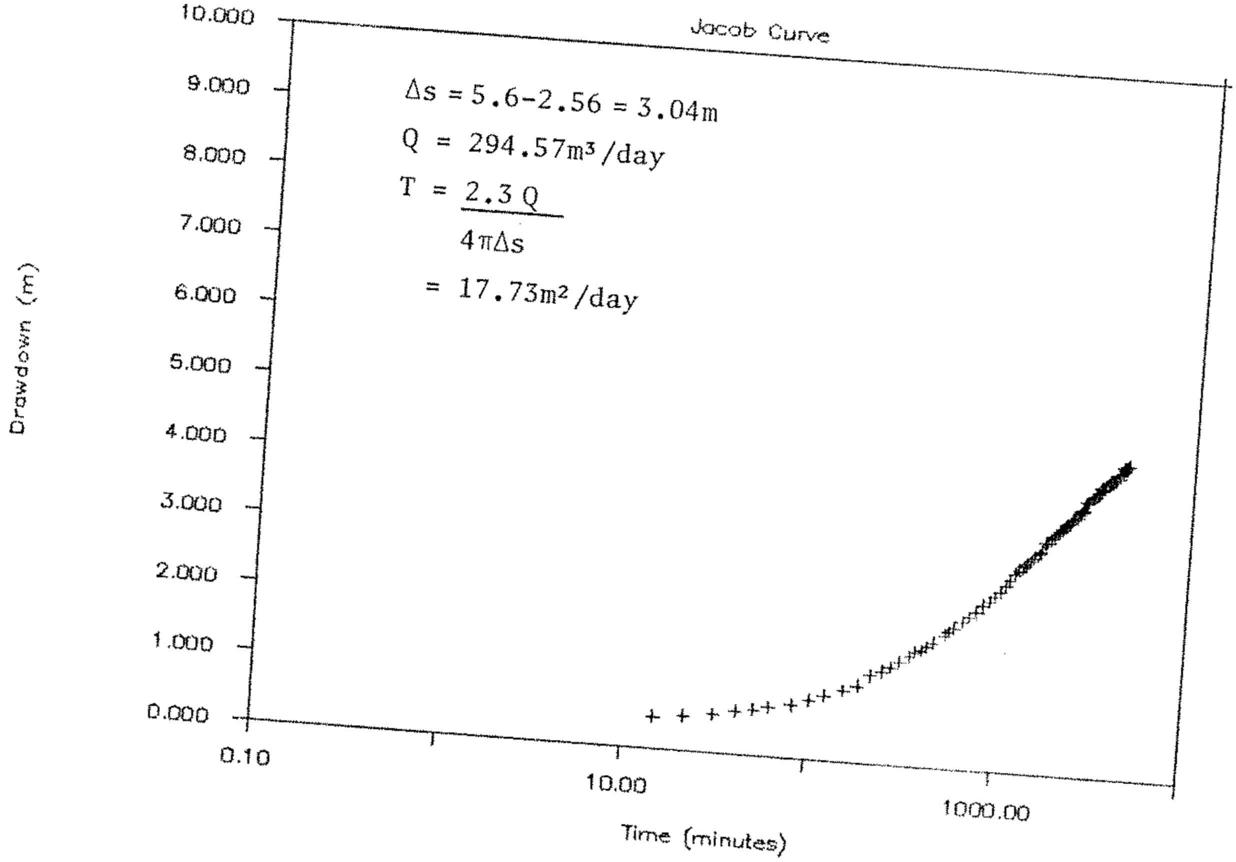
D7


Jacob Curve
Δs = 5.8-2.82 = 2.98m
Q = 294.57m³/day
T = 2.3 Q / 4πΔs
18.09m²/day
Drawdown (m)
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
0.10
10.00
1000.00
Time (minutes)

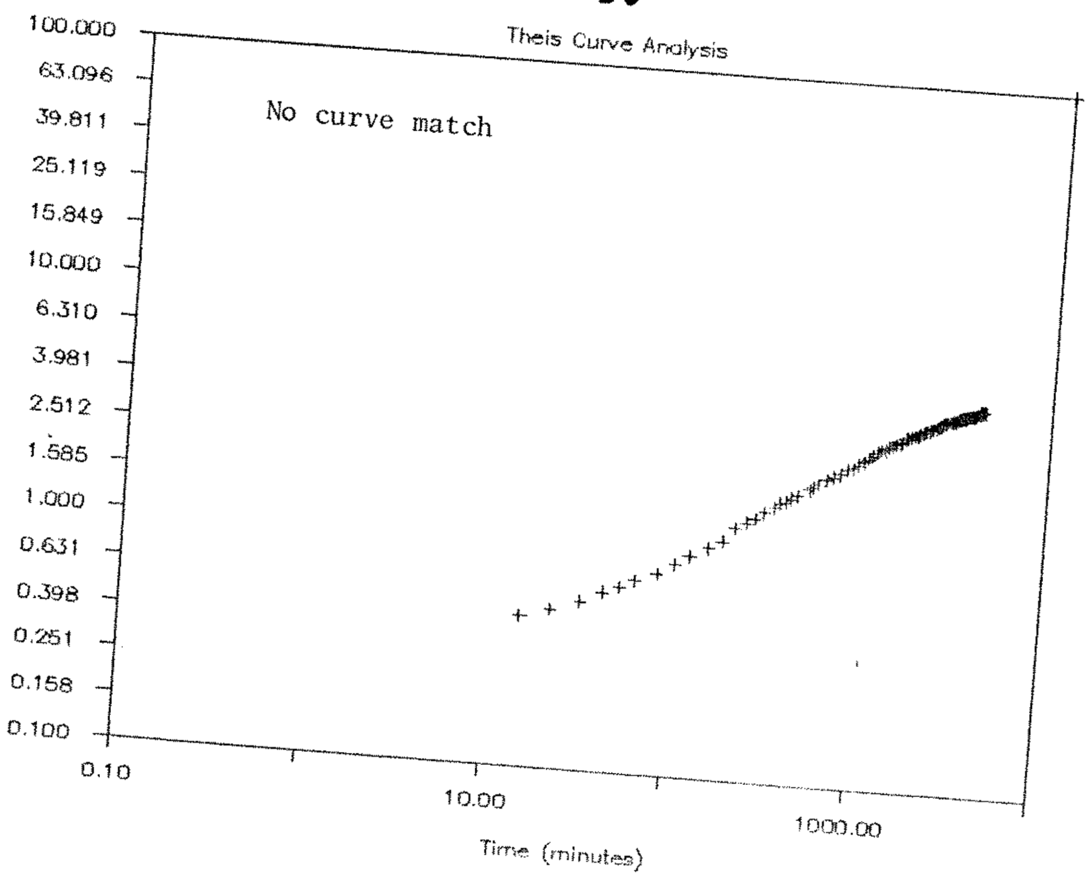
D7


Theis Curve Analysis
No curve match
Drawdown (m)
100.000
63.096
39.811
25.119
15.849
10.000
6.310
3.981
2.512
1.585
1.000
0.631
0.398
0.251
0.158
0.100
0.10
10.00
1000.00
Time (minutes)

