MCNEELY ENGINEERING LIMITED

HYDROGEOLOGICAL ASSESSMENT
COMMUNAL WATER SUPPLY
COMMUNITY OF MOOSE CREEK

TOWNSHIP OF ROXBOROUGH

APRIL 30, 1992

PROJECT NO. 30066

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April 30, 1992
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McNeely Engineering Consultants Ltd.
880 Taylor Creek
Orleans, Ontario
K1C 1T1

Attention: Mr. Don Lishman, P.Eng.

RE: HYDROGEOLOGICAL ASSESSMENT OF THE COMMUNAL WATER SUPPLY MOOSE CREEK

Dear Sir:

We are pleased to submit 10 copies of our final report on the hydrogeological assessment of the communal water supply for the community of Moose Creek.

The report contains the results of individual 72-hour pumping tests carried out on each of the three wells which have been constructed as gravel packed 400 mm diameter production wells. The report also contains the results of a 36-hour multi-well test conducted on the three production wells.

Based on this testing program, we have concluded that the yield from the three production wells will exceed the average daily demand of 314 m^3/day by 300% and the maximum daily demand of 861 m^3/day by 12%. We have further concluded that a fourth well will be required if additional significant demand is to be satisfied by the communal well system.

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Water quality in all wells is generally good and the concentration of all parameters meet the Ontario Drinking Water Objectives with some minor exceptions. The minor exceptions are H_2S, Na, and phenol in TW-2 and TW-4. Mixing of water from TW-1 and chlorination are expected to mitigate the exceedances.

We trust the above information meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

We thank you very much for this opportunity to be of assistance to you.

Yours truly,

JACQUES WHITFORD ENVIRONMENT LIMITED

Robert J. Rennie, M.Sc., P.Eng.
Project Manager

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Report

to

McNeely Engineering Limited

on

Hydrogeological Assessment
Communal Water Supply

Community of Moose Creek
Township of Roxborough

Jacques Whitford Environment Limited

April 30, 1992

Project No. 30066

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1.0 INTRODUCTION

1.1 Background

In 1989, Jacques Whitford Environment Limited was retained by McNeely Engineering Limited to carry out an evaluation of private wells in the community of Moose Creek, Ontario. The results of this investigation were submitted in our report dated December 1, 1989. The reasons for the evaluation were salt contamination of some wells and low yields. The principal conclusion of the evaluation was that a communal well supply should be considered for the community.

An office hydrogeological study was then carried out by Jacques Whitford Environment Limited to find a site for a communal well. A site was located at southeast of the community at the corner of Valley Street and Dyer Road (Figure 1). A total of four (4) test wells, designated TW-1, TW-2, TW-3 and TW-4, were subsequently drilled at the selected site. The drillers' well tests indicated that relatively high yields were possible. As a result two (2) of these test wells (TW-2 and TW-4) were reamed, gravel packed and pump tested for 72 hours. Jacques Whitford Environment Limited was then authorized to ream and gravel pack a third well (TW-1) which was also pump tested for 72 hours. Test well TW-3 was not reamed, gravel packed and tested because the drillers' tests indicated a potentially lower yield as compared to the other three. These three tests were followed by a 36-hour pump test in which all three (3) gravel packed wells were pumped simultaneously.

1.2 Purpose

The purpose of the hydrogeological assessment described in this report was to determine the quality and yield of the communal well system which includes the three (3) gravel packed wells. This report contains the results of the pumping tests carried out on one well at a time and by pumping all three (3) wells simultaneously. The results of water quality testing are also described. This communal well investigation was carried out in accordance with various letters of authorization from McNeely Engineering dating back to November 1989.

1.3 Design Demand

It is understood that the expected average and maximum daily demands are 314 m^3/day (48.5 igpm) and 861 m^3/day (133 igpm) respectively.

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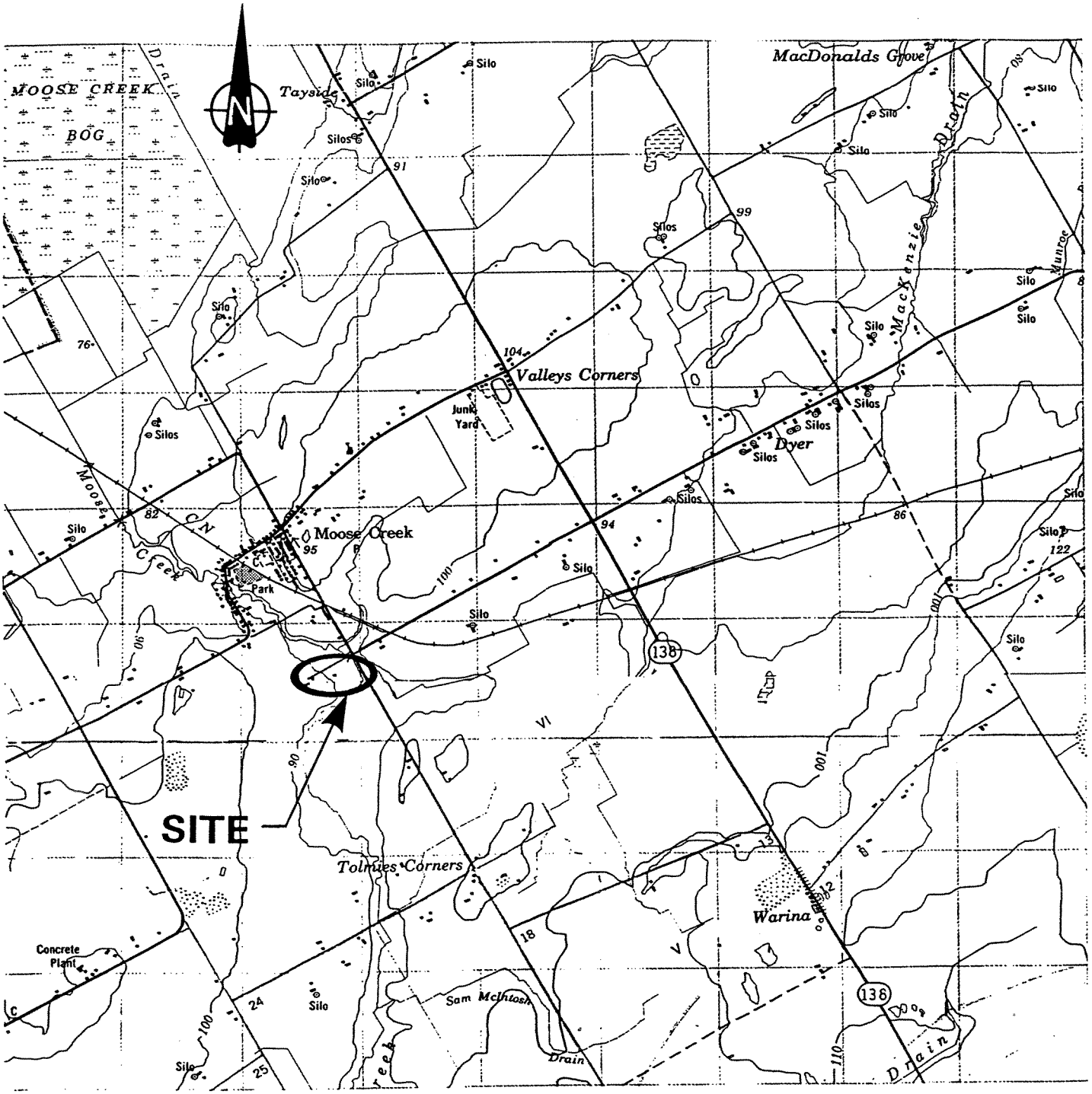

KEY PLAN

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FIGURE 1

2.0 SCOPE OF WORK

- To monitor construction of four test wells.
- To inspect the reaming and construction of gravel packs for test wells TW-1, TW-2 and TW-4.
- To conduct step drawdown pumping tests on test wells TW-1, TW-2, and TW-4.
- To plan and supervise a constant discharge pumping test on test wells TW-1, TW-2 and TW-4 for a period of 72 hours.
- To plan and supervise the simultaneous test pumping of TW-1, TW-2 and TW-4 for a period of 36 hours.
- To interpret the results of the above tests and develop conclusions and recommendations regarding yields and water quality of the communal well system.

3.0 FIELD INVESTIGATION

3.1 Siting of Test Wells

Available information on geology, hydrogeology, nearby water wells, topography, climatology and socio-economic conditions was gathered and used, along with discussions with well drillers, local residents and McNeely Engineering to determine the optimum location of the test wells.

Based on this information, two areas within 3 km of the community were initially identified as candidates for further investigation. These included an area southeast of the community, at the corner of Valley Street and the Dyer Road, and an area west of the community (Lots 25 to 30, Concession 8, Roxborough Township). After discussions with McNeely Engineering, it was decided to begin by investigating the area southeast of the community. After a site visit on July 25, 1990 and discussions with landowners it was finally determined that a test well and two observation wells would be drilled on property belonging to Fred Scott (see Figure 2).

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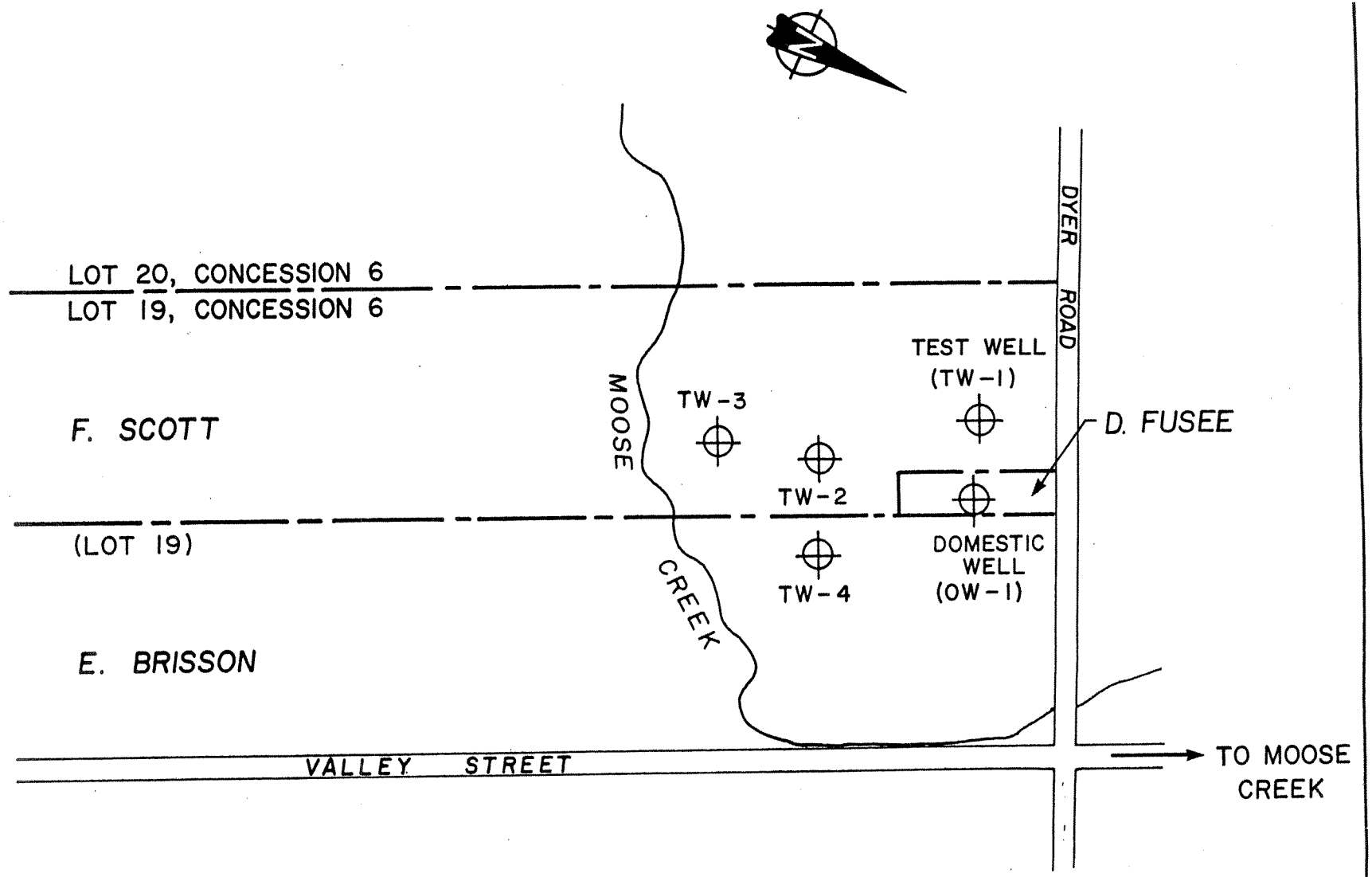

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COMMUNAL WATER SUPPLY - WELL LOCATION PLAN

MOOSE CREEK, ONTARIO

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Jacques, Whitford Limited

3.2 Well Construction

Drilling of the first three (3) test wells started on August 18, 1990. TW-1 encountered 12.2 m of overburden which consisted of mostly clay and clay till. Dark grey to black limestone was encountered below the limestone bedrock. Steel casing, 150 mm in diameter, was installed to a depth of 12 m. The well was drilled to a total depth of 30.5 m. TW-2 and TW-3 were drilled in a similar manner, with 13.1 m and 14.0 m of overburden, and 13.0 m and 14.9 m of casing, respectively. Very good water flows, in excess of 260 m^3/day in each case were encountered with TW-2 having the highest estimated yield and TW-3 the least.

Based on yields estimated by the driller it was decided to carry out a pumping test of TW-2, while using the other two wells as observation wells. A three-stage step drawdown test was performed on TW-2 in order to determine the optimum pumping rate for the long term constant discharge test.

A preliminary 72 hour pump test was performed on the 150 mm diameter test well TW-2, starting on August 20, 1990, at an average rate of 314 m^3/day (48 igpm). At this rate, the maximum drawdown in TW-2 was 8.45 m, while maximum drawdowns in TW-1 and TW-3 were 0.73 m and 3.18 m respectively. TW-1 and TW-3 are 170 m and 80 m from TW-2, respectively. After the pump was turned off at the end of 72 hours, depths of rising water levels were recorded in TW-2 for a period of 56 minutes at which time 97% recovery had taken place.

Due to the promising results obtained from the pumping test on TW-2, it was decided to ream this well. However, this was not possible at the time because of land access problems and it was therefore decided to drill a fourth well (TW-4) on adjacent property belonging to E. Brisson. A pilot hole for this well was drilled on March 7, 1991 and a high yield was indicated during well development. During the drilling of the pilot hole, well TW-4 encountered 12.5 m of overburden which generally consisted of sand and silt. Bedrock consisted of an upper 3.7 m thick fractured shale followed by a dark grey shale to the end of the hole at a depth of 32 m. Original flow estimates by the driller were in excess of 393 m^3/day. The total depth of TW-4 was 32 m. Upon completion, a preliminary step drawdown test was conducted. Low flow rates observed during this test were attributed to aquifer degradation within the bedrock formation. It was decided at that time that all selected production wells would be reamed and a gravel pack constructed. Reaming and construction of a gravel pack at TW-4 started on March 13, 1991.

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In general, the reaming and gravel pack procedure for well TW-4 and subsequently for wells TW-1 and TW-2 was as follows:

1. Drill a 500 mm diameter starter hole to a depth of 6 m.

2. Continue drilling below 6 m to bedrock with a 400 mm diameter hole and install a 400 mm diameter casing to a depth of about 0.6 m into bedrock.

3. Continue drilling into bedrock with a bit slightly smaller than the 400 mm diameter casing until water is encountered. Install two screens 200 mm diameter which are separated by 200 mm diameter casing and connected to 200 mm riser casing. The stainless steel screens were 100 slot in TW-2 and TW-4 and 80 slot in TW-1.

4. Fill the annular space between the 200 mm diameter screen and the 400 mm diameter hole and casing with silica gravel, 6 mm maximum size, to a level about 3 m above the top of the uppermost screen.

5. Grout the 400 mm casing into bedrock and the remaining annular space between the 400 mm and 200 mm diameter casings from the surface of the silica gravel to the ground surface.

Following the 72-hour pumping test of the reamed and gravel packed TW-4, access problems to the adjacent property on which TW-1, 2 and 3 were drilled were resolved. Also, it was concluded from the testing on TW-4 that at least three (3) production wells would be required to satisfy demand. Preliminary estimates indicated that TW-3 had the lowest potential yield of wells TW-1, TW-2 and TW-3, therefore, it was decided to ream, gravel pack and pump test TW-2 and TW-1.

The locations of the four wells including an existing domestic well are shown in Figure 2.

The depths of casing and the screens varied for each well. Figure 3 shows sections of the reamed and gravel packed wells TW-1, 2 and 4 and well TW-3 which was not reamed and gravel packed. Water well records are contained in Appendix 1.