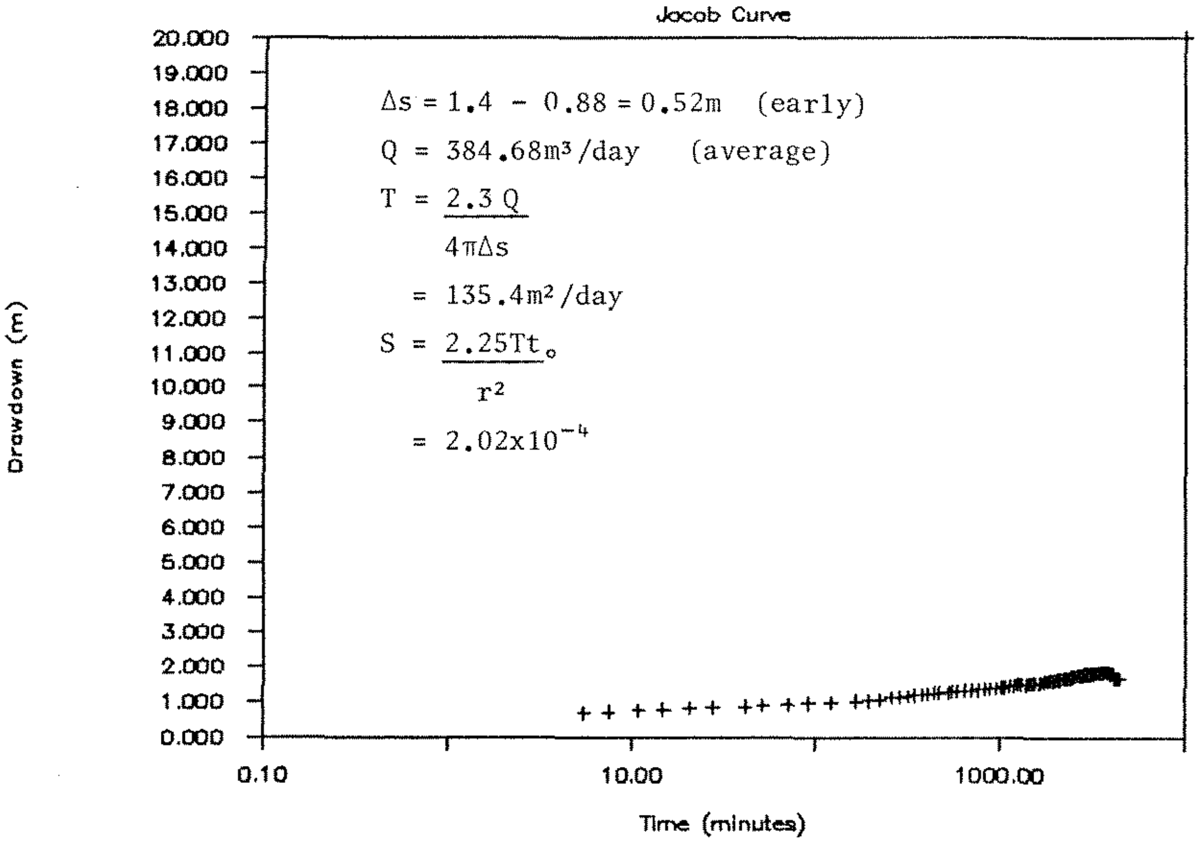
D9


Jacob Curve
Δs = 5.6-2.56 = 3.04m
Q = 294.57m³/day
T = 2.3 Q / 4πΔs
= 17.73m²/day
Drawdown (m)
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
0.10
10.00
1000.00
Time (minutes)