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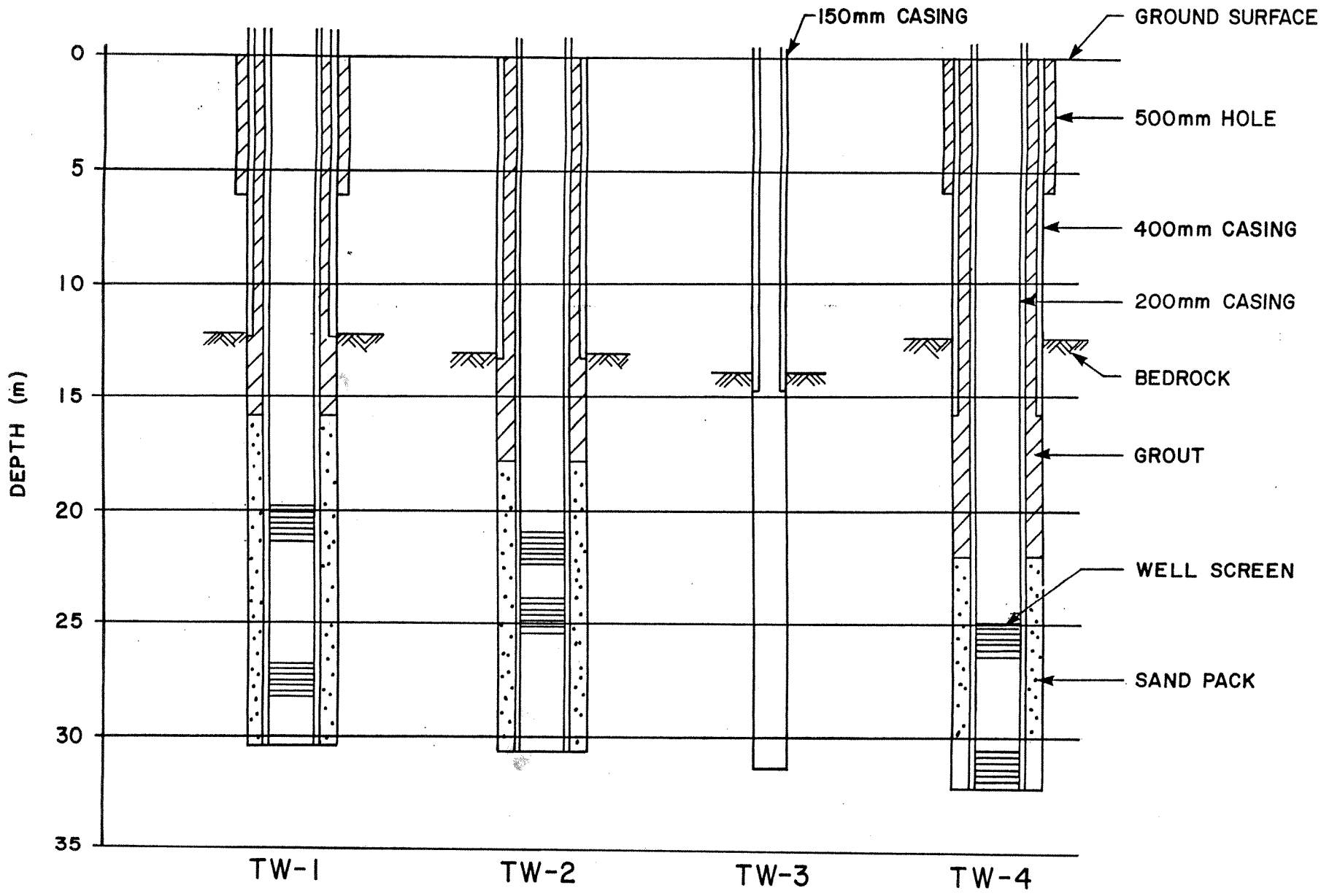

WELL CONSTRUCTION DETAILS

FIGURE

3.3 Pumping Tests

3.3.1 72-Hour Pumping Tests

A step discharge test and a 72 hour constant rate pumping test were conducted on wells TW-1, TW-2 and TW-4 after they had been reamed and gravel packed. The objective of the step tests was to determine a constant discharge rate that would not lower the water levels in the wells to unacceptable levels over a pumping period of 72 hours. For the step test, each well was pumped at a minimum of three (3) discharge rates for a short duration to determine the maximum acceptable rate for the 72 hour tests.

Water levels were monitored during the pumping tests in the pumping wells and the other three wells drilled for this project. A nearby domestic well was also monitored during the pumping test on TW-1.

In test well TW-1 the water level in the pumped well was monitored during recovery for a period of 130 minutes after which more than 95% recovery had taken place.

For well TW-2 the initial pumping rate of 360 m^3/day (60 igpm) was lowered to 327.5 m^3/day (50 igpm) after 15 minutes of pumping because of the large drawdown recorded. The water level in the pumped well was monitored during recovery for a period of 120 minutes after which more than 95% recovery had taken place.

A step test run on April 2, 1991 indicated TW 91-4 would yield less than 327 m^3/day (50 igpm) total flow and therefore the well was re-developed. Surging and water jetting were employed to remove fine sediments from the well screen and annulus. A second step test was run on April 8, 1991 and the increased specific capacity indicated that the re-development techniques had improved the transmissivity of the well and that the well could be pumped at 327 m^3/day (50 igpm) for the 72 hour test. The water level in TW-4 was monitored during recovery for a period of 46 minutes after which more than 95% recovery had taken place.

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3.3.2 36-Hour Pumping Test

The 36-hour simultaneous test pumping of TW-1, TW-2 and TW-4 began on November 12, 1991. Three pumps were started within the first 30 seconds of the test and were pumping at rates slightly higher than the final intended pumping rates for the test. Flow rates were adjusted downward over the next three hours depending on the drawdown characteristics of each well. The final rates for TW-1, TW-2, and TW-4 were 50, 45 and 45 igpm (327, 295 and 295 m^3/day). The pumps were shut down together and recovery was recorded in the pumping and observation wells for a period of 12 hours.

3.4 Sampling

Groundwater samples were collected from the pumped discharge from TW-1 after 3 hours and from TW-1, TW-2 and TW-4 after 72 hours of pumping and submitted to Areco Canada Limited Laboratories in Nepean for analysis. The 3 hour sample was analyzed for general water chemistry and bacteria and the samples taken at 72 hours were analyzed for the full chemistry suite of "Table 4" of the Ontario Drinking Water Objective Guidelines. This hydrochemistry testing is required by the Ministry of the Environment (MOE) for communal wells.

Groundwater samples were taken from each of the pumping wells at the end of the 36 hour multi-well test and analyzed for general chemistry and bacteria.

4.0 RESULTS AND ANALYSIS

4.1 Physiography and Geology

Moose Creek is located on the edge of the Winchester Clay Plain, which is an area of generally low relief with some more complex areas, lying within the drainage basin of the South Nation River. The topography of the community of Moose Creek consists of a drumlin ridge located north-northwest of the village from which the grade slopes downward to the west towards Moose Creek Bog, and to the southwest toward Moose Creek. A small portion of the community is located west of the creek, where the land again rises to the west.

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Surface drainage follows the topography, to the north and towards Moose Creek. Moose Creek itself is a sluggish stream, except during the spring runoff, with a grade of about 1% except just upgradient of where it crosses under County Road 15, where the gradient is about 2%. The creek enters the Moose Creek Bog about 4 km north of the village, eventually joining the South Nation River at Lemieux.

Bedrock in the area consists of limestone of the Lindsay Formation, Ottawa Group. Depths to bedrock within the community vary from 3 m to 28 m, averaging 13 m, as determined from Water Well Records.

The surficial geology is quite variable, ranging from sand and gravel, through clay, to glacial till. Ontario Soil Survey information indicates three soil types, Kars Gravel, Granby Sandy Loam and Rubicon Sandy Loam. The majority of the community is located in the Kars Gravel zone, which is a poorly sorted outwash consisting of gravelly sandy loam with good drainage.

The other soil types are granular with some poor drainage. The above classifications are agricultural and pertain mainly to the near surface soils.

4.2 Hydrogeology

4.2.1 TW-1: 72-Hour Pump Test

The 72-hour test pumping of TW-1 began on November 6, 1991. Four other wells were used for observation including TW-2, TW-3 and TW-4 and OW-1 which is a domestic well located on the property owned by Mr. Dwayne Fusee (see Figure 2). The results from both the pumping wells and the observation wells are given in Appendix 2.

As mentioned previously, a step-drawdown test was conducted prior to beginning the 72 hour test in order to determine the optimum and maximum pumping rates. The well was pumped at approximately 360 m^3/day (55 igpm) because at 393 m^3/day (60 igpm) the pumping level rapidly approached the pump intake.

The total drawdown in TW-1 was 14.3 m. After the pump was shut down, the water level recovered to within 90% of the static level after 10 minutes and to within 95% after 2 hours.

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Two transmissivity values were calculated from the pumping well data: i) an apparent transmissivity for the well itself, to be used in calculating safe well yield, and ii) an aquifer transmissivity, usually represented by late drawdown and recovery data in the pumping well. Transmissivity values also representative of the aquifer between the pumping and observation wells were calculated from observation well data.

The transmissivity of the well averages 115 m^2/day and from observation well data, the transmissivity for the aquifer averages 155 m^2/day. Storativity is low and was calculated to be 3.66×10^{-5}. All the calculations were made using the Jacob Method.

The safe well yields given below represent the maximum discharge rate that the well may be pumped over a 20-year period without exceeding the available drawdown in the well. Available drawdown is depth to top of screen less the depth to static water level.

From the data for TW-1 the theoretical safe yield of the well was calculated using Theis formula to be 1090 m^3/day (167 igpm) without exposing the well screen. This yield is about four to five times the estimated 20-year yield obtained by extrapolating the drawdown-log time curve over a period of 20 years. The principal reason for this discrepancy is that the well is quite inefficient. Distance-drawdown relationships between TW-1 and the observation wells indicate approximately 23% efficiency (80% efficiency is considered good). The poor efficiency results from the necessity of having to stabilize the formation with gravel pack. In view of this, the results suggest a safe well yield of 320 m^3/day (50 igpm) for TW-1.

The 23% efficiency of TW-1 is lower than 40% efficiency for TW-4 and 55% efficiency for TW-2 mentioned below. The wide variation in efficiencies is due less to well construction characteristics than to differences in the transmitting capacity of the aquifer. The well construction at each of the three wells is similar and they can transmit similar quantities of water. TW-2 and TW-4 can transmit more of the water which the aquifer can supply at these wells than TW-1, which can only transmit about one quarter of the water which the aquifer can supply at that point. Low efficiencies and low pumping levels can result in increased pumping costs.

The observation well data indicate that the safe yield of the aquifer is 2,146 m^3/day (328 igpm). This was estimated on the basis of an assumed drawdown of 25 m. Safe yields assume no boundary conditions such as recharge or impermeable boundaries.

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4.2.2 TW-2: 72 Hour Pump Test

The pumping test results, given in Appendix 3, were analyzed using several methods. The drawdown and recovery data of the pumping well (TW-2) were analyzed using the Jacob Straight-Line Method and the results are given in Table 3-3. The maximum drawdown was 18 m and 95% recovery was observed two (2) hours after the pump was shut down.

The initial 10 to 12 minutes of pumping represents removal of water from storage in the well (est. 2100 litres) and is therefore not suitable for calculation of well transmissivity. The initial drawdown of 11 m in one minute, and an initial recovery of 11 to 12 m within one minute indicate a well loss in the order of 11 m or about 55% of total drawdown. The pumping well drew down an additional 3 m from 10 minutes of pumping to 480 minutes of pumping after which apparent steady state pumping conditions were sustained to the end of the test.

A reasonable well transmissivity appears to be about 25 m^2/day using late drawdown from the pumping well (Table 3-3). Using an available drawdown of 19.3 m to the top of the screen, a safe well yield of production well TW-2 is about 270 m^3/day (42 igpm). The average aquifer transmissivity from late drawdown data is 47 m^2/day which generates a safe aquifer yield of 509 m^3/day (79 igpm) for an assumed drawdown of 25 m.

During the 72 hour pump testing of TW-2, maximum drawdowns of 1.70 m, 3.68 m and 2.63 m were recorded in TW-1, TW-3 and TW-4 respectively. The distances between these wells and the pumping well were 145.5, 72.8 and 71.5 m respectively.

The configuration of the time drawdown curves for observation wells in Appendix 3 indicates a significant degree of recharge during the test, resulting in steady state flow conditions. The effects of recharge were observed in the observation wells after about 2 hours of pumping.

The aquifer transmissivity values based on late observation well drawdown appear to be too large, since late drawdown is more influenced by recharge. Aquifer transmissivity and storativity values were therefore evaluated from the early drawdown data, as shown in Tables 3-5, 3-7 and 3-9 (Appendix 3). The mean aquifer transmissivity is 55.9 m^2/day, with an associated storativity of 2.7×10^{-5}. This mean aquifer transmissivity is about 100 percent higher than the apparent well transmissivity (25 m^2/day), and is consistent with the well losses of 55% observed at the well. The average transmissivity of the late drawdown and recovery data for the pumping well is 47 m^2/day, which is in line with the average aquifer transmissivity from observation well data (55.9 m^2/day).

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Using the average aquifer transmissivity of 55.9 m^2/day, the associated safe aquifer yield is 582 m^3/day (89 igpm) assuming 25 m of available drawdown.

4.2.3 TW-4: 72 Hour Test

The maximum drawdown in TW-4 after 72 hours of pumping at a constant rate of 327 m^2/day (50 igpm) was 24.7 m and 96% recovery was observed 45 minutes after the pump was shut down.

The pumping test results contained in Appendix 4 were analyzed using several methods. The drawdown and recovery data of the pumping well (TW-4) were analyzed using the Jacob straight-line method and the results are given in Table 4-3 in Appendix 4. They indicate an average transmissivity of 22.1 m^2/day which results in a 20 year safe well yield of 298 m^3/day (46 igpm) for an available drawdown of 24.2 m. The observation well data was analyzed using the Jacob Straight Line Method, the Theim method and the Jacob Distance Drawdown Method. The results of these analyses are summarized in Table 4-10 in Appendix 4. The results of the various methods agree fairly well. Based on the average aquifer transmissivity of 66.3 m^2/day, the calculated 20 year safe aquifer yield is 1,284 m^3/day (196 igpm) for an assumed available drawdown of 25 m. This can be considered a conservative estimate because transmissivities were determined from parts of the curves before leakage had been encountered. Subsequent flattening of the curves indicates aquifer leakage or recharge from some source.

4.2.4 Multi Well Pump Test

The 36 hour simultaneous test pumping of TW-1, TW-2 and TW-4 began on November 12, 1991. OW-1 and TW-3 were used for observation and the results from both pumping and observation wells are given in Appendix 5. The expected well interference was calculated before the test began and it was decided that TW-2 would have to be pumped at less than 324 m^3/day (50 igpm) to avoid major exposure of well screens. The pumping rates were set below the intended pumping rates and slowly raised at the beginning of the test. Figure 4 shows drawdown and pumping rates. The final pumping rates were 327.5 m^3/day (50 igpm) in TW-1 and 295 m^3/day (45 igpm) in both TW-2 and TW-4.

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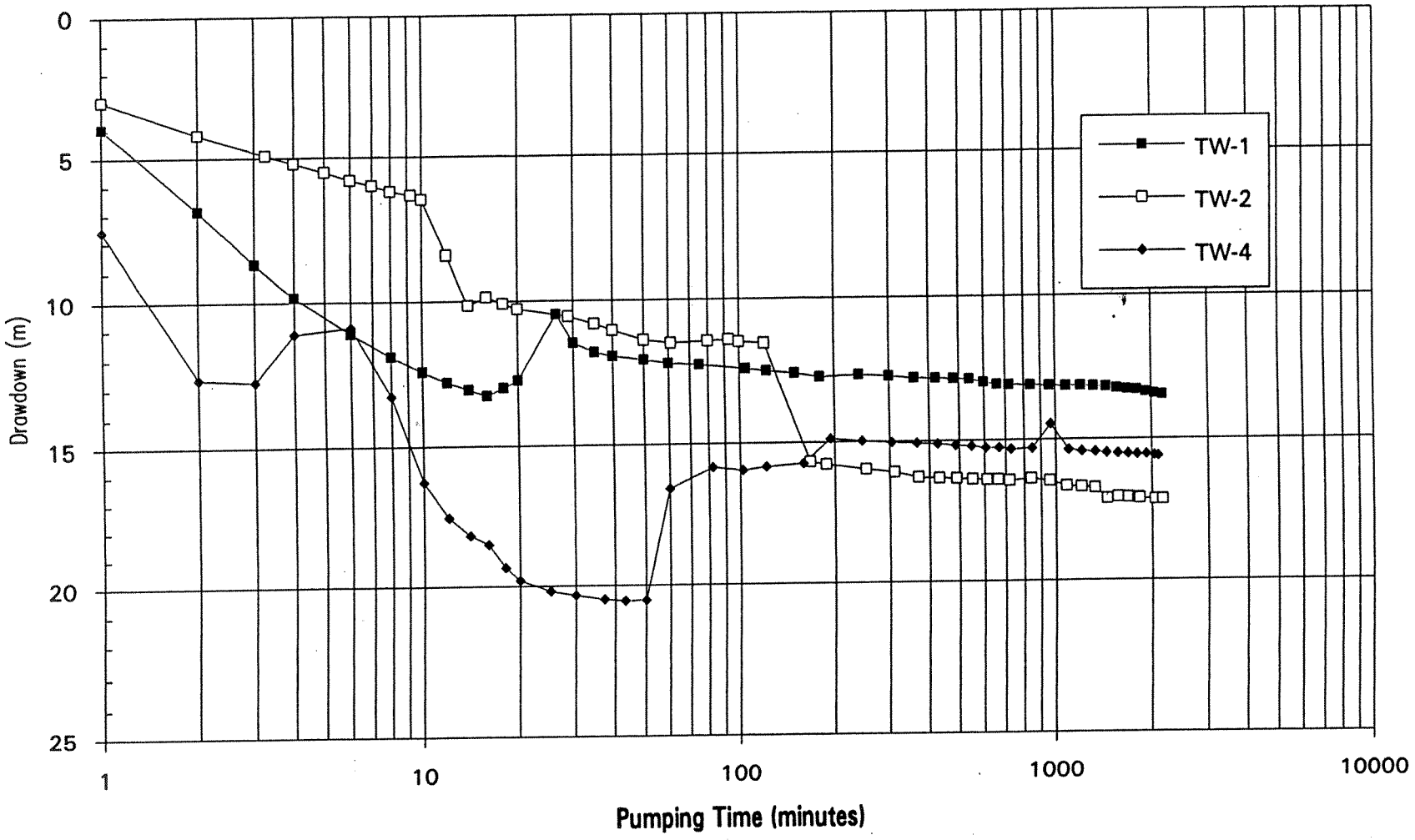
Drawdown in Pumping Wells During 36 Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4



Annotated figures indicate new pumping rates in imperial gallons per minute (igpm)

Figure 4

The pumping rates could have been set higher to total approximately 972 m^3/day (150 igpm) but the primary concern was the water level in the neighbouring domestic well OW-1 owned by Mr. Fusee (see Figure 2). The pump intake in this well is set at 6 m which would allow only 3.4 m drawdown. At a total pumping rate of 907 m^3/day (140 igpm) the final level in this well was within 30 cm of the intake as shown in Figure 5 which shows the drawdown of the two observation wells, TW-3 and OW-1.

In a system with homogeneous distribution of transmissivity, a greater drawdown and slope in OW-1 would be expected. However, the curves show approximately 50% more drawdown in TW-3 and a steeper slope. OW-1 is 20 m deep and is probably connected to TW-1 through the upper water bearing fractures which were encountered at about the 20 m depth. This information indicates a higher transmissivity in the northern portion of the aquifer beneath the well field.

The 20 year safe yield (i.e. continuous pumping) was estimated for the existing well field by extrapolating drawdown log time curves over a period of 20 years. The result is approximately 906 m^3/day (140 igpm). Based on drawdown characteristics during the 72 hour pumping test and on the efficiencies of the wells, pumping rates of 294 m^3/day (46 igpm), 306 m^3/day (47 igpm) and 306 m^3/day (47 igpm) for TW-1, TW-2, and TW-4 respectively are recommended. These rates assume that impermeable boundaries are not present. It is noted that a minor boundary condition was detected in TW-1 data in the last 12 hours of the multi-well pumping test. If this condition continues to develop, the 8-hour continuous pumping rate may have to be decreased.

The 36 hour test also indicated that the field can produce 970 m^3/day (150 igpm) for 8 hours continuously although the margin of safety will be small. Even an additional 65 m^3/day (10 igpm) from the well field will likely result in excessive drawdown in one or more of the wells. The recommended 8 hour pumping rates are 343 m^3/day (53 igpm), 323 m^3/day (50 igpm), and 304 m^3/day (47 igpm) for wells TW-1, TW-2 and TW-4 respectively which is again based on drawdown characteristics and efficiencies calculated from the test results.

Transmissivities were calculated using the Cooper-Jacob Method on observation well data. This method used the weighted mean of radii from the pumping wells and the weighting is based on the contribution to total flow which each well provides. The transmissivity calculated from TW-3 data for the southern side of the well field was 129 m^2/day which is in the upper range of values calculated for the earlier three 72-hour pump tests using the Jacob Method.

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Drawdown in Observation Wells During 36 Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4

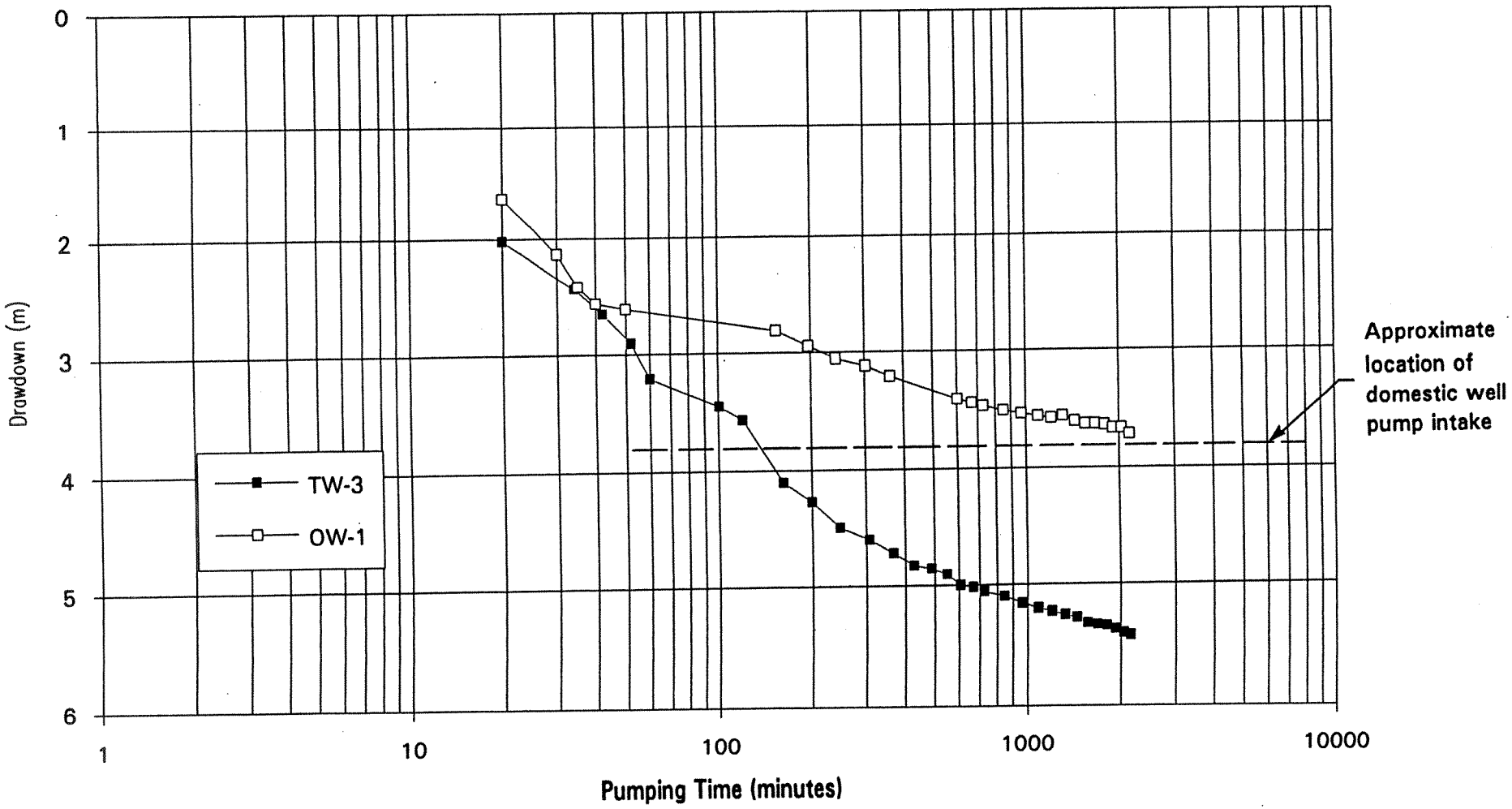


Figure 5

The transmissivity of the northern side of the well field was calculated from OW-1 data to be 215 m^2/day. This is higher than any of the previous calculations, and again indicates higher transmissivity in the northern part of the aquifer beneath the well field.

The transmissivity values of 129 m^2/day and 215 m^2/day translate into theoretical 20-year safe aquifer yields of 1,758 m^3/day (268 igpm) and 2,929 m^3/day (447 igpm) respectively assuming 25 m of available drawdown. Based on the slope of the curve after the boundary was encountered in TW-1, the 20 year safe yield for this well is not likely to be reduced to below 292 m^3/day (45 igpm). No other distinct boundary conditions other than recharge were noted in the other wells or during any of the other pumping tests.

Recovery curves for the pumping and observation wells are shown in Figure 6. These curves also indicate that the northern portion of the aquifer below the well field has greater transmissivity than the southern portion. TW-1 recovers much more quickly after pumping than either TW-2 or TW-4, and TW-2 recovers much more quickly than TW-4. It is interesting to note that water levels in the vicinity of the well field rebound together after 100 minutes of recovery. This indicates high transmitting capacity in the aquifer but poor storage. The area of influence of this well field is expected to be quite large.

Table 4.1 is a compilation of aquifer parameters obtained from the four pumping tests conducted to date. Figure 7 shows the areal distribution of transmissivity over the well field. The vectors represent transmissivity between the pumping well and the observation well located in the direction of the vector. The shaded circles indicate well transmissivity obtained during each 72 hour pumping test.

Figure 7 shows a definite areal zonation of transmissivity. Transmissivity is generally a higher in the northern and eastern portion of the aquifer beneath the well field than in the southern part. In addition to this, the transmissivity between TW-1 and OW-1, both of which are in the northern "zone", is considerably higher than that between TW-2 and the wells in the southern "zone". From this information, it appears that the main water producing zone is in the north. Based on the asymmetry of drawdown in observation wells, both TW-2 and TW-4 obtain a proportion of water from the northern zone. The nature and orientation of the boundary between the two zones is unknown. It may be a small fault or a pinching out of horizontal fractures.

Recycled Paper

Recovery of Pumping and Observation Wells Following 36 Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4

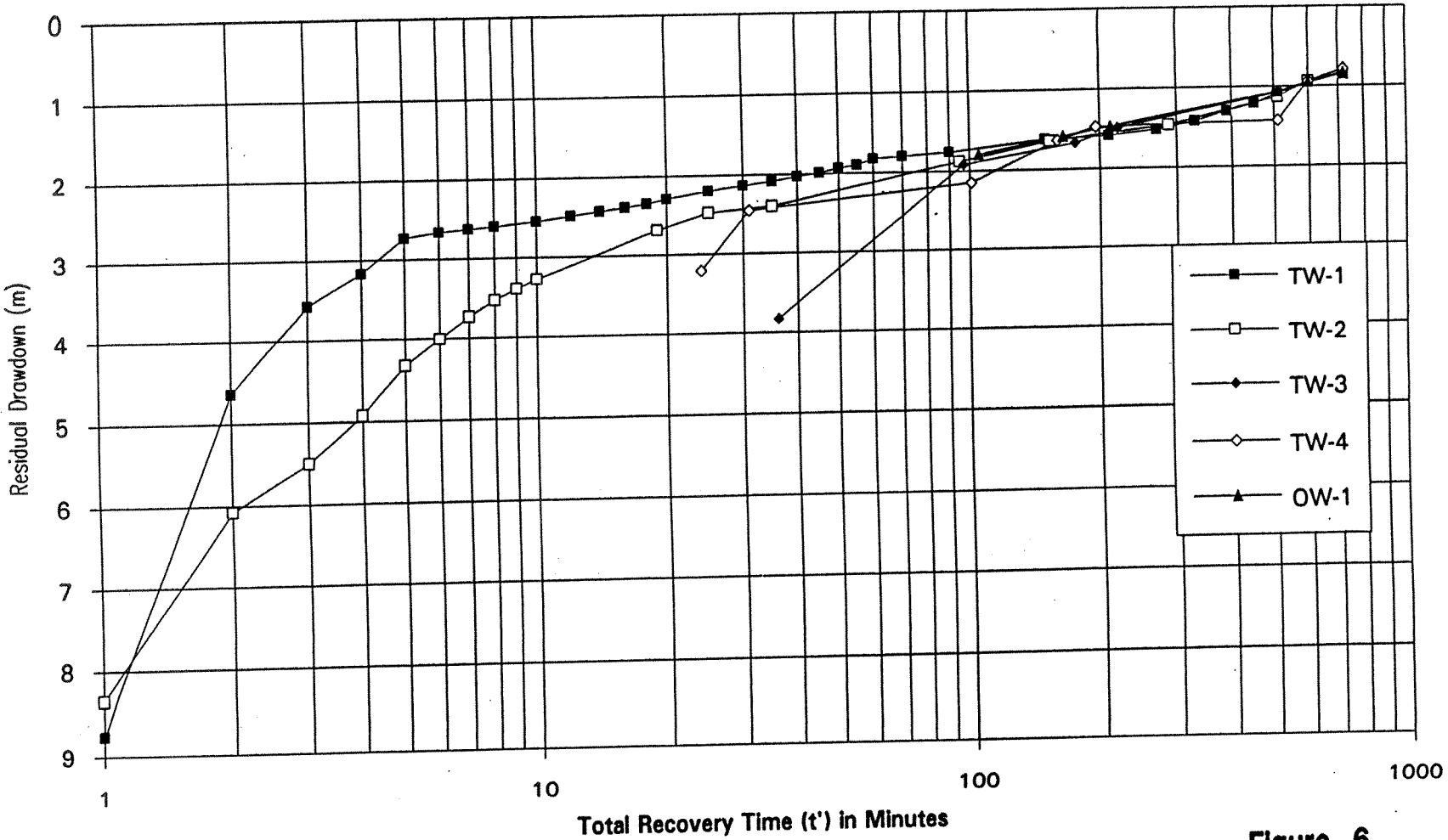


Figure 6

Table 4.1 - Summary of Aquifer Parameters From Pumping Test Results

Well Transmissivities Obtained From 72 Hour Pumping Tests

Well No	Pumping	Method	T (avg.) m2/day	S	20 Year Safe Yield* m3/day	igpm
TW-1	TW-1	Jacob	115	-	1090	167
TW-2	TW-2	Jacob	25	-	270	42
TW-4	TW-4	Jacob	22	-	298	45

Aquifer Transmissivities Between Wells

Between			Pumping	Method	T (avg.) m2/day	S	20 Year Safe Yield** m3/day	igpm
TW-1	and	TW-2	TW-1	Jacob	165	7.3E-05	2285	349
TW-1	and	TW-3	TW-1	Jacob	146	1.2E-05	2031	310
TW-1	and	TW-4	TW-1	Jacob	132	3.6E-05	1829	279
TW-1	and	OW-1	TW-1	Jacob	176	5.6E-05	2438	372
TW-2	and	TW-1	TW-2	Jacob	76	2.3E-05	1054	161
TW-2	and	TW-3	TW-2	Jacob	37	1.9E-05	508	78
TW-2	and	TW-4	TW-2	Jacob	55	3.9E-04	764	117
TW-4	and	TW-1	TW-4	Jacob	123	3.3E-05	1699	259
TW-4	and	TW-2	TW-4	Jacob	80	4.8E-05	1111	170
TW-4	and	TW-3	TW-4	Jacob	75	3.6E-05	1041	159
TW-1	and	TW-2	TW-4	Theim	56	-	759	116
TW-1	and	TW-3	TW-4	Theim	32	-	437	67
TW-2	and	TW-3	TW-4	Theim	72	-	968	148

Aquifer Parameters In Northern and Southern Portions of Aquifer

	Well No	Pumping	Method	T (avg.) m2/day	S	20 Year Safe Yield** m3/day	igpm
Southern:	TW-3	TW-1,2,4	Cooper-Jacob	129	3.2E-02	1758	189
Northern:	OW-1	TW-1,2,4	Cooper-Jacob	215	1.7E-03	2043	315

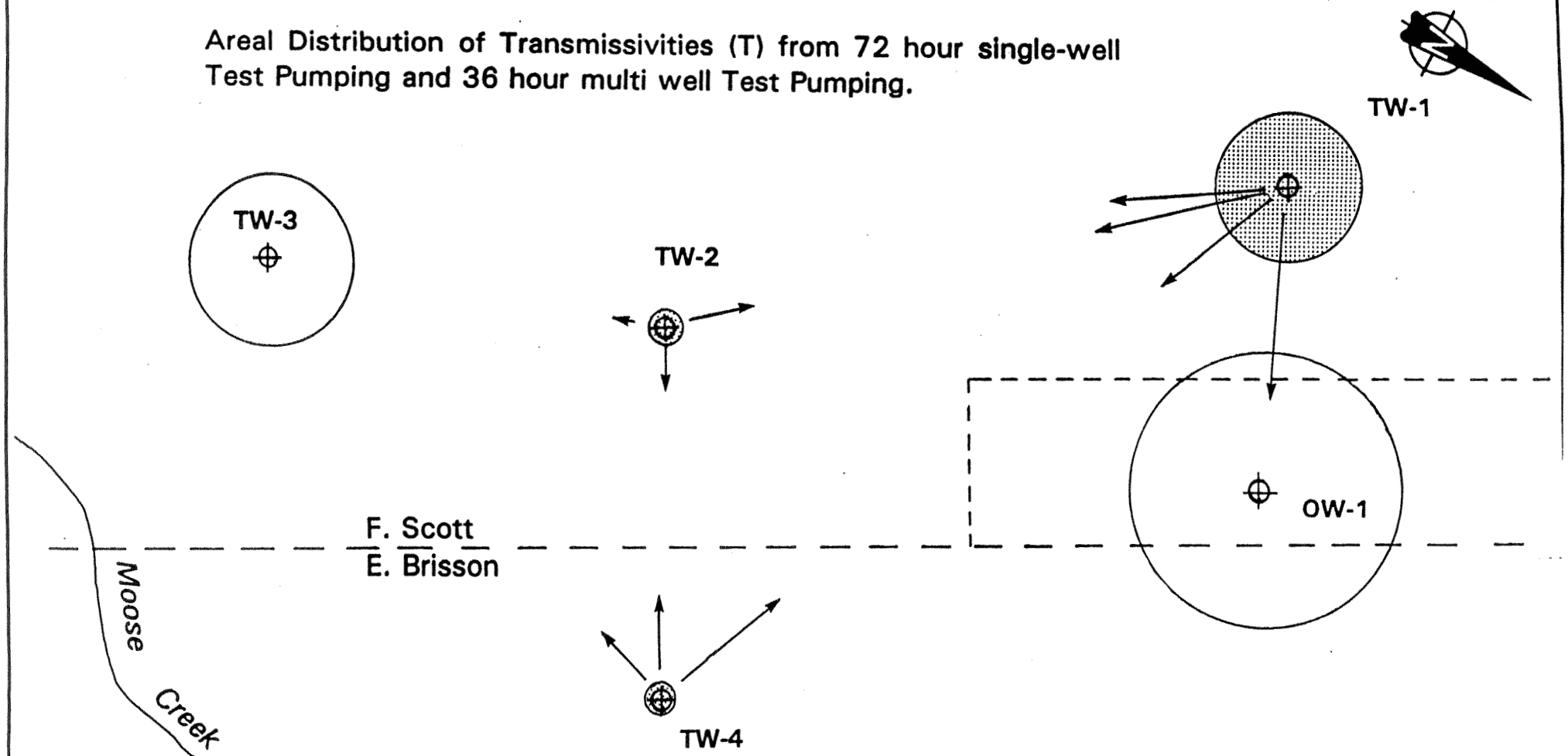
Note:

* Available drawdown in individual wells used in calculations.

** Available drawdown assumed to be 25 m.

Recycled Paper

Areal Distribution of Transmissivities (T) from 72 hour single-well Test Pumping and 36 hour multi well Test Pumping.