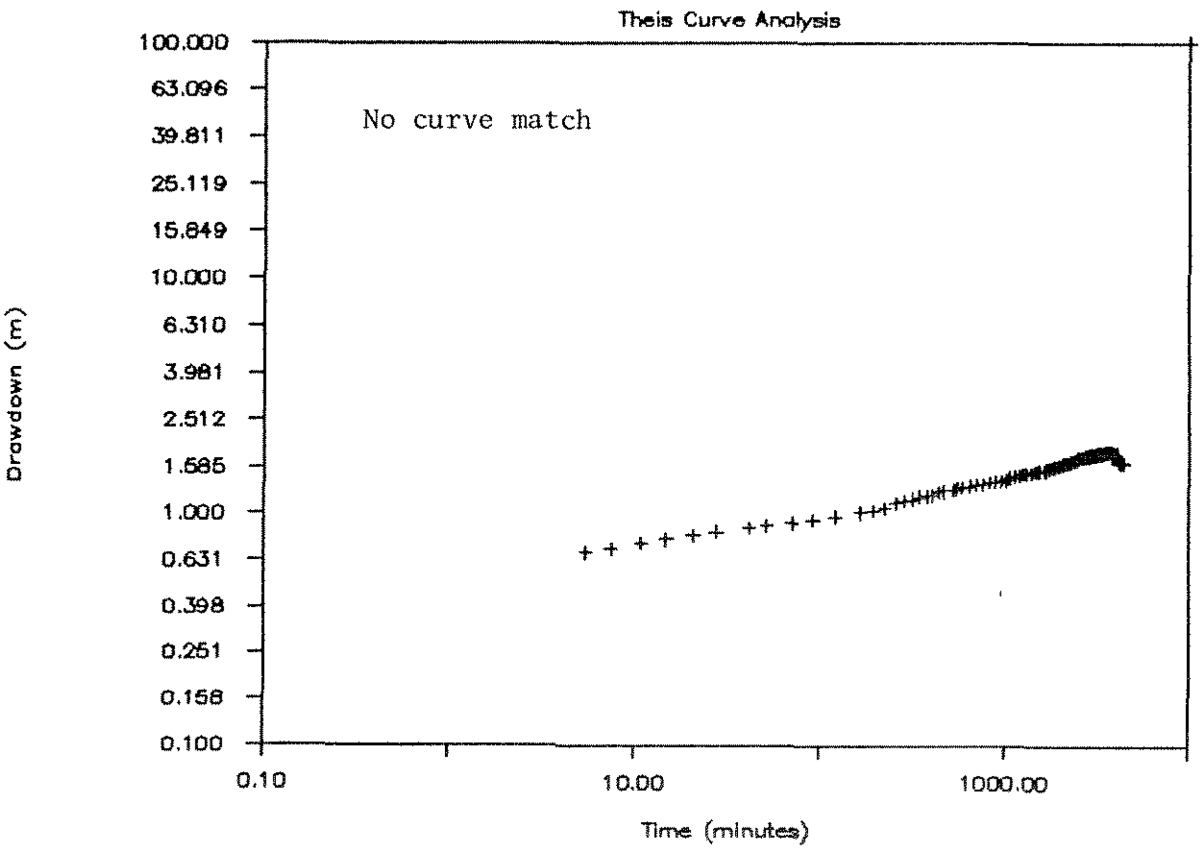
D8


Theis Curve Analysis
No curve match
100.000
63.096
39.811
25.119
15.849
10.000
6.310
3.981
2.512
1.585
1.000
0.631
0.398
0.251
0.158
0.100
0.10
10.00
1000.00
Time (minutes)

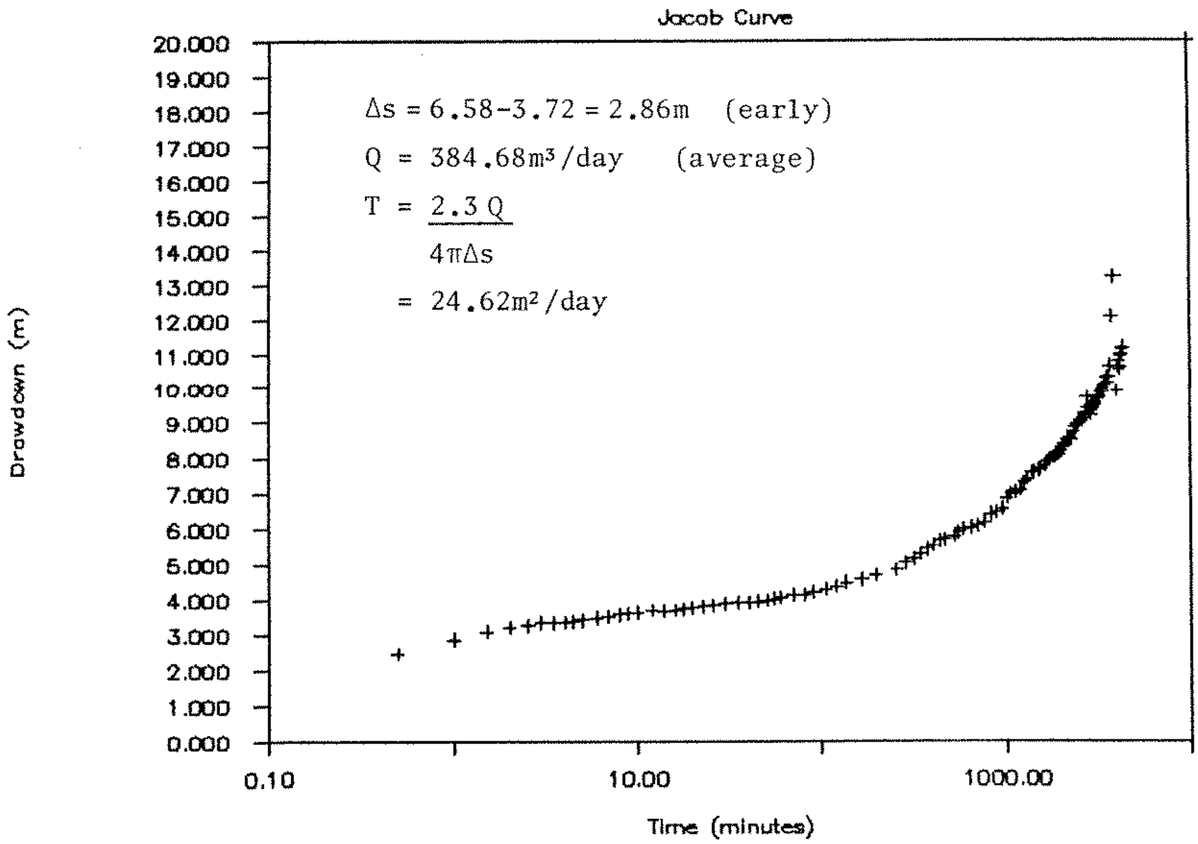
D9


Jacob Curve
Δs = 1.4 - 0.88 = 0.52m (early)
Q = 384.68m³/day (average)
T = 2.3 Q / 4πΔs
= 135.4m²/day
S = 2.25Tt₀ / r²
= 2.02x10⁻⁴
Drawdown (m)
Time (minutes)
20.000
19.000
18.000
17.000
16.000
15.000
14.000
13.000
12.000
11.000
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
0.10
10.00
1000.00