Well T from 72 hour single test well data (Jacob Method)
: 1 cm of radius = 100 m^2/day

Aquifer T in each direction during 72 hour single well test pumping (Jacob Method)
: 1 cm of vector = 50 m^2/day

Aquifer T in each region from 36 hour multi-well test data (Cooper-Jacob Method)
: 1 cm of radius = 100 m^2/day

Scale 1:1,250	Figure 7	
Date: 92/04/30	Dwn. By: GBB	Appd:

Jacques, Whitford Limited

If it is determined in future that a fourth well is required, it should be located in the northern portion of the well field, just east of the property owned by Mr. Fusee. If this property is acquired the well could be located next to the existing domestic well which appears to have high yield. In this case, steps should be taken to remove the existing septic tank on the site. If the property is not acquired, the domestic pump intake will have to be lowered in order to prevent well interference from interrupting the domestic water supply.

The results of the multi-well test also demonstrated the sensitivity of drawdown and the relationship of well losses to pumping rate. For example, the drawdown for well TW-4 was 24.6 m and 15.5 m at pumping rates of 327.5 m^3/day (50 igpm) in the 72 hour test (Appendix 4) and 295 m^3/day (45 igpm) in the multi-well test respectively. For a 5 igpm difference in pumping rate, an additional 9 m of drawdown was observed. This effect is attributed to a dramatic increase in well losses at the higher pumping rate. Obviously it will be desirable not to exceed a long term pumping rate of 295 m^3/day in TW-4 by more than a small amount.

The additional drawdown at higher pumping rates in the other two wells was not nearly as dramatic. Indeed, if the observed drawdowns in wells TW-1 and TW-2, when pumped at the higher rates in the 72-hour tests, are corrected for the lower rates in the multi-well test, the corrected drawdowns are equal to or slightly less than the multi-well test drawdowns. Therefore, the pumping rates for TW-1 and TW-2 in the multi-well test may be adjusted upward somewhat for short term pumping without fear of an unacceptable large drawdown.

4.3 Water Quality

During the 72-hour tests and the 36-hour multi-well testing on wells TW - 1 TW -2 and TW-4, sets of water samples were recovered from the pumped discharge for water quality testing. Samples were tested for general chemistry including bacteria and for the full suite of parameters outlined in " Table 4" of the ODWO which is required by the MOE for communal wells. The overall testing program is summarized in Table 4.2 below.

Recycled Paper

TABLE 4.2 WATER QUALITY TEST PROGRAM						
	72 hour Test				36 Hour Multi Well Test	
Test Well	General Chemistry	Time (hrs)	Table 4 ODWO	Time (hrs)	General Chemistry	Time (hrs)
TW - 1	X	3	X	72	X	36
TW - 2			X	72	X	36
TW - 3			X	72	X	36

The results of the analyses on samples recovered in the 72-hour pump tests are given in Tables 6-1 to 6-2, Appendix 6. By the end of the tests there were no parameters above the guideline limits except turbidity in TW-1 and background bacteria in TW-2. Bacteria and turbidity were tested again in the multi-well test program and results were below ODWO in all pumping wells.

H_2S was monitored in TW-1 throughout the 72-hour test. The H_2S concentration trend was similar to that noted in the 36 hour test which is described below. The concentration at the beginning of the test was above the guideline limit (0.05 mg/1) but dropped below the limit about half way through the test.

At the end of the 36 hour simultaneous test pumping of TW-1, TW-2, and TW-4, samples were taken for general chemistry and bacteria from each of the pumping wells and the results are given in Tables 6-3 to 6-5, Appendix 6. Water quality parameters monitored throughout the test consisted of H_2S, pH, electrical conductivity (EC), temperature and dissolved oxygen (DO) which are shown in Figures 8 through 12.

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The major ion chemical data which was gathered during the three 72-hour pump tests and the multi well test are shown on Figure 13. Seven sets of major ion data are included here; two each from TW-2 and TW-4 and three from TW-1. Three data sets were taken from the "Table 4" analyses from samples taken at the end of each 72 hour test. The "Table 4" suite of parameters does not normally include CA, Mg, Na or K but the lab must analyze for these in order to determine total dissolved solids (TDS) concentration. The lab was contacted and these parameters were given to us and hence, the numbers do not appear in the "Table 4" results contained in Appendix 6.

Figures 8 through 13 show distinct trends and distinct differences in water chemistry among samples. In particular, they clearly show two different groundwater sources: one which supplies TW-1 and the other which supplies both TW-2 and TW-4.

The major ion chemistry for waters from TW-1 is dominated by Ca^{2+} and HCO_3-. SO_4^{2-} is also elevated but the amount of NaCl dissolved in the water is relatively low. Figure 13 shows the equivalence concentration of Na^+ to be 2.5 to 4.5 times higher than that of Cl^- which suggests a degree of ion exchange.

The temporal water quality data gathered during the 36 hour test for TW-1 shows the following trends:

- H_2S above the guideline limit of 0.05 mg/l but dropping below detection by 18 hours (Figure 8).

- pH which is fairly constant, averaging 7.55.

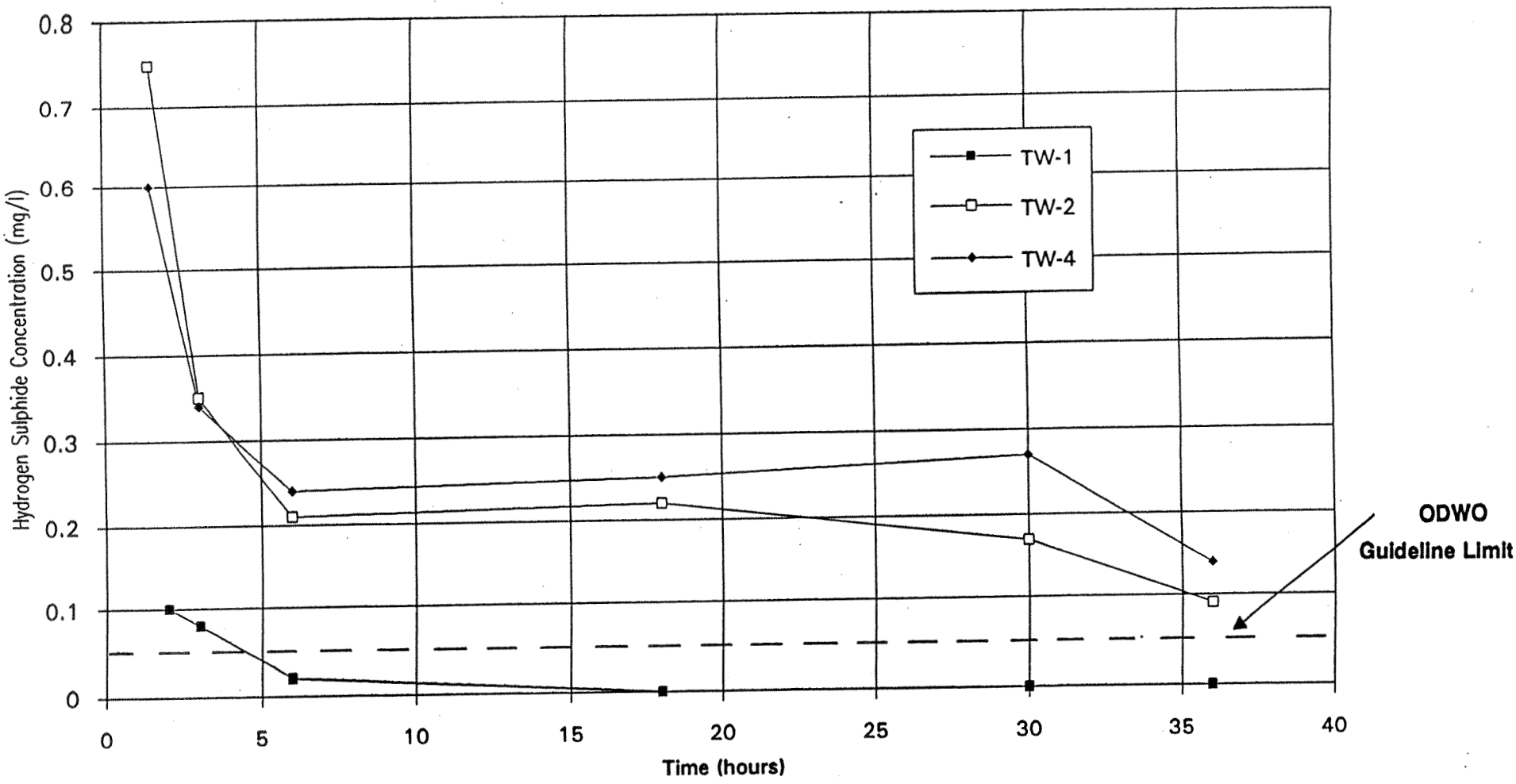
- Temperature climbs from 7°C after 1 hour to >8.5°C after 36 hours (Figure 11). This could be a result of drawing water from part of the formation where exothermic reactions are taking place but is more likely due to drawing water from a deeper source.

- EC (Figure 10) is the highest of the three wells and climbs from 482 uS/cm at one (1) hour to 543 μS/cm after 36 hours. This is the equivalent of an increase in TDS of approximately 25 mg/l.

- Dissolved oxygen Figure 12 is generally the lowest of the three wells but the significance of this is unknown.

Recycled Paper

Hydrogen Sulphide Concentration During 36-Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4



ODWO = Ontario Drinking Water Objectives

Figure 8

pH During 36-Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4

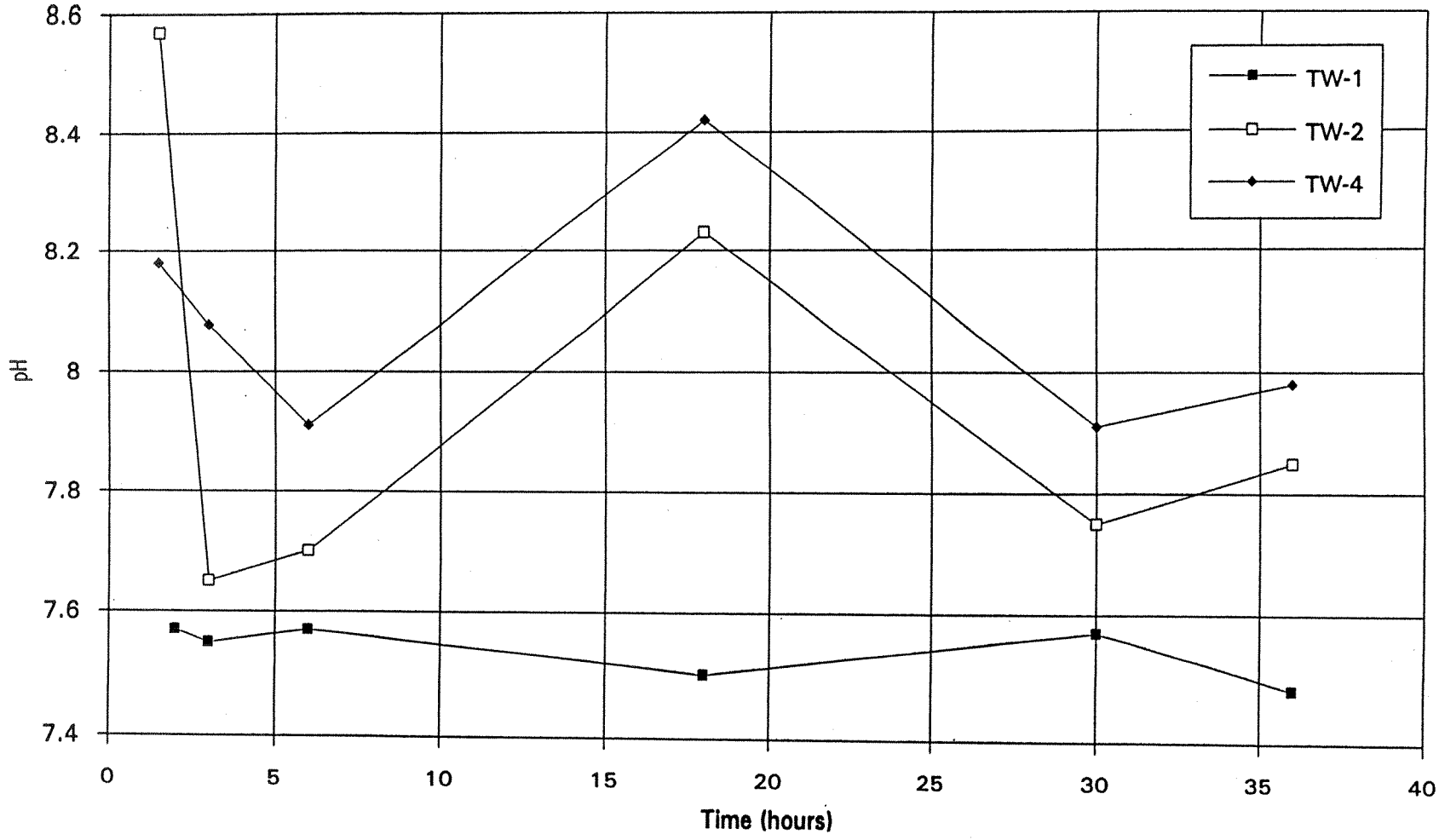


Figure 9

Electrical Conductivity During 36-Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4

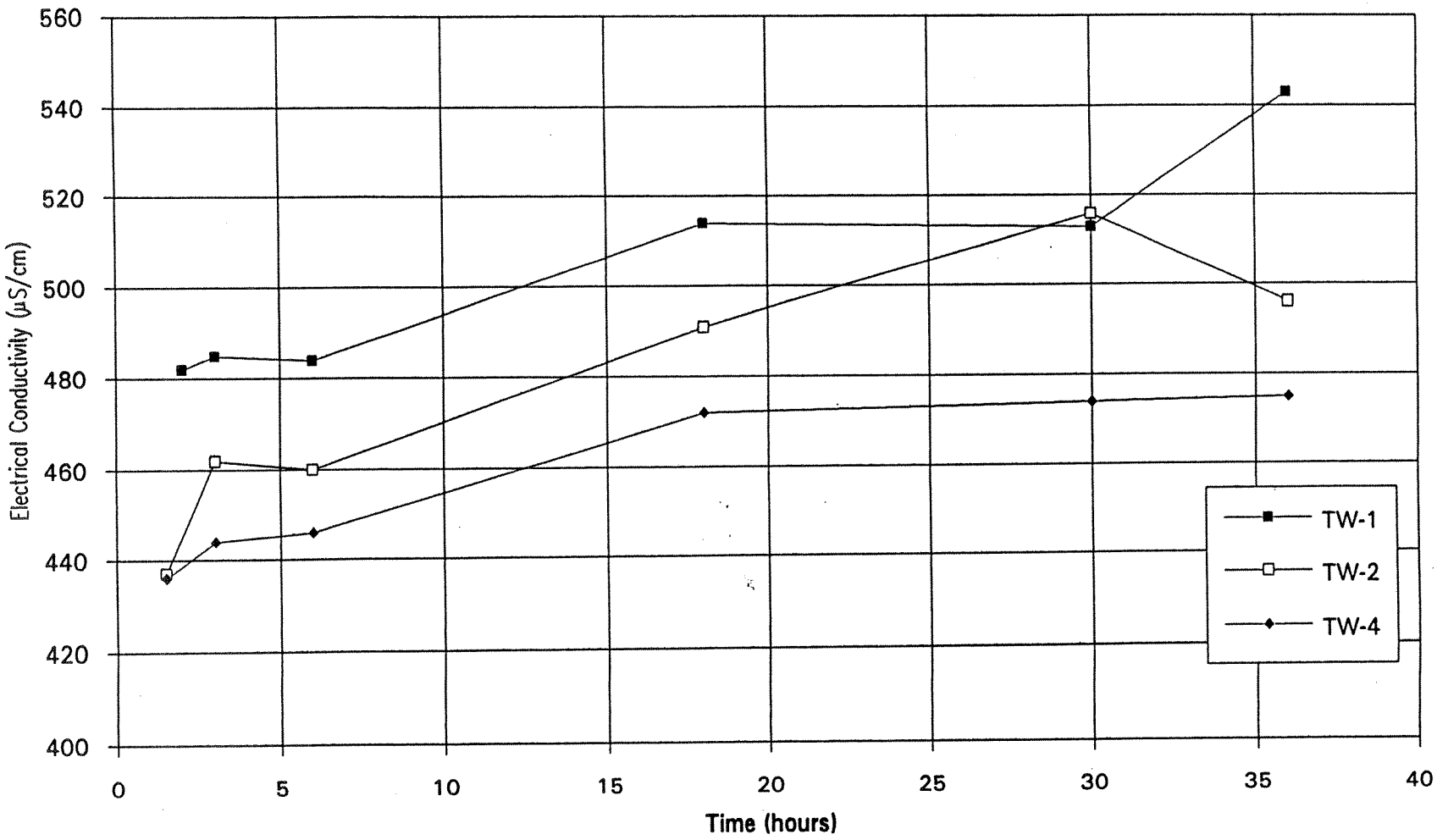


Figure 10

Temperature During 36-Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4

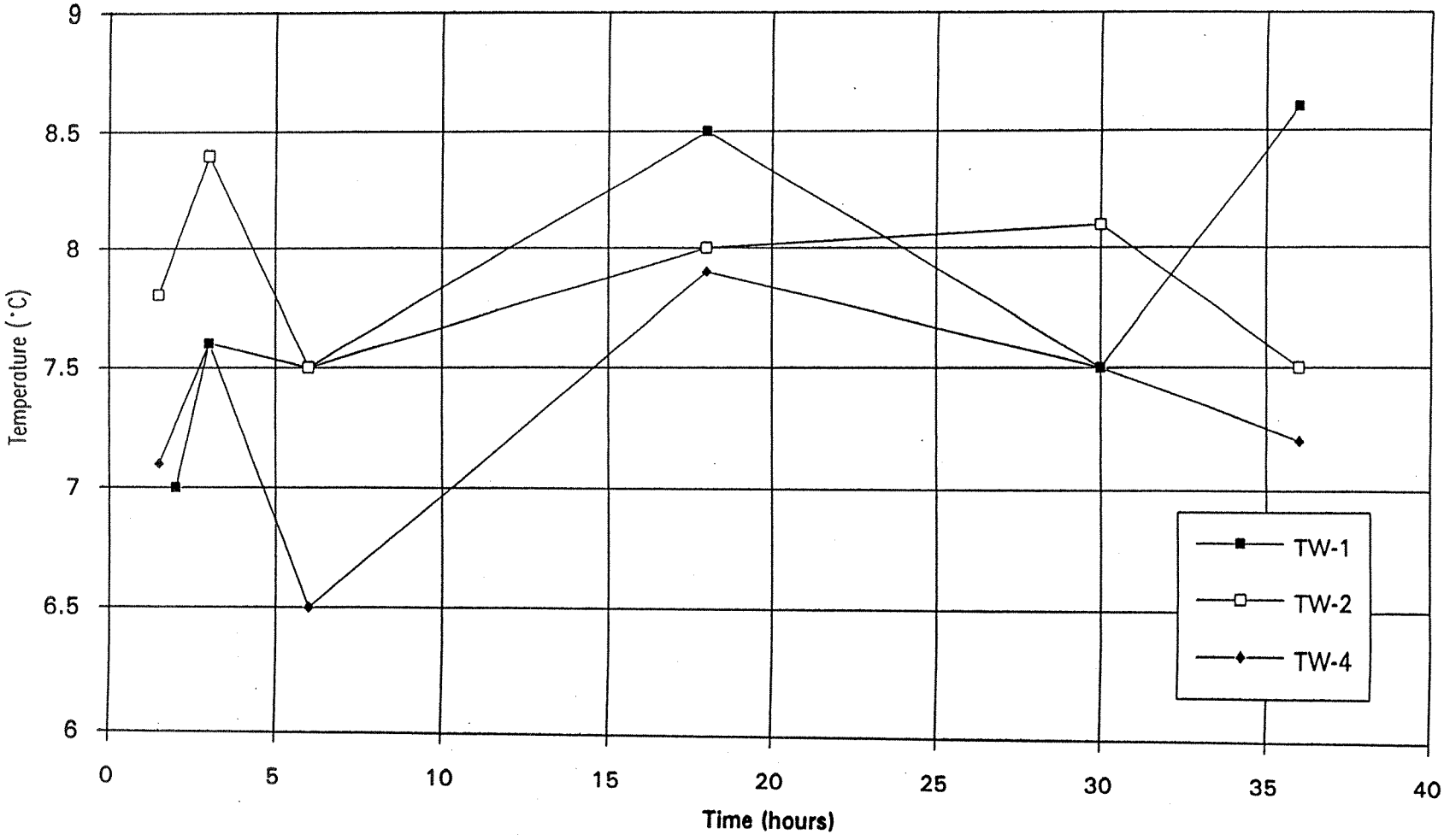


Figure 11

Dissolved Oxygen During 36-Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4

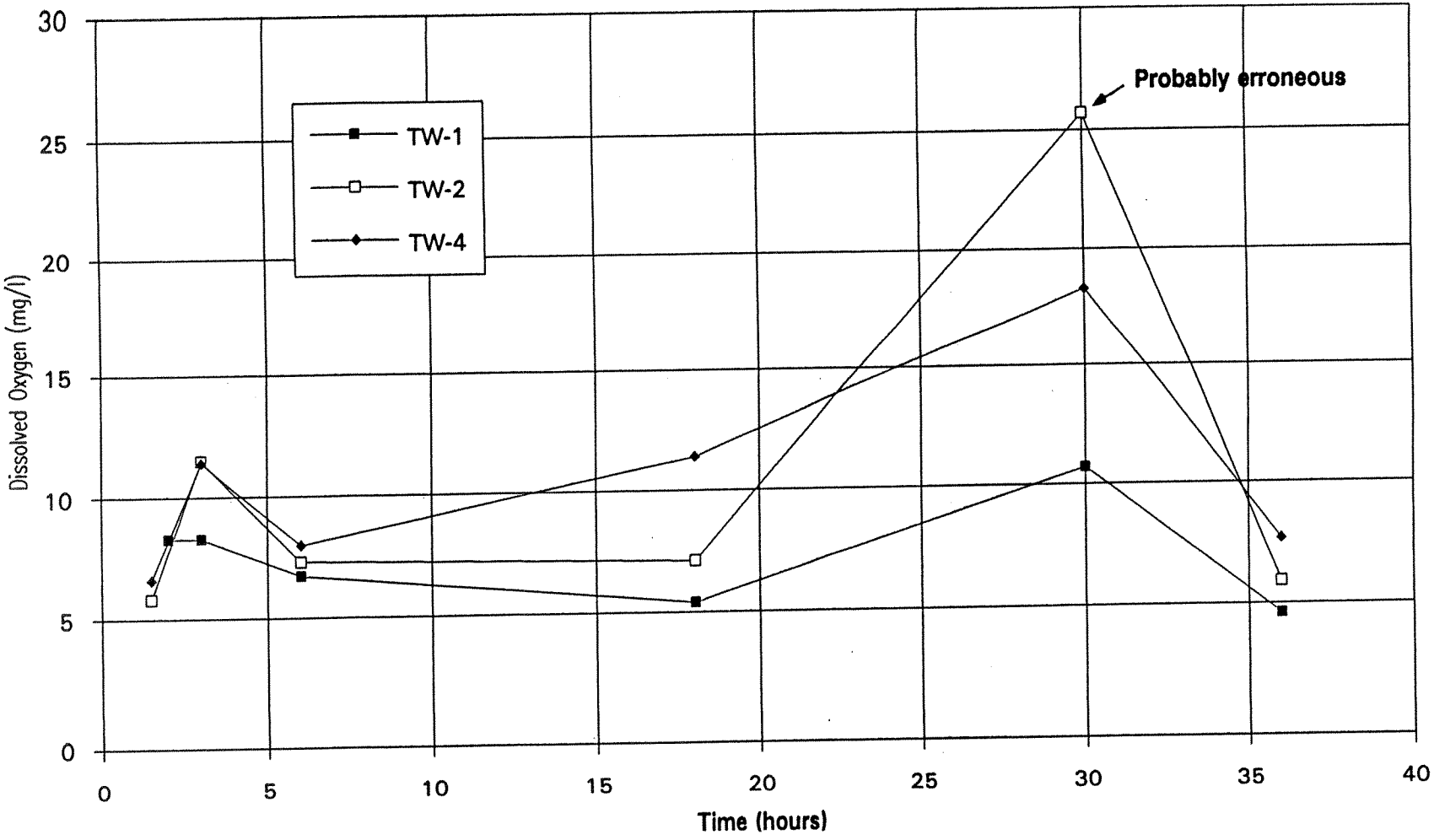
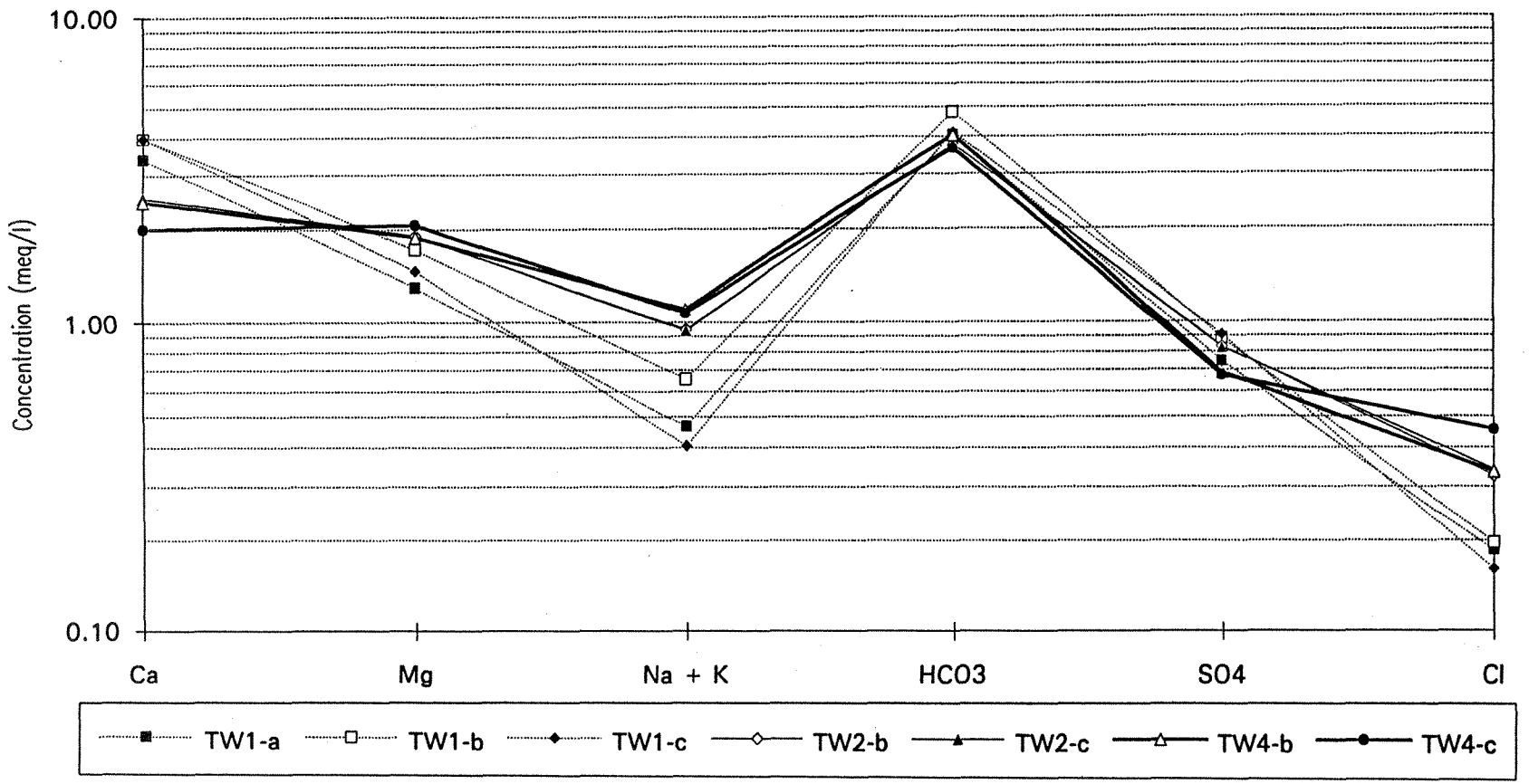


Figure 12

Major Ion Concentrations in Water Samples From TW-1, TW-2 and TW-4



Test well (TW) numbers followed by:

(a) were sampled 3 hours after the beginning of their respective 72 hour tests.
(b) were sampled 72 hours after the beginning of their respective 72 hour tests.
(c) were sampled 36 hours after the beginning of their respective 36 hour multi-well test.

Figure 13

The major ion chemistry and temporal water quality changes in TW-2 and TW-4 show close similarities. The major ion data indicates water which is dominated by Mg^{2+} but, on the whole with a smaller component of dissolved limestone and a larger component of dissolved NaCl than did TW-1. However, excess Na^{+} with respect to Cl^{-} again indicates ion exchange.

Throughout the 36 hour test H_2S, pH, EC, temperature and DO all simultaneously fluctuate in water from wells TW-2 and TW-4. The similarity in trends is so great that they are dealt with below as one water type. The trends are as follows:

- H_2S is very high but drops throughout the test from greater than 0.6 to around 0.1 mg/l. This is still twice the ODWO limit.

- pH is fairly high throughout the test but fluctuates within a range of about 0.5 pH units. The mean pH of both is about 8.0 and, although they fluctuate together, water from TW-4 has consistently higher pH.

- EC increases in both TW-2 and TW-4 throughout the test as it did with TW-1.

- The temperature fluctuates together in the two wells during pumping within the range of 1.5°C but does not show an increasing or decreasing trend.

- DO is generally higher than in water from TW-1 but, again the significance of this is not known.

- In all parameters, TW-2 has intermediate values between TW-1 and TW-4, indicating a larger component of flow from the northern zone in TW-2 than in TW-4.

The evidence for ion exchange suggests moderately long term contact with the host formation shales. The Ca^{2+} and Mg^{2+} in water are exchanged for Na^{+} in the rock in a natural water softening process. The low Cl^{-} indicates a low degree of NaCl in the water, and this coupled with the evidence for ion exchange suggests that the salt present is likely from natural sources.

At the end of the 36 hour test pumping, the sodium was slightly above the ODWO guideline limits in TW-4 and slightly below in TW-2. This should not be a problem in the water supply because mixing with water from TW-1, which has lower sodium, should result in water which is below the limit with respect to sodium. This should be confirmed by testing following start-up of the communal supply.

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Turbidity and colour exceeded ODWO in the 72-hour test for TW-1. However, levels of these parameters decreased with pumping time. Water samples taken at the end of the 36-hour multi-well test showed these parameters to be below ODWO. It is commonly observed that these parameters decrease with development time, therefore, the initial high readings should not be a concern.

The concentration of iron was 0.96 mg/L at the end of the 72-hour test for TW-1, which is about three times higher than the ODWO. However, following completion of the 36-hour multi-well test, which removed a considerable volume of water from the aquifer, the concentration was 0.22 mg/L which is less than the ODWO of 0.3 mg/L. Since iron is an aesthetic parameter, and based on the acceptable iron levels in the multi-well test, iron treatment is not considered necessary.

Background bacteria was too numerous to count (TNTC) for the 72-hour sample recovered from TW-2, but bacteria counts as a whole were acceptable following the 36-hour multi-well test. It is suspected that the TNTC result reflected a sample contaminated by handling.

Phenols exceeded ODWO in samples taken from TW-2 and TW-4 following completion of the multi-well test. This is likely an organic source commonly found in shale and shaley limestone bedrock which was observed in the test wells. Sodium concentrations higher than chloride concentrations suggest relatively long residence time of the pumped water. Therefore, the slightly elevated phenols are unlikely to be indicative of surface contamination.

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5.0 CONCLUSIONS AND RECOMMENDATIONS

The communal well investigation consisted of drilling four (4) test wells. Three (3) of these wells, TW-1, 2 and 4 were reamed and gravel packed to be used as production wells. This was followed by 72 hour pumping tests on each well and a 36 hour multi-well pumping test of TW-1, TW-2 and TW-4 at a combined rate of 140 igpm (917 m^3/day). Water quality was analyzed in the 72-hour and 36-hour multi-well tests. In the 72-hour pumping tests, samples were tested for general water chemistry and for "Table 4" of the Ontario Drinking Water Objective (ODWO) Guidelines. In the multi-well test, samples were taken at the end of the 36-hour test from each of the pumping wells and were analyzed for general water chemistry. During the 36-hour test, the discharge from each well was monitored for hydrogen sulphide (H_2S), electrical conductivity (EC), pH, temperature and dissolved oxygen (DO).

Pumping test and water quality data show clearly that there are two main "zones" in the aquifer underlying the well field. These are referred to as the northern and southern zones. Both zones are portions of a fractured rock aquifer and there is relatively poor connection between them. The production wells TW-2 and TW-4 and the observation well TW-3 are located in the southern zone. The production well TW-1 and observation well OW-1 are located in the northern zone. The northern zone is characterized by high transmissivity and water quality which is good with all parameters meeting ODWO guidelines. The southern zone has lower transmissivity and distinctly different water chemistry.

The pumping tests and water quality analyses point to the following conclusions and recommendations:

- TW-1 has a well transmissivity of about 115 m^2/day but low efficiency. It is capable of producing an individual long-term safe yield of approximately 168 igpm (1,090 m^3/day). The safe yield assumes 17.1 m of available drawdown and no major boundary conditions.

- TW-2 and TW-4 have well transmissivities in the order of 20 to 30 m^2/day. However, aquifer transmissivities, calculated from observation well data in the 72-hour pump tests ranged from 37 m^2/day to 123 m^2/day in the area of TW-2, TW-3 and TW-4.

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- The three production wells have a collective 20 year safe yield of 140 igpm (906 m^3/day). The recommended pumping rates for TW-1, TW-2 and TW-4 are 294 m^3/day (46 igpm), 306 m^3/day (47 igpm) and 306 m^3/day (47 igpm) respectively.

- The wells will sustain a collective pumping rate of 970 m^3/day (150 igpm) for 8 hours continuously although the margin of safety will be small. A minor boundary condition was detected in the TW-1 data in the last 12 hours of the multi-well pumping test. If this condition continues to develop without compensating recharge, the 8 hour continuous pumping rate may have to be decreased.

- Water quality in TW-1 is good and all parameters passed the ODWO guideline limits at the end of multi-well test. TW-2 and TW-4 also have good water quality with the exception of sodium and H_2S. Sodium is slightly above the limit in TW-4 and slightly below in TW-2 but when mixed with water from TW-1 in the distribution system the result should be below the limit. H_2S was high in both TW-2 and TW-4 although it dropped throughout the test. By the end of the 36 hour test it was still twice the ODWO limit. The water will likely have to be treated to lower this level. Chlorination will oxidize H_2S and may be sufficient to lower it to acceptable limits. Phenols were slightly above ODWO in TW-2 and TW-4 but it is concluded that phenols are naturally occurring and that since this is an aesthetic parameter, no additional treatment is required.

- Long term aquifer safe yield has been calculated for the northern and southern zones in the aquifer using data from the multi-well test. The transmissivity of the southern zone is 129 m^2/day which is somewhat higher than values obtained from the earlier test pumping of TW-2 and TW-4. The transmissivity of the northern zone is 215 m^2/day which is also higher than previously calculated from 72-hour test data. Based on this information, at least one more well of similar yield could be added to the well field without over-pumping the aquifer. If another well is added, it should be put in the north-east corner of the well field, preferably on the eastern side of the domestic well shown on Figure 2.

- The high transmitting capacity of the aquifer and low storage will likely result in a wide area of influence for the well field. Assuming an average daily demand of 50 igpm (327 m^3/day) and low infiltration factor of 15% of annual precipitation, the area needed to recharge the well field will be less than one square kilometre.