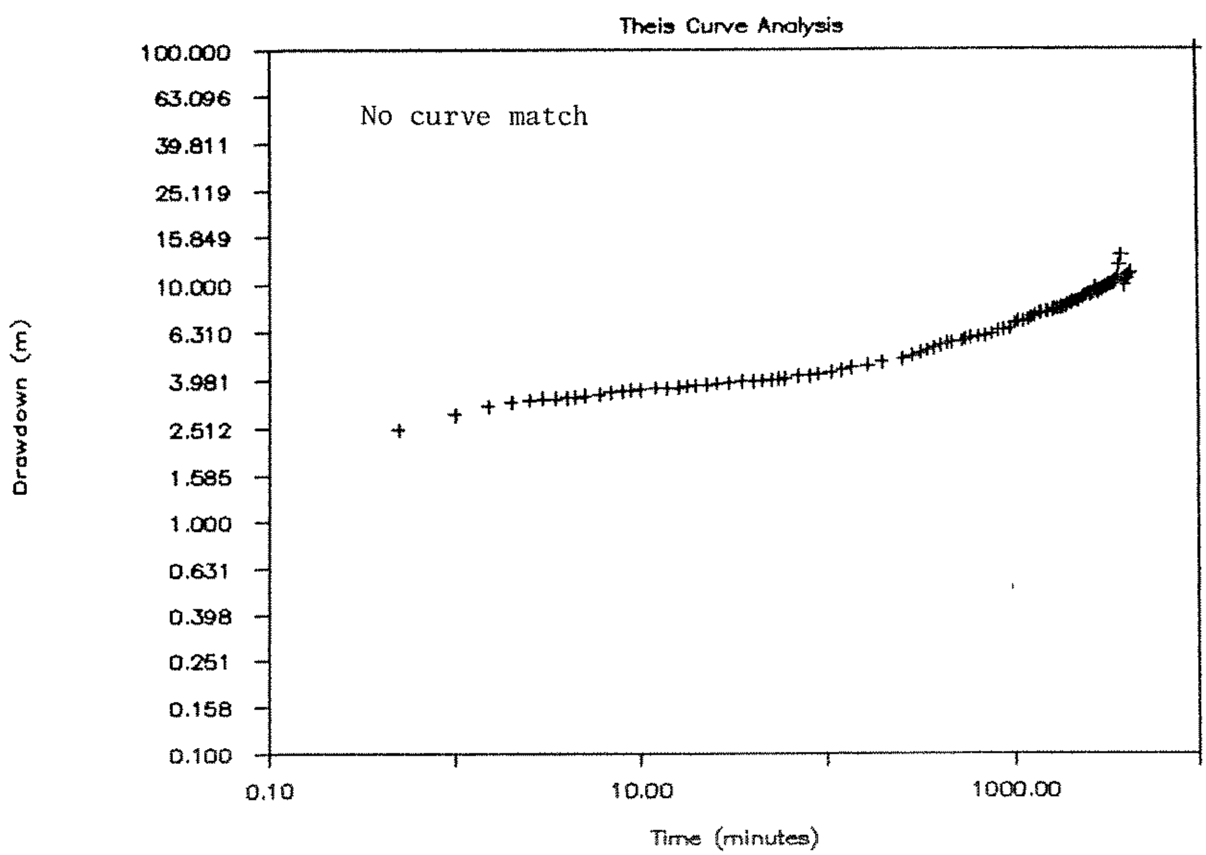
D9


Theis Curve Analysis
No curve match
Drawdown (m)
Time (minutes)
100.000
63.096
39.811
25.119
15.849
10.000
6.310
3.981
2.512
1.585
1.000
0.631
0.398
0.251
0.158
0.100
0.10
10.00
1000.00

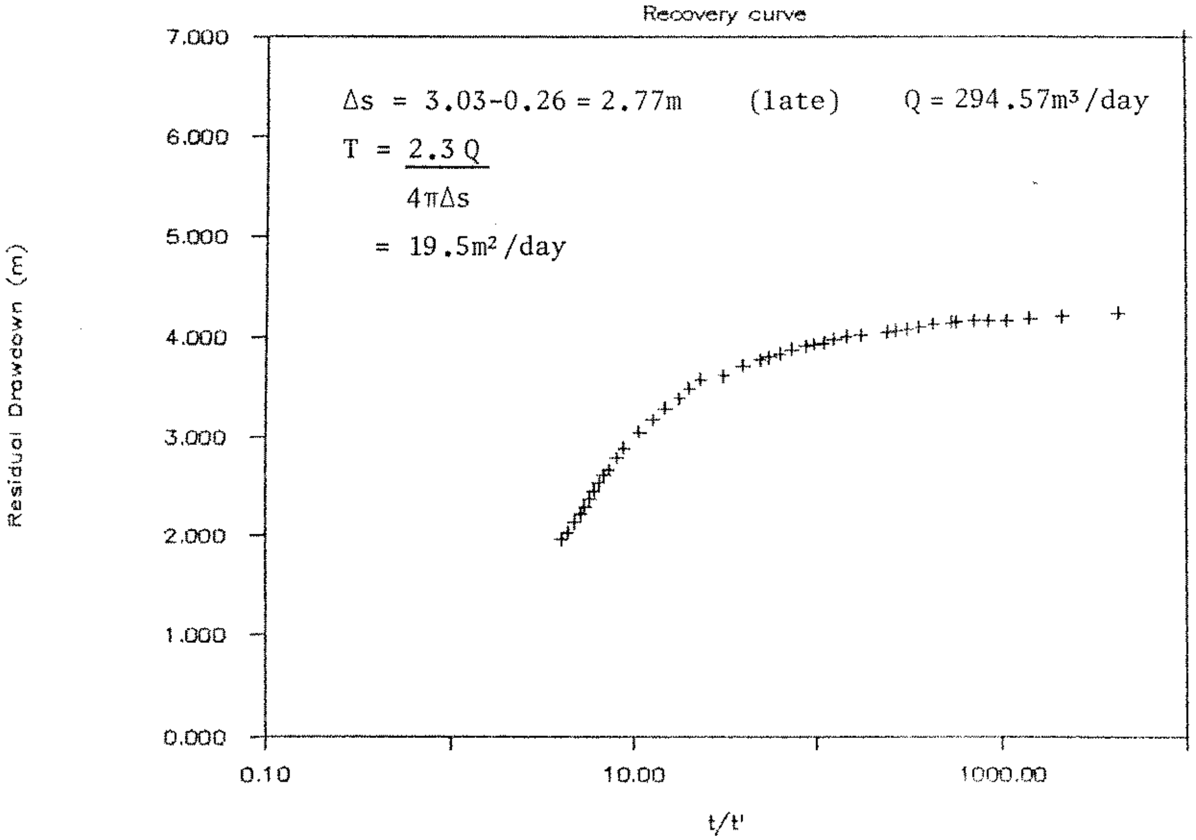
D10


Jacob Curve
Δs = 6.58-3.72 = 2.86m (early)
Q = 384.68m³/day (average)
T = 2.3 Q / 4πΔs
= 24.62m²/day
Drawdown (m)
20.000
19.000
18.000
17.000
16.000
15.000
14.000
13.000
12.000
11.000
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
0.10
10.00
1000.00
Time (minutes)

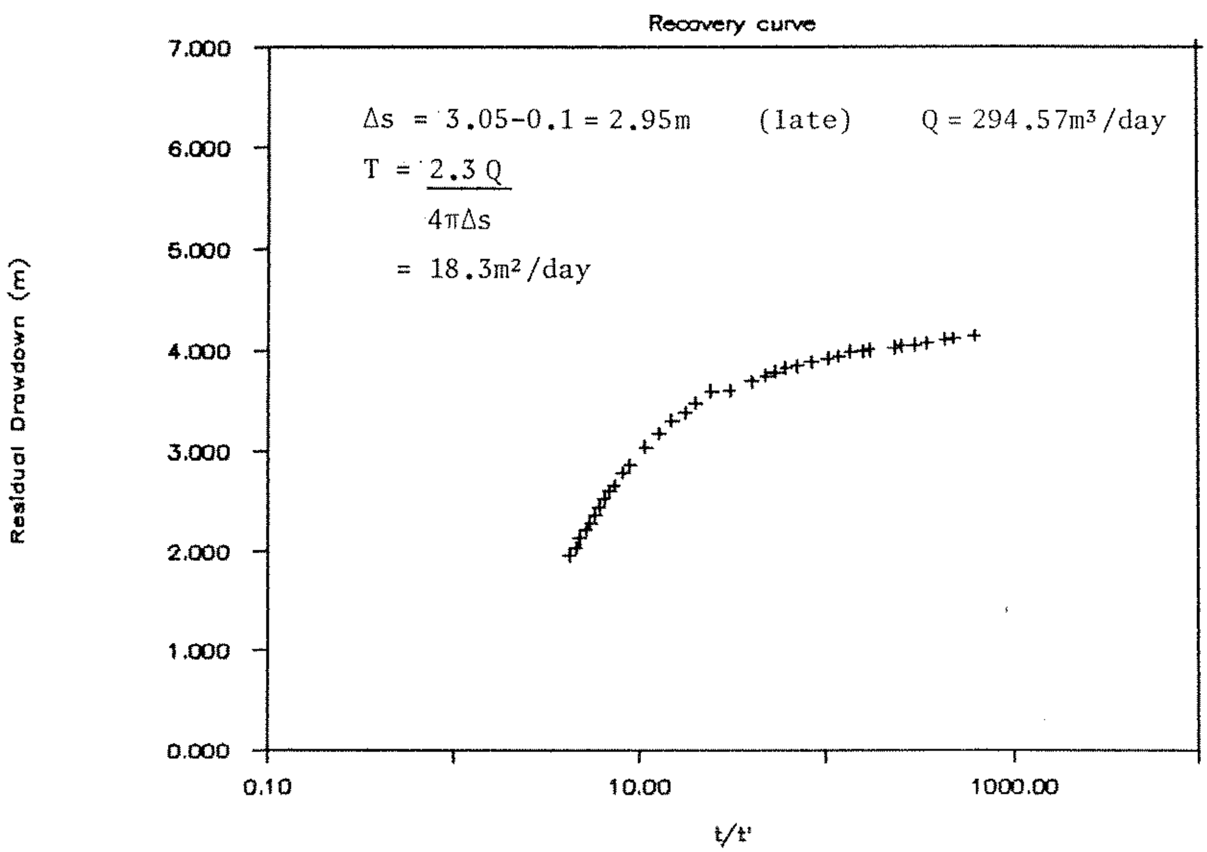
D10


Theis Curve Analysis
No curve match
Drawdown (m)
100.000
63.096
39.811
25.119
15.849
10.000
6.310
3.981
2.512
1.585
1.000
0.631
0.398
0.251
0.158
0.100
0.10
10.00
1000.00
Time (minutes)