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- Low efficiencies were calculated for the three production wells. Efficiencies of 23%, 40% and 55% were calculated for TW-1, TW-4 and TW-2 respectively. The relatively higher efficiencies of TW-2 and TW-4 are due to the fact that the aquifer, at these locations, can only deliver marginally more water than what was being pumped. The lower efficiency of TW-1 is due to the fact that the aquifer can deliver considerably more water than can be pumped from TW-1 because of the necessity of having to stabilize the formation by gravel packing. Efficiencies can be improved significantly in these wells by lowering the pumping rate a relatively small amount. Low efficiencies can lead to increased pumping costs.

- It is understood that the expected average and maximum daily demands are 314 m^3/day (48.5 igpm) and 861 m^3/day (133 igpm) respectively. The yield from the three production wells exceed these demands by approximately 300% and 12% respectively. It is clear though that a fourth well will be required if additional significant demands such as from a new residential subdivision are to be satisfied by the communal well system.

- In light of the low margin of safety in maximum pumping rates and the low well efficiencies, it is recommended that calculations be done to determine the cost effectiveness of drilling a fourth production well in the well field. It may be possible to recover drilling costs in a few years of operation because of the decreased pumping costs associated with lower drawdowns and greater efficiencies.

- If the neighbouring property owned by Mr. Fusee is not acquired, steps will need to be taken to lower his pump intake. The existing domestic well on that property is approximately 20 m deep but the pump intake is only 6 m from surface. During the 36 hour multi-well test, the water level dropped to within 30 cm of the intake. If the property is acquired, the existing septic tank should be removed.

- Land use restrictions will need to be considered in the regions surrounding the well field.

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TW 3

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Ontario

TW III.

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON	BLOCK, TRACT, SURVEY ETC	LOT
STORMONT	ROXBOROUGH	6	PART	19

OWNER (SURNAME FIRST)	ADDRESS	DATE COMPLETED
SCOTT F	MOOSE CREEK	DAY 19 MO AUG YR 90

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
BROWN	SAND			0	6
GREY	FINE SAND			6	46
GREY	LIMESTONE				103

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
53	☒ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
103	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS

CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
6¼	☒ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	188	0	47
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN FEET

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
		3 BAGS HIGH EARLY

PUMPING TEST

PUMPING TEST METHOD	PUMPING RATE	DURATION OF PUMPING
☒ PUMP ☐ BAILER	25 GPM	1 HOURS ___ MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING ☐ PUMPING ☐ RECOVERY			
		15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
FEET	FEET	FEET	FEET	FEET	FEET

IF FLOWING, GIVE RATE	PUMP INTAKE SET AT	WATER AT END OF TEST
GPM	FEET	☐ CLEAR ☐ CLOUDY

RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING	RECOMMENDED PUMPING RATE
☐ SHALLOW ☐ DEEP	FEET	25 GPM

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.

DRILLERS REMARKS

100564

FINAL STATUS OF WELL	☒ WATER SUPPLY ☐ OBSERVATION WELL ☒ TEST HOLE ☐ RECHARGE WELL	☐ ABANDONED, INSUFFICIENT SUPPLY ☐ ABANDONED, POOR QUALITY ☐ UNFINISHED ☐ DEWATERING
WATER USE	☐ DOMESTIC ☐ STOCK ☐ IRRIGATION ☐ INDUSTRIAL	☐ COMMERCIAL ☐ MUNICIPAL ☐ PUBLIC SUPPLY ☐ COOLING OR AIR CONDITIONING ☐ OTHER TEST DRILLING ☐ NOT USED
METHOD OF CONSTRUCTION	☐ CABLE TOOL ☐ ROTARY (CONVENTIONAL) ☐ ROTARY (REVERSE) ☒ ROTARY (AIR) ☐ AIR PERCUSSION	☐ BORING ☐ DIAMOND ☐ JETTING ☐ DRIVING ☐ DIGGING ☐ OTHER

CONTRACTOR

NAME OF WELL CONTRACTOR	WELL CONTRACTOR'S LICENCE NUMBER
MALOUGHNEY WATER WELL DRILLING	3701

ADDRESS	
1110 FISHER AVE	OTTAWA

NAME OF WELL TECHNICIAN	WELL TECHNICIAN'S LICENCE NUMBER
J. MALOUGHNEY	70584

SIGNATURE OF TECHNICIAN/CONTRACTOR	SUBMISSION DATE
	DAY 19 MO AUG YR 90

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Ontario

The Ontario Water Resources Act

WATER WELL RECORD

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COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON	BLOCK	TRACT, SURVEY, ETC	LOT
Stormont	Roxborough	Con. 6			PL-19

OWNER (SURNAME FIRST): Jacques Whitford Ltd.
ADDRESS: Unit C20-2285 St.Laurent Blv.OTTAWA
DATE COMPLETED: DAY 16 MO 04 YR 91

16" X 8" GRAVEL PACK WELL (MOOSE CREEK ONT.)

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
Black	Top Soil			0'	2'
Grey	Quick Sand			2'	41'
Black	Fracture bedrock shales			41'	53'
Dark Grey	Shales			53'	105'

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER	
45'	☒ FRESH ☐ SALTY	☐ SULPHUR ☐ MINERALS ☐ GAS
85'	☒ FRESH ☐ SALTY	☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY	☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY	☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY	☐ SULPHUR ☐ MINERALS ☐ GAS

CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
17½"	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☒ OPEN HOLE ☐ PLASTIC		0'	53'
16"	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC		53'	105'
8"	☒ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	.188	+ 2'	105'

SCREEN

SIZE-SLOT OF OPENING (SLOT NO.): 100 slot
DIAMETER: 8" INCHES
LENGTH: 10' FEET
MATERIAL AND TYPE: Stainless Steel Screen
SETTING FROM WELL TOP: 82'
SLOT # 5' @ 100' FEET

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

PUMPING TEST

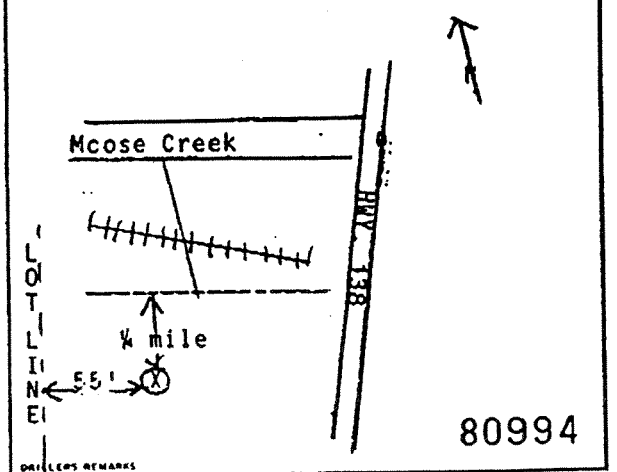
PUMPING TEST METHOD: ☒ PUMP ☐ BAILER
PUMPING RATE: 50 GPM
DURATION OF PUMPING: 72 HOURS
STATIC LEVEL: .41m FEET
WATER LEVEL END OF PUMPING: 26.10m FEET
WATER LEVELS DURING: ☐ PUMPING ☐ RECOVERY

10 MINUTES	20 MINUTES	45 MINUTES	60 MINUTES
22.75m FEET	23.39m FEET	23.78m FEET	23.89m FEET

IF FLOWING GIVE RATE: GPM
PUMP INTAKE SET AT: 96' FEET
WATER AT END OF TEST: ☒ CLEAR ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☒ DEEP
RECOMMENDED PUMP SETTING: 96' FEET
RECOMMENDED PUMPING RATE: 50 GPM

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW



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DRILLERS REMARKS:

FINAL STATUS OF WELL	☒ WATER SUPPLY ☐ OBSERVATION WELL ☐ TEST HOLE ☐ RECHARGE WELL ☐ ABANDONED INSUFFICIENT SUPPLY ☐ ABANDONED POOR QUALITY ☐ UNFINISHED ☐ DEWATERING
WATER USE	☐ DOMESTIC ☐ STOCK ☐ IRRIGATION ☐ INDUSTRIAL ☐ OTHER ☒ COMMERCIAL ☐ MUNICIPAL ☐ PUBLIC SUPPLY ☐ COOLING OR AIR CONDITIONING ☐ NOT USED
METHOD OF CONSTRUCTION	☐ CABLE TOOL ☐ ROTARY (CONVENTIONAL) ☐ ROTARY (REVERSE) ☒ ROTARY (AIR) ☐ AIR PERCUSSION ☐ BORING ☐ DIAMOND ☐ JETTING ☐ DRIVING ☐ DIGGING ☐ OTHER

CONTRACTOR

NAME OF WELL CONTRACTOR: OLYMPIC DRILLING CO.LTD.
WELL CONTRACTOR'S LICENCE NUMBER: 4006
ADDRESS: Box 9180 OTTAWA, Ont. K1G 3T9
NAME OF WELL TECHNICIAN: WAYNE RENWICK
WELL TECHNICIAN'S LICENCE NUMBER: TO-327
SIGNATURE OF TECHNICIAN/CONTRACTOR: W.D. Renwick (Sec.)
SUBMISSION DATE: DAY 22 MO 04 YR 91

CONTRACTOR'S COPY

OFFICE USE ONLY

FORM NO. 0506 (11/86) FORM 9

TABLE 2-1: PUMPING TEST SUMMARY

TEST WELL TW 1, Moose Creek, Ontario

Test Conducted By:	Jacques Whitford Environment Limited
Pumping Began:	November 6, 1991 @ 10:00 a.m.
Pumping Ended	November 8, 1991 @ 10:00 a.m. (72 hours)
Recovery Began:	November 8, 1991 @ 10:00 a.m.
Recovery Ended:	November 8, 1991 @ 12:10 p.m. (2 hours, 10 minutes)

Well Data

Elevation (Assumed):	84 m	(TOC)
Depth:	30.5 m	
Casing Length:	31.7 m	
Diameter:	200 mm	
Driller:	Olympic Drilling Co. Ltd.	
Pump Type:	40 h.p. Submersible	
Pump Setting:	25.9 m	
Static Water Level (from TOC):	3.91 m	
Casing Stickup:	1.20 m	
Available Drawdown:	17.1 m	
Recorded Drawdown:	14.30 m	
Pumping Rate (avg.):	360 m3/day	

Lithology

0 m - 0.6 m - Topsoil
0.6 m - 12.2 m - Grey clay with silt and sand
12.2 m - 12.7 m - Fractured Shale
12.7 m - 30.5 m - Shale and shaley limestone

Chemical Analyses

General analyses and bacteria at 3 hours, Table 4 (ODWO) at 72 hours

Observation Wells

OW 1	r = 70 m	depth = 19.8 m	(1.66 m drawdown)
TW 2	r = 145 m	depth = 30.8 m	(1.67 m drawdown)
TW 3	r = 218 m	depth = 31.4 m	(1.62 m drawdown)
TW 4	r = 169 m	depth = 32.0 m	(1.59 m drawdown)

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TABLE 2-2: FIELD PUMP TEST INFORMATION

Pumping TW 1

Well No:	TW 1	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	25.9 m
Date:	November 6 to 8, 1991	Static Water Level:	3.91 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
0		3.91	0.00			360
1		17.30	13.39			
2		23.00	19.09			
3		20.85	16.94			
4		19.13	15.22			
5		18.38	14.47			
6		18.09	14.18			
7		18.02	14.11			
8		17.98	14.07			
10		17.81	13.90			
12		17.61	13.70			
14		17.49	13.58			
16		17.53	13.62			
18		17.56	13.65			
20		17.63	13.72			
25		17.45	13.54			
30		16.29	12.38			
35		16.95	13.04			
40		16.95	13.04			
50		16.97	13.06			
60		16.99	13.08			
75		17.23	13.32			
90		17.12	13.21			
120		17.21	13.30			
150		17.29	13.38			
180		17.36	13.45			
240		17.39	13.48			
300		17.42	13.51			
360		17.48	13.57			
420		17.51	13.60			
480		17.45	13.54			
540		17.53	13.62			
600		17.55	13.64			
660		17.60	13.69			
720		17.63	13.72			
840		17.65	13.74			
960		17.63	13.72			

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TABLE 2-2: FIELD PUMP TEST INFORMATION (con't)

Pumping TW 1

Well No:	TW 1	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	25.9 m
Date:	November 6 to 8, 1991	Static Water Level:	3.91 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
1080		17.60	13.69			
1200		17.58	13.67			
1320		17.60	13.69			
1440		17.70	13.79			
1560		17.68	13.77			
1680		17.91	14.00			
1800		17.88	13.97			
1920		17.80	13.89			
2040		17.60	13.69			
2160		17.50	13.59			
2280		18.27	14.36			
2400		18.23	14.32			
2520		18.21	14.30			
2640		18.17	14.26			
2760		18.35	14.44			
2880		18.52	14.61			
3000		18.45	14.54			
3120		18.35	14.44			
3240		18.47	14.56			
3360		18.37	14.46			
3480		18.44	14.53			
3600		18.58	14.67			
3720		18.51	14.60			
3840		18.45	14.54			
3960		18.45	14.54			
4080		18.45	14.54			
4200		18.45	14.54			
4320		18.25	14.34			

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TABLE 2-2: FIELD PUMP TEST INFORMATION (con't)

Pumping TW 1

Well No:	TW 1	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	25.9 m
Date:	November 6 to 8, 1991	Static Water Level:	3.91 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
4321	1	11.12		7.21	4321	
4322	2	8.70		4.79	2161	
4323	3	7.31		3.40	1441	
4324	4	6.50		2.59	1081	
4325	5	5.96		2.05	865	
4326	6	5.64		1.73	721	
4327	7	5.44		1.53	618	
4328	8	5.36		1.45	541	
4329	9	5.30		1.39	481	
4330	10	5.25		1.34	433	
4332	12	5.23		1.32	361	
4334	14	5.17		1.26	310	
4336	16	5.14		1.23	271	
4338	18	5.12		1.21	241	
4340	20	5.10		1.19	217	
4345	25	5.03		1.12	174	
4355	35	5.00		1.09	124	
4360	40	4.93		1.02	109	
4365	45	4.90		0.99	97	
4370	50	4.87		0.96	87	
4375	55	4.86		0.95	80	
4380	60	4.83		0.92	73	
4410	90	4.73		0.82	49	
4440	120	4.66		0.75	37	
4450	130	4.63		0.72	34	

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TABLE 2-3: PUMP TEST ANALYSIS

Pumping TW 1

Calculation of Transmissivity from Pump Test Curves (Jacob Straight Line Method)

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown (early)	-	360	14.67	24.5	-
Drawdown (late)	0.30	360	14.67	24.5	219.6
Recovery (early)	0.33	360	-	-	199.7
Recovery (late)	6.6	360			10.0

Calculation of Safe Yields from Transmissivities

	T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
Maximum T	219.6	6.5*	792.3	121.2
Minimum T	10.0	17.1	94.7	14.5
Average T	114.8	17.1	1089.5	166.7

6.5* = Available drawdown after well loss

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Figure 2-1

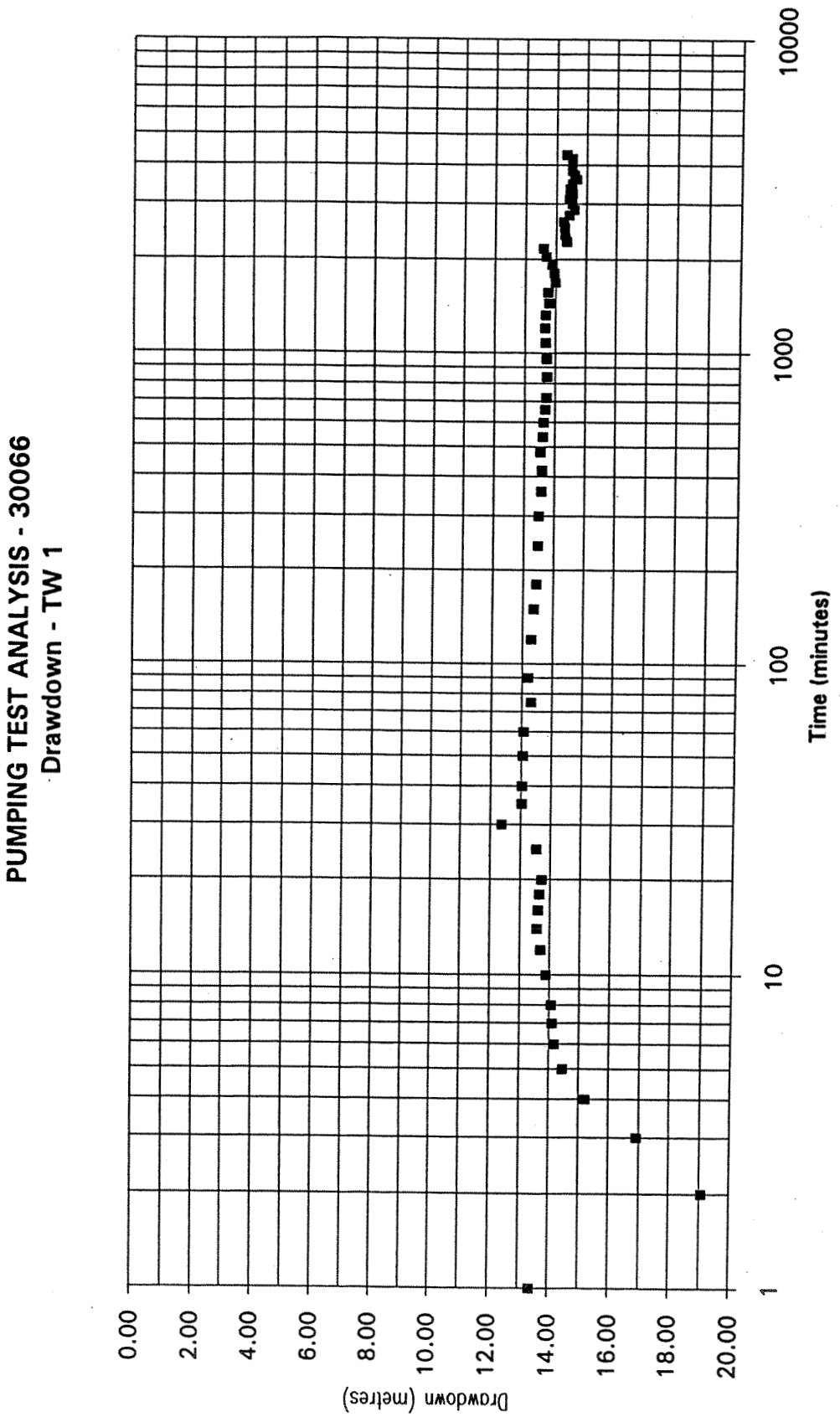
PUMPING TEST ANALYSIS - 30066
Drawdown - TW 1
Drawdown (metres)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
1
10
100
1000
10000
Time (minutes)