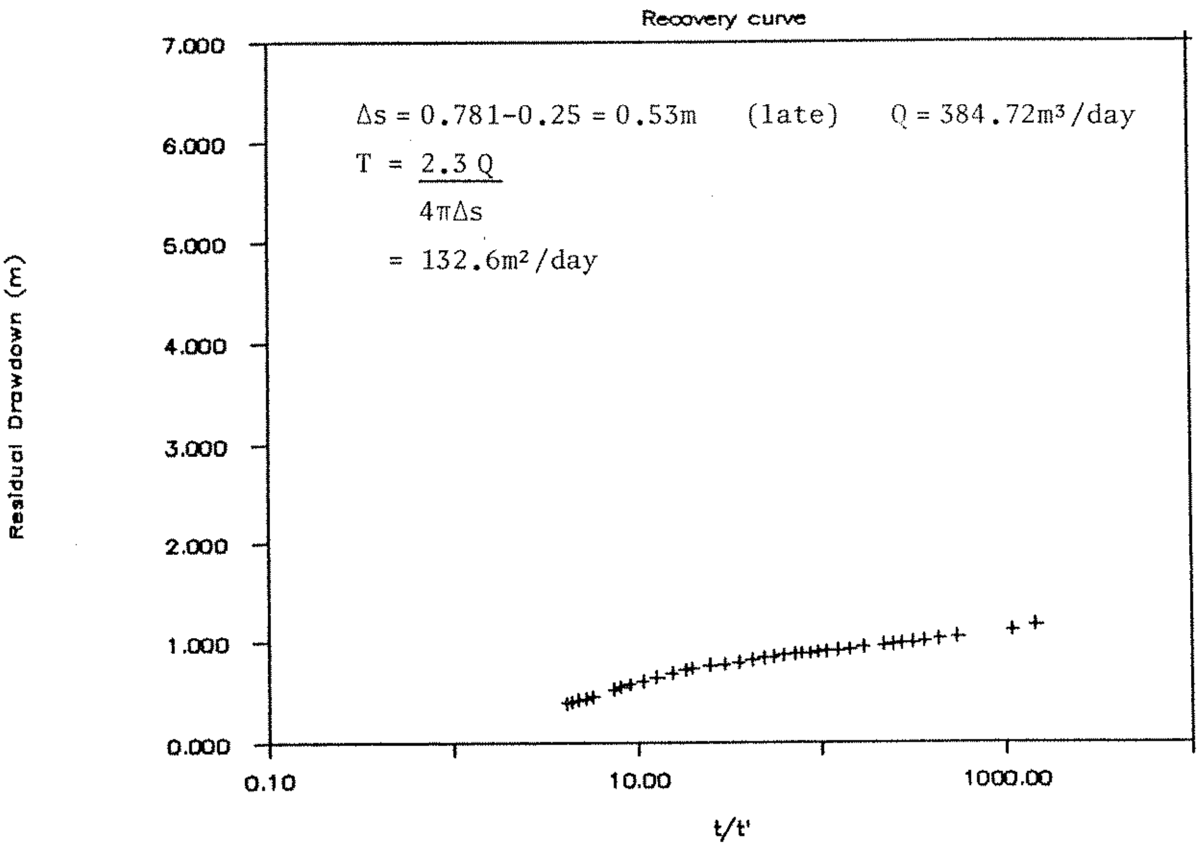
RECOVERY DATA FOR D7



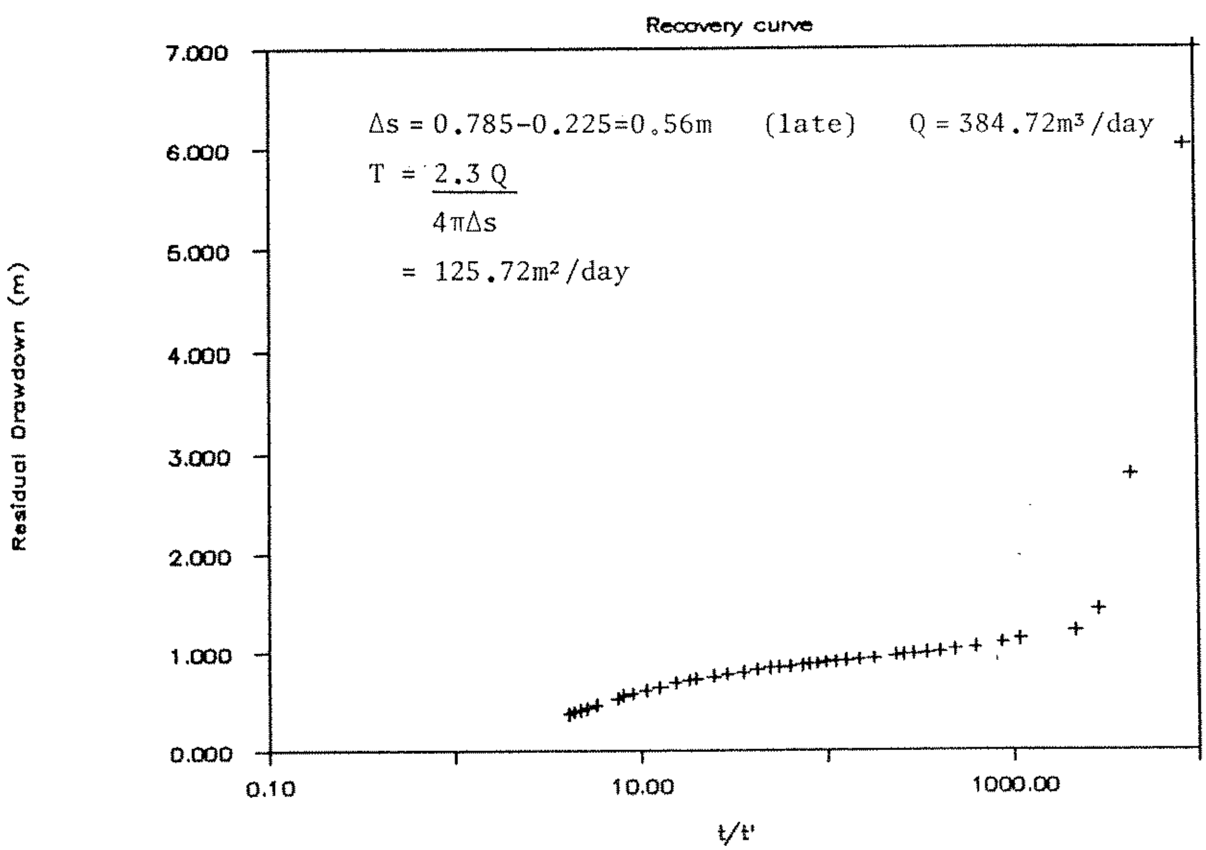
RECOVERY DATA FOR D8



RECOVERY DATA FOR D9



RECOVERY DATA FOR D10



APPENDIX D

THEORETICAL AQUIFER YIELD
AND
WELL INTERFERENCE CALCULATIONS

THEORETICAL AQUIFER YIELD AND WELL INTERFERENCE CALCULATIONS

Theoretical Aquifer Yields

The theoretical aquifer yield can be calculated using the following formula:

$Q_{max} = \frac{4\pi T \ \Delta smax}{W(u)}$ where Q_{max} = maximum discharge [m³/day]

T = transmissivity [m²/day]

$\Delta smax$ = maximum allowable drawdown [m]

W(u) = well function [N]

The well function is derived by means of well function tables that are based on the following:

$u = \frac{r^2 S}{4Tt}$ where r = radial distance from pumping well

S = storativity [N]

t = time since pumping began [days]

Δs = 18 m maximum available D10

S = 4.56×10^{-3} from D9 13 hours

r = 0.1 m

T = 40 m²/day or 120 m²/day

t = 1 for 24 hour maximum
3650 for ten year safe yield
7300 for twenty year safe yield

t = 1 day, T = 40 m²/day u = 2.85×10^{-7}
W(u) = 14.49
Q_{max} = 7.2 1/sec (95 IGPM)

t = 1 day, T = 120 m²/day u = 9.5×10^{-8}
W(u) = 15.59
Q_{max} = 20.15 1/sec (255 IGPM)

t = 3650 days (10 years)	T = 40 m^2/day	$u = 7.81 \times 10^{-11}$ $W(u)$ = 22.69 Q_{max} = 4.61 1/sec (60.9 IGPM)
t = 3650 days (10 years)	T = 120 m^2/day	$u = 2.6 \times 10^{-11}$ $W(u)$ = 23.79 Q_{max} = 13.2 1/sec (174.29 IGPM)
t = 7300 days (20 years)	T = 40 m^2/day	$u = 3.9 \times 10^{-11}$ $W(u)$ = 23.44 Q_{max} = 4.47 1/sec (58.97 IGPM)
t = 7300 days (20 years)	T = 120 m^2/day	$u = 1.3 \times 10^{-11}$ $W(u)$ = 24.49 Q_{max} = 12.83 1/sec (169.3 IGPM)

Well Interference

The same equations used to calculate aquifer yield can also be used to determine theoretical well interference data. Here, however, Q is kept constant and the drawdown is calculated.

$r = 1$ m $Q = 6.82$ l/sec (589.14 m^3/day 90 IGPM)

$t = 10$ years (3650 days) $\Delta S = 4.56 \times 10^{-3}$

$T = 120$ m^2/day

$$u = \frac{(1)^2(4.56 \times 10^{-3})}{4(120)(3650)} = 2.6 \times 10^{-9}$$

W(u) from tables = 19.19

$$s = \frac{(589.14)(19.19)}{4\pi(120)} = 7.5 \text{ m}$$

The following table shows drawdown for various radial distances and pumping rates.

Radius (m)	u	W(u)	Q60 IGPM	Q90 IGPM
			Δs (m)	
0.1	2.6×10^{-11}	23.79	6.20	9.3
1	2.6×10^{-9}	19.19	5.00	7.5
10	2.6×10^{-7}	14.85	3.87	5.8
100	2.6×10^{-5}	9.98	2.60	3.9
300	2.34×10^{-4}	7.78	2.03	3.04
380	3.76×10^{-4}	7.315	1.91	2.86
500	6.51×10^{-4}	6.76	1.76	2.64
1000	2.6×10^{-3}	5.38	1.40	2.10

APPENDIX E

WATER QUALITY

Clinical Laboratories

MICROBIAL MONITORING REPORT

INSTITUTION WATER & EARTH SCIENCE
DATE COLLECTED set up 5-6-87
DATE REPORTED June 8/87
TECH SIGNATURE K. Reid
PHONED

NO	SITE DESCRIPTION	LABORATORY REPORT					NOTES
	WATER ANALYSIS as per drinking water standards	TOTAL COUNT	TOTAL COLIFORM	FAECAL COLIFORM	FAECAL STREPT		
WESA #1	D10 72 hr. 06-05-87	11col/ml	0col/100ml	absent	absent		
WESA #2	D10 24 hr 06-05-87	11col/ml	0col/100ml	absent	absent		
WESA #3	D7 24 hr 06-05-87	1col/ml	0col/100ml	absent	absent		
WESA #4	D7 72 hr 06-05-87	2col/ml	0col/100ml	absent	absent		

KEY:
NG = No Growth
NSG = No Significant Growth
NFL = Normal Flora

CC = Colony Count
NP = Non pathogenic
PP = Potential pathogen
MG = Mixed growth non-pathogenic and potential pathogens

DRINKING WATER: TT = Total Count
TC = Total Coliform
FC = Faecal Coliform
FS = Faecal Strept.

The results contained in this report are only representative of the sample(s) received by our laboratory.
Interpretation of the results should include a consideration of the integrity of both the sampling technique and protocol.

Form MMR 5/83

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-2516 (COMPLETE)

REFERENCE INFO: 1120B

CLIENT: WATER & EARTH SCIENCES
PROJECT: NONE

SUBMITTED BY: L. ELLIOTT
DATE PRINTED: 4-AUG-87

ORDER	ELEMENT		NUMBER OF ANALYSES	LOWER DETECTION LIMIT	EXTRACTION	METHOD
1	Fe tot	Iron (total)	2	0.01 PPM		
2	Mn	Manganese -Assay	2	0.01 PPM		
3	Cl	Chloride -Assay	2	1 PPM		
4	Na	Sodium -Assay	2	1 PPM		
5	TDS	Tot. Diss. Solids	2	1 PPM		
6	N-NO2	Nitrite Nitrogen	1	0.01 PPM		
7	N-NO3	Nitrate Nitrogen	1	0.01 PPM		
8	Turb	Turbidity	1	0.1 JCU		
9	H2S	Hydrogen Sulphide	1	0.01 PPM		

SAMPLE TYPES	NUMBER	SIZE FRACTIONS	NUMBER	SAMPLE PREPARATIONS	NUMBER
WATER	2	AS RECEIVED	2	AS RECEIVED, NO SP	2

REMARKS: < MEANS LESS THAN.
NOTE: THIS IS A CORRECTION CERTIFICATE. THIS COPY SUPERCEDES ALL PREVIOUS COPIES OF THIS REPORT.

REPORT COPIES TO: LINDA ELLIOTT

INVOICE TO: LINDA ELLIOTT

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-2516

PROJECT: NONE

SAMPLE NUMBER	ELEMENT UNITS	Fe tot PPM	Mn PPM	Cl PPM	Na PPM	TDS PPM	N-NO2 PPM	N-NO3 PPM	Turb JCU	H2S PPM
D7/72/1120B		<0.05	<0.05	79	216	662				
D7/24/1120B		<0.05	<0.05	104	221	764	<0.10	<0.10	<1.0	0.16

BONDAR-CLEGG

5420 CANOTEK ROAD, OTTAWA, ONTARIO K1J 8X5 PHONE: 749-2220 TELEX: 053-3233 BONCO GLO

REPORT OF: Water Analysis REPORT NO: 417-2480

PROJECT: DATE: July 2, 1987

REPORTED TO: Water & Earth Sciences

c/o Linda Elliott

PO Box 430

Carp Ontario KOA 1LO

1120B

Sample Identification: The sample was submitted in plastic bottles labelled D10/72/1120B

Test Results:

CS 137	L 1.0 BQ/L
I 131	L 1.0 BQ/L (as of June 16, 87)
Ra 226	0.1 BQ/L
H-3	L 100 BQ/L
SR_{90}	L 1.0 BQ/L

note: L means less than.

Peter Haulena
Chief Chemist

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario.
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-2480 (COMPLETE)

REFERENCE INFO: 1120B

CLIENT: WATER & EARTH SCIENCES
PROJECT: NONE

SUBMITTED BY: L. ELLIOTT
DATE PRINTED: 2-JUL-87

ORDER	ELEMENT		NUMBER OF ANALYSES	LOWER DETECTION LIMIT	EXTRACTION	METHOD
1	H2S	Hydrogen Sulphide	1	0.01 PPM		
2	Phen	Phenols -Assay	1	0.001 PPM		
3	As	Arsenic -Assay	1	0.01 PPM		
4	Color	Colour -Assay	1	0.1 UNT		
5	Ba	Barium -Assay	1	0.1 PPM		
6	B	Boron -Assay	1	0.01 PPM		
7	Cd	Cadmium	1	0.001 PPM		
8	Cr	Chromium -Assay	1	0.01 PPM		
9	Cl	Chloride -Assay	1	1 PPM		
10	Cu	Copper -Assay	1	0.01 PPM		
11	CN-	Cyanide -Assay	1	0.01 PPM		
12	F	Fluorine -Assay	1	0.01 PPM		
13	Fe tot	Iron (total)	1	0.01 PPM		
14	Pb	Lead -Assay	1	0.01 PPM		
15	Mn	Manganese -Assay	1	0.01 PPM		
16	Hg	Mercury -Assay	1	0.1 PPB		
17	N-NH3	Ammonia Nitrogen	1	0.01 PPM		
18	N-NO3	Nitrate Nitrogen	1	0.01 PPM		
19	N-NO2	Nitrite Nitrogen	1	0.01 PPM		
20	pH	pH -Assay	1	0.01		
21	Se	Selenium -Assay	1	0.01 PPM		
22	Ag	Silver -Assay	1	0.01 PPM		
23	SO4	Sulphate -Assay	1	1 PPM		
24	TDS	Tot. Diss. Solids	1	1 PPM		
25	Turb	Turbidity	1	0.1 JCU		
26	U	Uranium -Assay	1	0.01 PPM		
27	Zn	Zinc -Assay	1	0.01 PPM		

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-2480

PROJECT: NONE

PAGE 1A

SAMPLE NUMBER	ELEMENT UNITS	H2S PPM	Phen PPM	As PPM	Color UNT	Ba PPM	B PPM	Cd PPM	Cr PPM	Cl PPM	Cu PPM	CN- PPM
D10/72/1120B		0.12	<0.002	<0.01	36.0	0.9	0.89	<0.005	<0.01	84	<0.01	<0.10