Figure 2-2

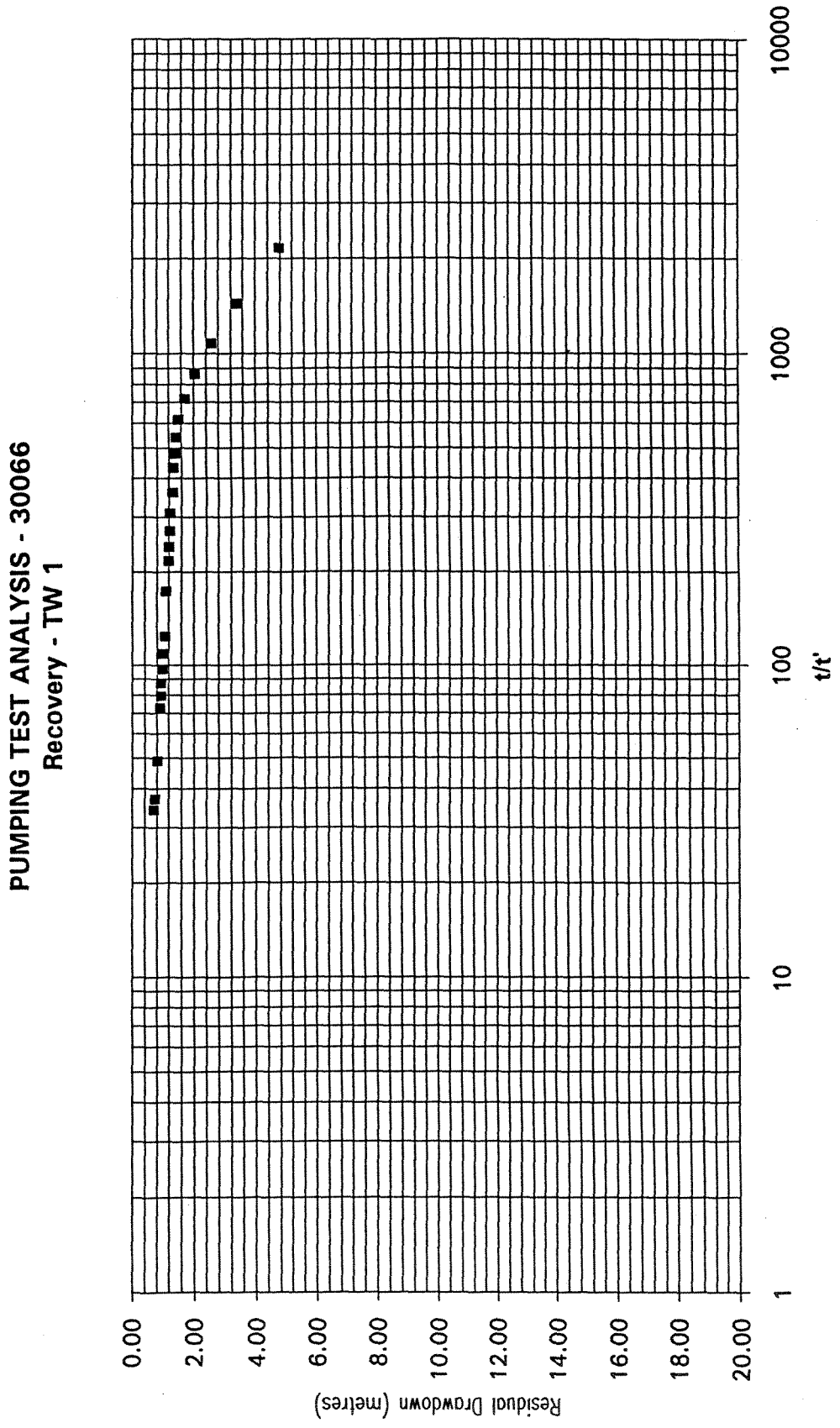
PUMPING TEST ANALYSIS - 30066
Recovery - TW 1
Residual Drawdown (meters)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
1
10
100
1000
10000
t/t'

TABLE 2-4: FIELD PUMP TEST INFORMATION

Observation Well OW 1, Pumping TW 1

Well No:	OW 1	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Distance:	70 m
Date:	November 6 to 8, 1991	Static Water Level:	2.38 m

Time (min)	W.L. (m)	Drawdown (m)
0	2.38	0.00
70	3.25	0.87
133	3.33	0.95
192	3.41	1.03
254	3.46	1.08
315	3.50	1.12
374	3.54	1.16
446	3.56	1.18
495	3.57	1.19
560	3.60	1.22
618	3.67	1.29
678	3.67	1.29
727	3.69	1.31
850	3.68	1.30
970	3.69	1.31
1090	3.71	1.33
1210	3.75	1.37
1338	3.75	1.37
1455	3.76	1.38
1575	3.77	1.39
1695	3.80	1.42
1815	3.80	1.42
1935	3.82	1.44
2042	3.84	1.46
2044	3.83	1.45
2164	3.85	1.47
2284	3.91	1.53
2404	3.90	1.52
2524	3.90	1.52
2644	3.89	1.51
2760	3.90	1.52
2895	3.93	1.55
3015	3.93	1.55
3140	3.94	1.56
3243	3.97	1.59
3375	3.97	1.59

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TABLE 2-4: FIELD PUMP TEST INFORMATION(con't)

Observation Well OW 1, Pumping TW 1

Well No:	OW 1	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Distance:	70 m
Date:	November 6 to 8, 1991	Static Water Level:	2.38 m

Time (min)	W.L. (m)	Drawdown (m)
3482	3.98	1.60
3602	3.89	1.51
3722	3.95	1.57
3842	4.01	1.63
3962	4.02	1.64
4082	4.03	1.65
4202	4.05	1.67
4305	4.04	1.66

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TABLE 2-5: PUMP TEST ANALYSIS
Observation Well OW 1, Pumping TW 1

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown	0.38	360.00	1.66	-	175.73

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
175.73	7.03E-04	70.00	5.67E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
175.73	25.00	2438.30	372.48

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PUMPING TEST ANALYSIS - 30066
Drawdown OW 1, Pumping TW 1

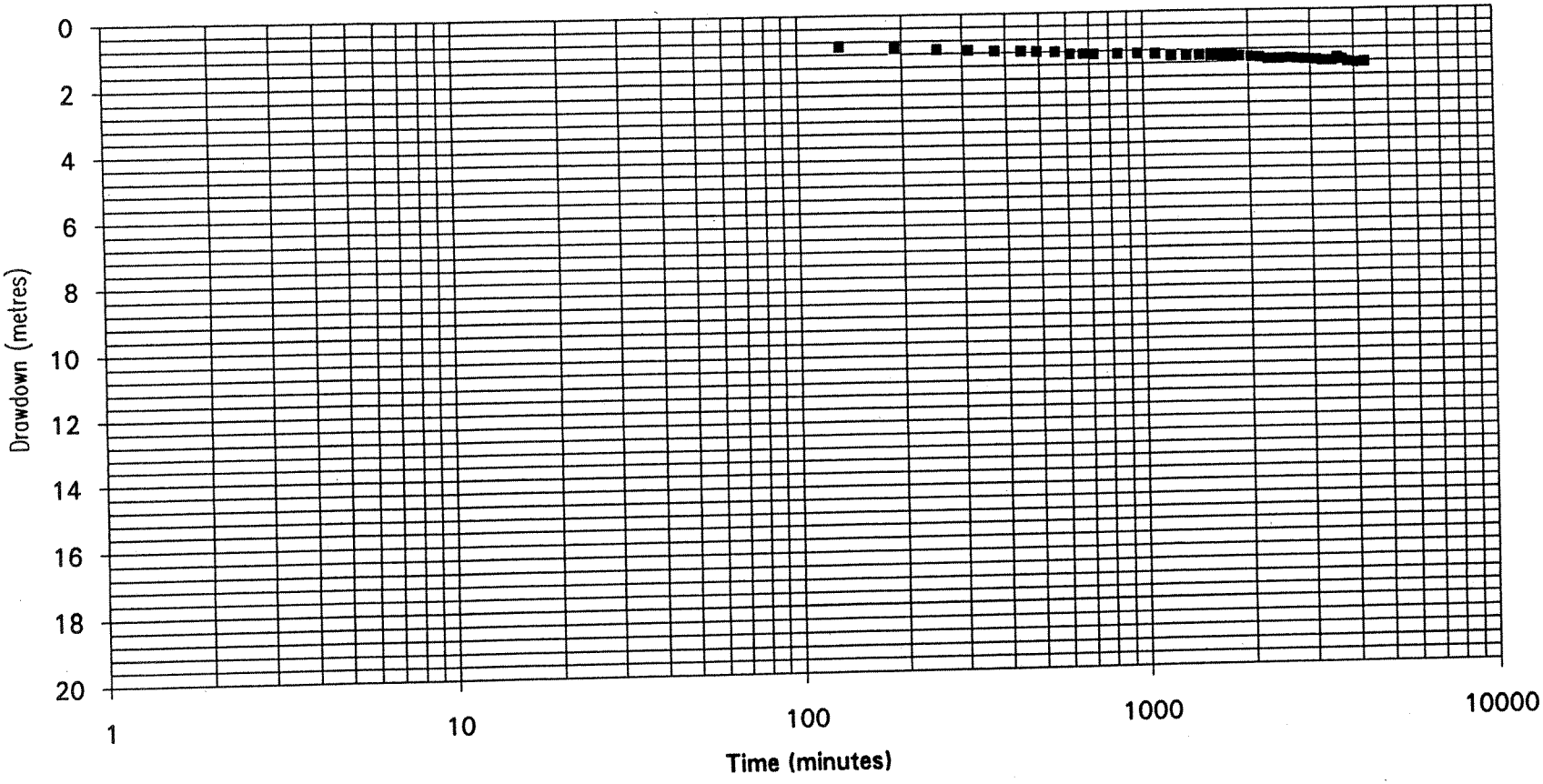

TABLE 2-6: FIELD PUMP TEST INFORMATION

Observation Well TW 2, Pumping TW 1

Well No:	TW 2	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Distance:	145 m
Date:	November 6 to 8, 1991	Static Water Level:	2.07 m

Time (min)	W.L. (m)	Drawdown (m)
0	2.07	0.00
60	2.71	0.33
124	3.00	0.62
183	3.07	0.69
244	3.16	0.78
305	3.25	0.87
364	3.28	0.90
435	3.27	0.89
485	3.26	0.88
546	3.30	0.92
606	3.30	0.92
670	3.37	0.99
733	3.38	1.00
854	3.36	0.98
947	3.38	1.00
1084	3.39	1.01
1204	3.41	1.03
1325	3.42	1.04
1445	3.43	1.05
1565	3.44	1.06
1685	3.47	1.09
1805	3.45	1.07
1925	3.47	1.09
2055	3.48	1.10
2170	3.53	1.15
2293	3.58	1.20
2413	3.58	1.20
2533	3.58	1.20
2653	3.58	1.20
2760	3.54	1.16
2885	3.59	1.21
3005	3.60	1.22
3120	3.61	1.23
3252	3.64	1.26
3365	3.65	1.27

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TABLE 2-6: FIELD PUMP TEST INFORMATION (con't)

Observation Well TW 2, Pumping TW 1

Well No:	TW 2	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Distance:	145 m
Date:	November 6 to 8, 1991	Static Water Level:	2.07 m

Time (min)	W.L. (m)	Drawdown (m)
3493	3.65	1.27
3613	3.68	1.30
3733	3.68	1.30
3853	3.70	1.32
3973	3.71	1.33
4093	3.72	1.34
4213	3.74	1.36
4314	3.74	1.36

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TABLE 2-7: PUMP TEST ANALYSIS

Observation Well TW 2, Pumping TW 1

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown	0.40	360.00	1.36	-	164.72

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
164.72	4.17E-03	145.00	7.34E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
164.72	25.00	2285.53	349.14

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PUMPING TEST ANALYSIS - 30066
Drawdown TW 2, Pumping TW 1

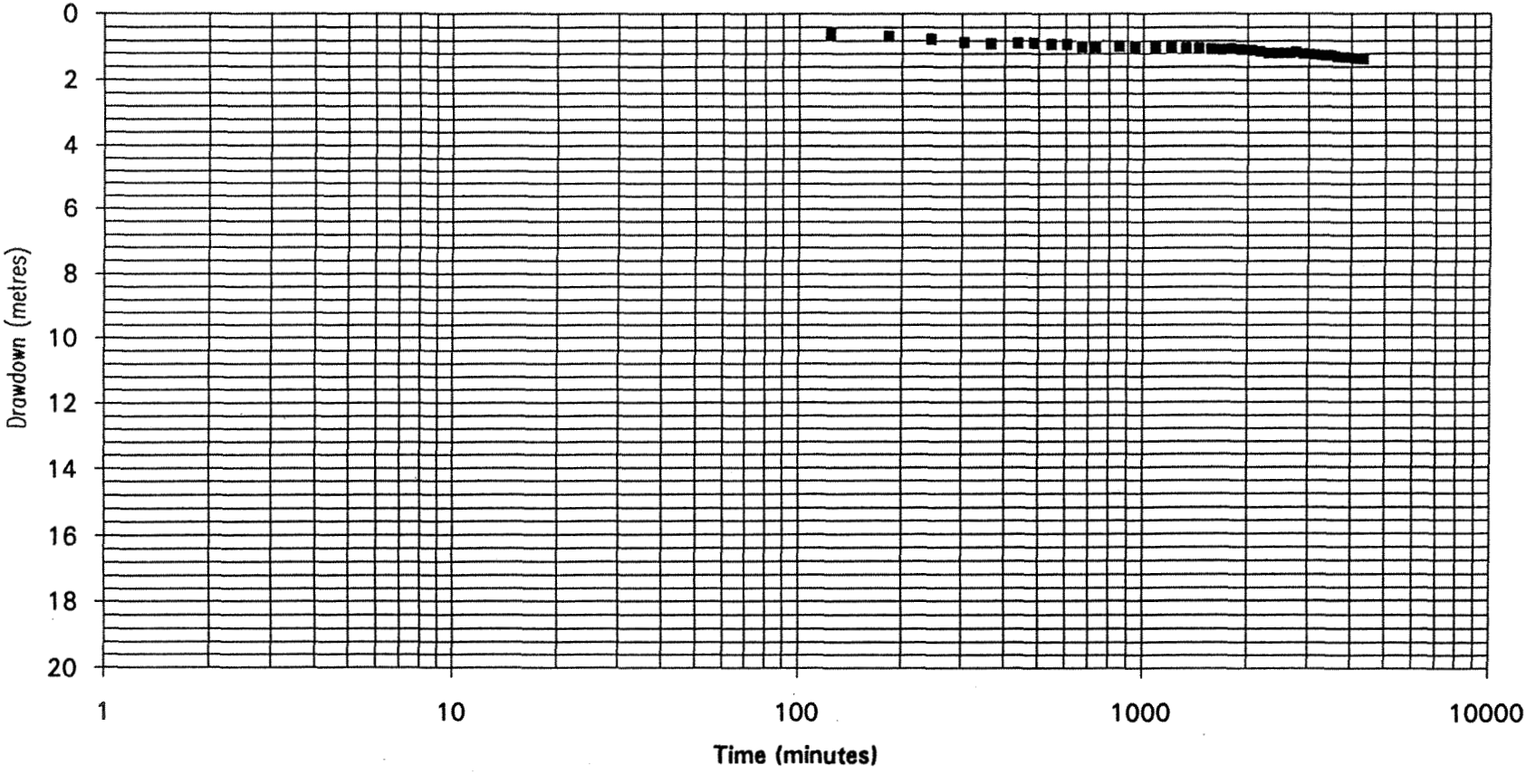

Figure 2-4

TABLE 2-8: FIELD PUMP TEST INFORMATION

Observation Well TW 3, Pumping TW 1

Well No:	TW 3	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Distance:	218 m
Date:	November 6 to 8, 1991	Static Water Level:	0.88 m

Time (min)	W.L. (m)	Drawdown (m)
0	0.88	0.00
62	1.56	0.68
126	1.72	0.84
185	1.82	0.94
246	1.87	0.99
308	1.92	1.04
366	1.96	1.08
437	1.99	1.11
487	2.00	1.12
549	2.06	1.18
610	2.06	1.18
672	2.07	1.19
675	2.09	1.21
736	2.12	1.24
856	2.13	1.25
976	2.14	1.26
1096	2.15	1.27
1216	2.18	1.30
1327	2.20	1.32
1447	2.21	1.33
1567	2.22	1.34
1687	2.25	1.37
1807	2.26	1.38
1927	2.27	1.39
2052	2.27	1.39
2172	2.28	1.40
2292	2.30	1.42
2412	2.32	1.44
2532	2.33	1.45
2652	2.35	1.47
2760	2.36	1.48
2887	2.38	1.50
3007	2.39	1.51
3132	2.39	1.51
3250	2.41	1.53

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TABLE 2-8: FIELD PUMP TEST INFORMATION (con't)

Observation Well TW 3, Pumping TW 1

Well No:	TW 3	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Distance:	218 m
Date:	November 6 to 8, 1991	Static Water Level:	0.88 m

Time (min)	W.L. (m)	Drawdown (m)
3367	2.42	1.54
3490	2.44	1.56
3610	2.45	1.57
3730	2.47	1.59
3850	2.47	1.59
3970	2.48	1.60
4090	2.49	1.61
4210	2.50	1.62
4310	2.50	1.62