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-2480

PROJECT: NONE

SAMPLE NUMBER	ELEMENT UNITS	F PPM	Fe tot PPM	Pb PPM	Mn PPM	Hg PPB	N-NH3 PPM	N-NO3 PPM	N-NO2 PPM	pH	Se PPM	Ag PPM
D10/72/1120B		1.00	0.02	0.01	<0.01	<0.1	0.99	<0.10	<0.10	8.10	<0.01	<0.01

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-2480

PROJECT: NONE

SAMPLE NUMBER	ELEMENT UNITS	SO4 PPM	TDS PPM	Turb JCU	U PPM	Zn PPM
D10/72/1120B		3	752	<1.0	<0.01	0.01

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-2479 (COMPLETE)

REFERENCE INFO: 1120B

CLIENT: WATER & EARTH SCIENCES
PROJECT: NONE

SUBMITTED BY: L.ELLIOTT
DATE PRINTED: 15-JUN-87

ORDER	ELEMENT		NUMBER OF ANALYSES	LOWER DETECTION LIMIT	EXTRACTION	METHOD
1	H2S	Hydrogen Sulphide	1	0.01 PPM		
2	Ag	Silver -Assay	1	0.01 PPM		
3	Ba	Barium -Assay	1	0.1 PPM		
4	CN-	Cyanide -Assay	1	0.01 PPM		
5	F	Fluorine -Assay	1	0.01 PPM		
6	N-NO2	Nitrite Nitrogen	1	0.01 PPM		
7	B	Boron -Assay	1	0.01 PPM		

SAMPLE TYPES	NUMBER	SIZE FRACTIONS	NUMBER	SAMPLE PREPARATIONS	NUMBER
HEAVY MINERAL CONC.	1	AS RECEIVED	1	AS RECEIVED, NO SP	1

REMARKS: < MEANS LESS THAN.

REPORT COPIES TO: LINDA ELLIOTT

INVOICE TO: LINDA ELLIOTT

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-2479

PROJECT: NONE

SAMPLE NUMBER	ELEMENT UNITS	H2S PPM	Ag PPM	Ba PPM	CN- PPM	F PPM	N-NO2 PPM	B PPM
D7/72/11208		<0.10	<0.01	0.1	<0.10	1.00	<0.10	0.88

Chief Chemist

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-3274 (COMPLETE)

REFERENCE INFO: 1120B

CLIENT: WATER & EARTH SCIENCES
PROJECT: NONE

SUBMITTED BY: L. ELLIOTT
DATE PRINTED: 17-JUL-87

ORDER		ELEMENT	NUMBER OF ANALYSES	LOWER DETECTION LIMIT	EXTRACTION	METHOD
1	Na	Sodium -Assay	1	1 PPM		
2	Cl	Chloride -Assay	1	1 PPM		
3	N-NH3	Ammonia Nitrogen	1	0.01 PPM		

SAMPLE TYPES	NUMBER	SIZE FRACTIONS	NUMBER	SAMPLE PREPARATIONS	NUMBER
HEAVY MINERAL CONC.	1	AS RECEIVED	1	AS RECEIVED, NO SP	1

REPORT COPIES TO: LINDA ELLIOTT

INVOICE TO: LINDA ELLIOTT

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-3274

PROJECT: NONE

SAMPLE NUMBER	ELEMENT UNITS	Na PPM	Cl PPM	N-NH3 PPM
D10772/1120B		208	86	0.61

Chief Chemist

Zenon Environmental Inc.
845 Harrington Court, Burlington, Ontario L7N 3P3 Canada Telephone: (416) 639-6320 Telex: 061-8734

File No: AN878136

July 16, 1987

Ms. Linda Elliot
Water & Earth Sciences
Carp Road
West of City of Ottawa
1 Mile North of Queensway
(Behind Ottawa Ford Tractor Sales)
Carp, Ontario
K0A 1L0

Dear Ms. Elliot:

Please find enclosed written confirmation of the requested analyses on sample D10/72/1120B (ZENON ID #: 873406).

Should any questions arise, please do not hesitate to contact me.

Yours truly,

M G Foster

for Ronald A. McLeod, Ph.D.
Senior Chemist

RAM/jas

Encl.

ANALYSIS OF SAMPLE FOR DRINKING WATER PARAMETERS

	Detection Limit (µg/L)	873406 D10/72/1120B
Aldrin	0.001	ND
Dieldrin	0.001	ND
Carbaryl	0.1	ND
a-Chlordane	0.001	ND
g-Chlordane	0.001	ND
o,p-DDT	0.001	ND
p,p-DDT	0.001	ND
Diazinon	0.1	ND
Endrin	0.001	ND
Heptachlor	0.001	ND
Heptachlor Epoxide	0.001	ND
Lindane	0.001	ND
Methoxychlor	0.001	ND
Methyl parathion	0.1	ND
Parathion	0.1	ND
Toxaphene	0.1	ND
2,4-D	0.1	ND
2,4,5-TP	0.1	ND
PCB s	0.05	ND
Trihalomethanes	0.1	ND
TOC	1.0	22mg/L
%Recovery D10 Anthracene		33
%Recovery D12 benzo(a)pyrene		80

MANN

MANN TESTING LABORATORIES LTD.
5550 McADAM ROAD, MISSISSAUGA, ONTARIO L4Z 1P1
PHONE: 890-2555 • TELEX: 06-960496

CUSTOMER: Water & Earth Science Assoc. Ltd.
Box 430
Carp, Ontario
KOA 1LO

REPORT #: 877759

CUSTOMER REF.#

ATTN: Mr. Tom Keil

DATE SUBMITTED: July 10, 1987

CERTIFICATE OF ANALYSIS

Sample Description: **WATER**

Preparation: Samples were prepared as per modified EPA Method 430.1

Note: **Additional information is available on request.**

Methodology: NTA - *extraction & colorimetric*

Chemical Results: See Table 1.

DATE: July 23, 1987

CERTIFIED BY:
ROY G. SMITH, C.CHEM.

GEN-H

CLIENT: WATER & EARLY SCIENCE ASSOCIATES LTD.
REF. NO.: 877759
TABLE: 1

CHEMICAL ANALYSIS - GENERAL
CONC = mg/L

CHEMICAL PARAMETERS	MDL mg/L	QA/QC mg/L EXP'T	QA/QC mg/L TRUE	WELL WATER D10/72/1120B				
NTA	0.02			<0.02				

MDL = INSTRUMENT/METHOD DETECTION LIMIT
NS = NON SUFFICIENT SAMPLE
-- = *NO ANALYSIS REQUIRED*

a= EPA WP 1083 ICAP 19/7
b= EPA WP 386 TRACE METALS - I
c= NBS 1643b TRACE ELEMENTS IN WATER
d= EPA WP 1185+WS 378 MINERALS +NO3/F-6