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TABLE 2-9: PUMP TEST ANALYSIS

Observation Well TW 3, Pumping TW 1

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown	0.45	360.00	1.62	-	146.38

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
146.38	1.73E-03	218.00	1.20E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
146.38	25.00	2031.02	310.26

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PUMPING TEST ANALYSIS - 30066
Drawdown TW 3, Pumping TW 1

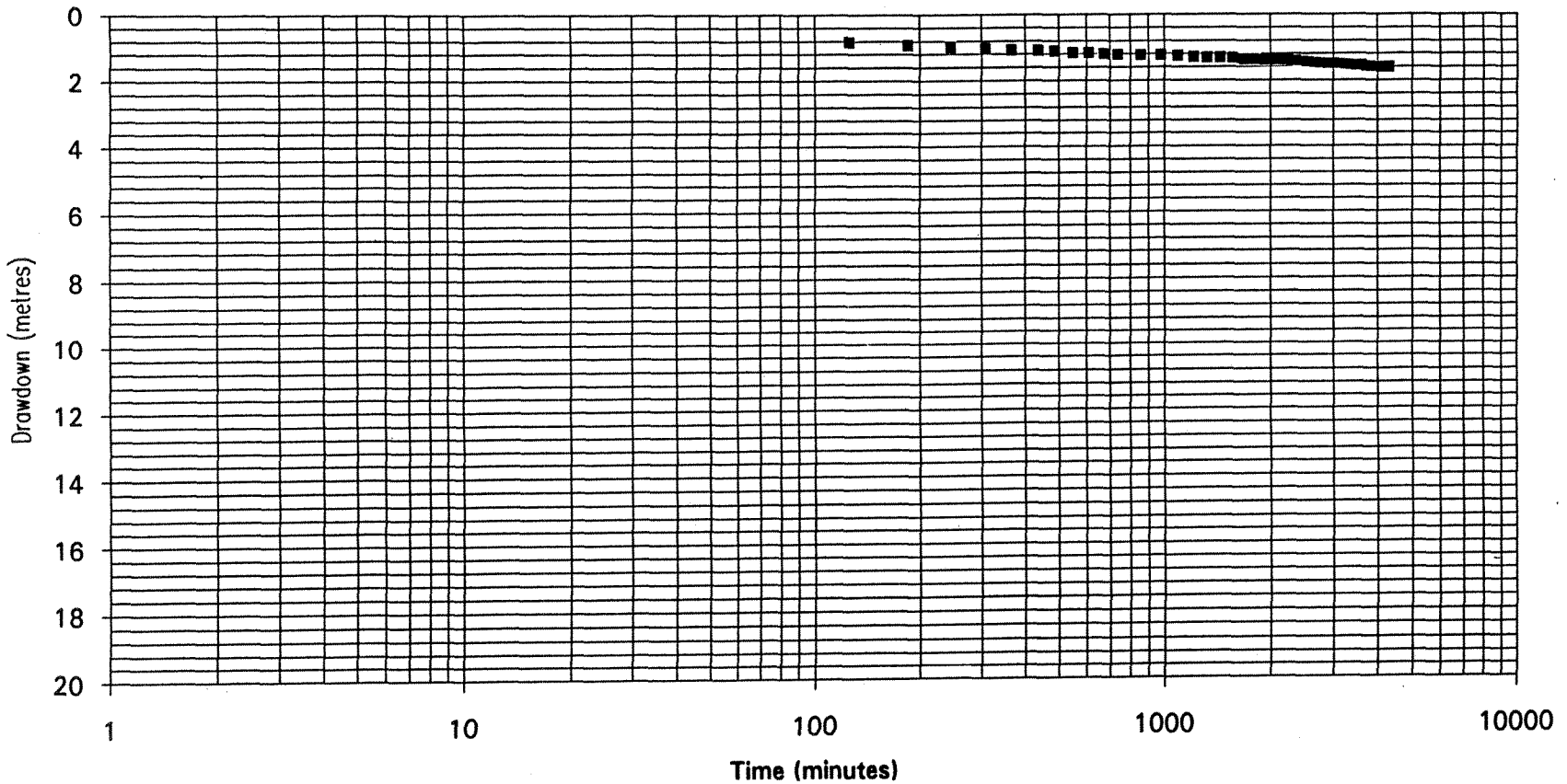

TABLE 2-10: FIELD PUMP TEST INFORMATION

Observation Well TW 4, Pumping TW 1

Well No:	TW 4	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Distance:	169 m
Date:	November 6 to 8, 1991	Static Water Level:	2.06 m

Time (min)	W.L. (m)	Drawdown (m)
0	2.06	0.00
66	2.75	0.69
129	2.87	0.81
189	2.97	0.91
250	3.09	1.03
310	3.17	1.11
370	3.17	1.11
442	3.13	1.07
491	3.15	1.09
554	3.19	1.13
613	3.21	1.15
675	3.30	1.24
677	3.32	1.26
737	3.27	1.21
857	3.28	1.22
977	3.29	1.23
1097	3.32	1.26
1217	3.35	1.29
1335	3.35	1.29
1450	3.35	1.29
1570	3.36	1.30
1690	3.38	1.32
1810	3.39	1.33
1930	3.40	1.34
2048	3.42	1.36
2169	3.45	1.39
2290	3.49	1.43
2410	3.49	1.43
2530	3.50	1.44
2650	3.50	1.44
2760	3.50	1.44
2890	3.50	1.44
3010	3.53	1.47
3135	3.54	1.48
3247	3.55	1.49
3370	3.55	1.49

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TABLE 2-10: FIELD PUMP TEST INFORMATION (con't)

Observation Well TW 4, Pumping TW 1

Well No:	TW 4	Pumping Rate (avg):	360 m3/day
Well Loc.:	Moose Creek	Distance:	169 m
Date:	November 6 to 8, 1991	Static Water Level:	2.06 m

Time (min)	W.L. (m)	Drawdown (m)
3485	3.57	1.51
3605	3.60	1.54
3725	3.64	1.58
3845	3.70	1.64
3965	3.69	1.63
4085	3.68	1.62
4205	3.67	1.61
4307	3.65	1.59

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TABLE 2-11: PUMP TEST ANALYSIS
Observation Well TW 4, Pumping TW 1

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown	0.50	360.00	1.59	-	131.84

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
131.84	3.48E-03	169.00	3.61E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
131.84	25.00	1829.34	279.45

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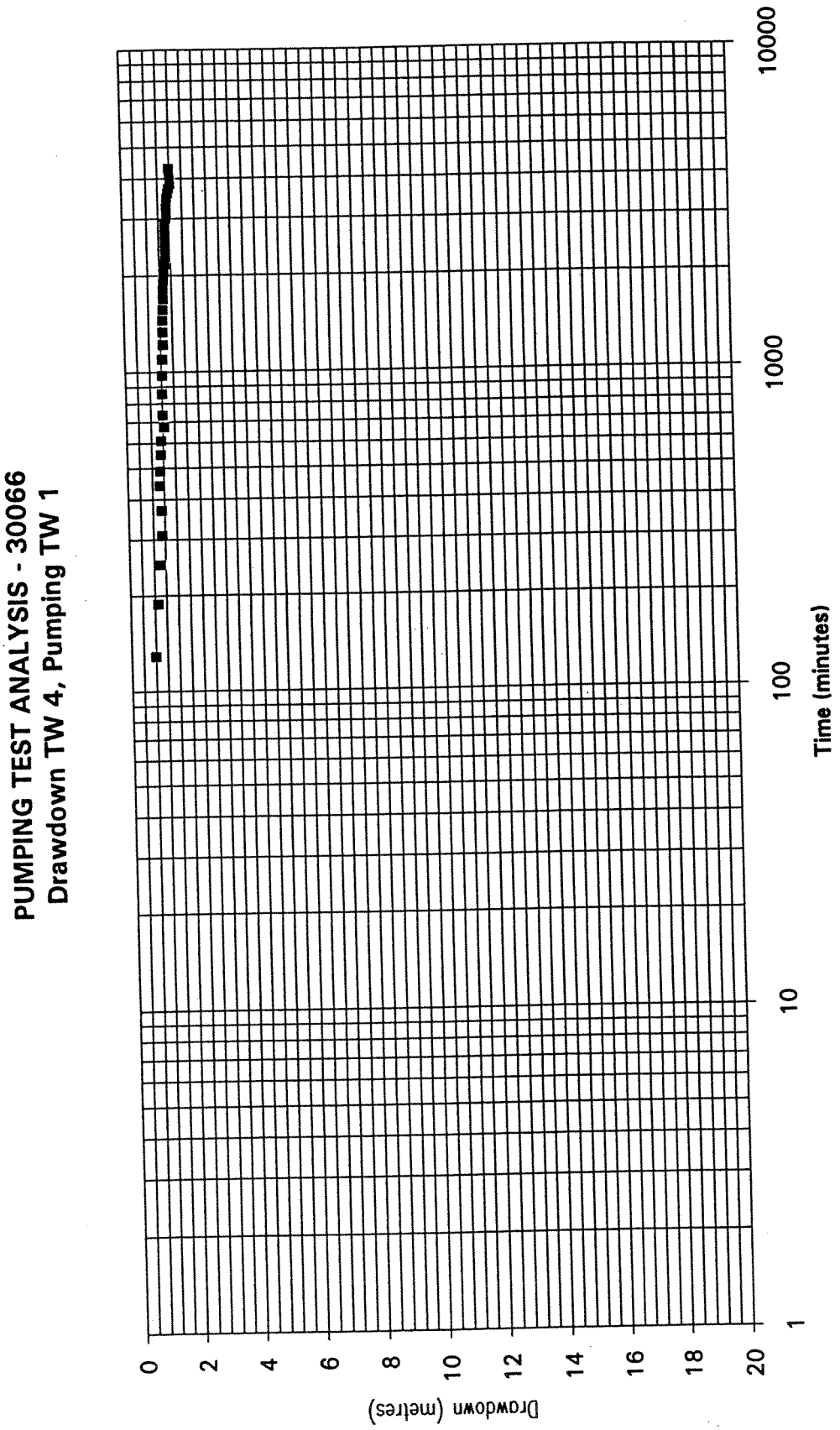
PUMPING TEST ANALYSIS - 30066
Drawdown TW 4, Pumping TW 1
Drawdown (meters)
0
2
4
6
8
10
12
14
16
18
20
1
10
100
1000
10000
Time (minutes)

TABLE 2-12: SUMMARY OF AQUIFER PARAMETERS

bservation Well Data, Pumping TW 1

Transmissivity, Jacob Straight Line Method

OW 1	T=	175.7
TW 2	T=	164.7
TW 3	T=	146.4
TW 4	T=	131.8
	Avg T =	154.7 m2/day

Storativity , Jacob Straight Line Method

OW 1	S=	5.60E-05
TW 2	S=	7.34E-05
TW 3	S=	1.20E-05
TW 4	S=	3.61E-05
	Avg S=	3.66E-05

20 Year Aquifer Safe Yield

		m3/day	igpm
OW 1	=	2438.3	372.3
TW 2	=	2285.5	348.9
TW 3	=	2031.0	310.1
TW 4	=	1829.3	279.3
Average	=	2146.0	327.6

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TABLE 3-1: PUMPING TEST SUMMARY

TEST WELL TW 2, MOOSE CREEK, ONTARIO

Test Conducted By:	Jacques, Whitford Limited
Pumping Began:	10:30 a.m., August 14, 1991
Pumping Ended:	10:30 a.m., August 17, 1991 (72 hours)
Recovery Began:	10:30 a.m. , August 17, 1991
Recovery Ended:	12:30 p.m., August 17, 1991 (>95% recovery)

Well Data

Elevation:	83.0 m
Depth:	30.8 m
Casing Length:	14.0 m
Casing Stick-up	0.9 m
Diameter:	400 mm
Driller:	Olympic Drilling Ltd.
Pump Type:	40 hp Submersible
Pump Setting:	26.8 m
Static Water Level:	2.6 m
Available Drawdown:	19.3 m
Recorded Drawdown:	18.0 m
Pumping Rate (avg.):	327.5 m3/day

Lithology

0 - 13.1 m	overburden
13.1 - 31.4 m	fractured limestone bedrock

Chemical Analyses

Table 4, Ontario Drinking Water Objectives (MOE) and bacteria at 72 hours

Observation Wells

TW 1	r=145.5	depth = 30.5 m	(drawdown = 1.70 m)
TW 3	r=72.8 m	depth = 31.4 m	(drawdown = 3.68 m)
TW 4	r=71.5 m	depth = 32.0 m	(drawdown = 2.61 m)

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TABLE 3-2: FIELD PUMP TEST INFORMATION
Pumping TW 2

Well No:	TW 2	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 14, 1991	Static Water Level:	2.58 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
0		2.58	0.00			360
1		13.70	11.12			
2		14.65	12.07			
3		14.95	12.37			
4		15.65	13.07			
5		16.28	13.70			
6		16.85	14.27			
7		17.35	14.77			
8		17.86	15.28			
9		18.28	15.70			
10		18.62	16.04			
15		19.28	16.70			327.5
20		19.51	16.93			
25		19.72	17.14			
30		19.90	17.32			
40		20.20	17.62			
50		20.41	17.83			
60		20.56	17.98			
90		20.72	18.14			
120		20.93	18.35			
150		21.07	18.49			
180		21.16	18.58			
210		21.27	18.69			
240		21.38	18.80			
300		21.45	18.87			
360		21.70	19.12			
420		21.72	19.14			
480		21.75	19.17			
540		22.43	19.85			
600		21.30	18.72			
660		21.20	18.62			
720		21.26	18.68			
780		21.52	18.94			
840		21.50	18.92			
900		21.34	18.76			

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TABLE 3-2: FIELD PUMP TEST INFORMATION (cont'd)
Pumping TW 2

Well No:	TW 2	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 14, 1991	Static Water Level:	2.58 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
960		21.35	18.77			
1020		21.50	18.92			
1080		21.40	18.82			
1140		21.38	18.80			
1200		21.55	18.97			
1260		21.58	19.00			
1320		21.35	18.77			
1380		21.37	18.79			
1440		21.40	18.82			
1500		21.35	18.77			
1560		21.34	18.76			
1620		21.32	18.74			
1680		21.52	18.94			
1740		21.58	19.00			
1800		21.60	19.02			
1860		21.68	19.10			
1920		21.70	19.12			
1980		21.63	19.05			
2040		21.59	19.01			
2100		21.51	18.93			
2160		21.54	18.96			
2220		23.34	20.76			
2280		19.73	17.15			
2340		20.15	17.57			
2400		20.40	17.82			
2460		20.38	17.80			
2520		20.34	17.76			
2580		20.37	17.79			
2640		20.40	17.82			
2700		20.48	17.90			
2760		20.42	17.84			
2820		20.42	17.84			
2880		20.43	17.85			
2940		20.41	17.83			
3000		20.42	17.84			

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TABLE 3-2: FIELD PUMP TEST INFORMATION (cont'd)
Pumping TW 2

Well No:	TW 2	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 14, 1991	Static Water Level:	2.58 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
3060		20.42	17.84			
3120		20.40	17.82			
3180		20.38	17.80			
3240		20.36	17.78			
3300		20.50	17.92			
3360		20.46	17.88			
3420		20.55	17.97			
3480		20.55	17.97			
3540		20.65	18.07			
3600		20.53	17.95			
3660		20.45	17.87			
3720		20.43	17.85			
3780		20.41	17.83			
3840		20.40	17.82			
3900		20.44	17.86			
3960		20.47	17.89			
4020		20.48	17.90			
4080		20.53	17.95			
4140		20.54	17.96			
4200		20.68	18.10			
4260		20.63	18.05			
4320		20.60	18.02			
4321	1	13.83	11.25	11.25	4321	
4322	2	10.55	7.97	7.97	2161	
4323	3	8.13	5.55	5.55	1441	
4324	4	7.05	4.47	4.47	1081	
4325	5	6.28	3.70	3.70	865	
4326	6	5.70	3.12	3.12	721	
4327	7	5.30	2.72	2.72	618	
4328	8	4.98	2.40	2.40	541	
4329	9	4.75	2.17	2.17	481	
4330	10	4.58	2.00	2.00	433	
4332	12	4.41	1.83	1.83	361	
4334	14	4.28	1.70	1.70	310	
4336	16	4.22	1.64	1.64	271	

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TABLE 3-2: FIELD PUMP TEST INFORMATION (cont'd)
Pumping TW 2

Well No:	TW 2	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 14, 1991	Static Water Level:	2.58 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
4338	18	4.15	1.57	1.57	241	
4340	20	4.11	1.53	1.53	217	
4345	25	4.02	1.44	1.44	174	
4350	30	3.94	1.36	1.36	145	
4355	35	3.88	1.30	1.30	124	
4360	40	3.84	1.26	1.26	109	
4365	45	3.80	1.22	1.22	97	
4370	50	3.76	1.18	1.18	87	
4375	55	3.72	1.14	1.14	80	
4380	60	3.70	1.12	1.12	73	
4390	70	3.65	1.07	1.07	63	
4400	80	3.59	1.01	1.01	55	
4410	90	3.55	0.97	0.97	49	
4420	100	3.53	0.95	0.95	44	
4440	120	3.48	0.90	0.90	37	

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TABLE 3-3: PUMP TEST ANALYSIS
Pumping TW 2

Calculation of Transmissivity from Pump Test Curves (Jacob Straight Line Method)

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown (early)	7.90	360.00	16.04	22.44	8.35
Drawdown (late)	2.40	327.50	18.02	18.17	25.01
Recovery (early)	10.80	327.50	-	-	5.56
Recovery (late)	0.87	327.50	-	-	69.00
Representative T					**25.01**

Calculation of Safe Yields from Transmissivities

Transmissivity	T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
Representative	25.01	19.30	270.30	41.70
Minimum	5.56	19.30	60.00	9.30

Calculation of Transmissivity and Storativity From Observation Well Data
(Jacob method,distance vs. drawdown at constant t)

Delta s (m)	Time (days)	r0 (meters)	Transmissivity (m2/day)	Storativity
2.7	0.063	345.00	44.40	5.25E-05

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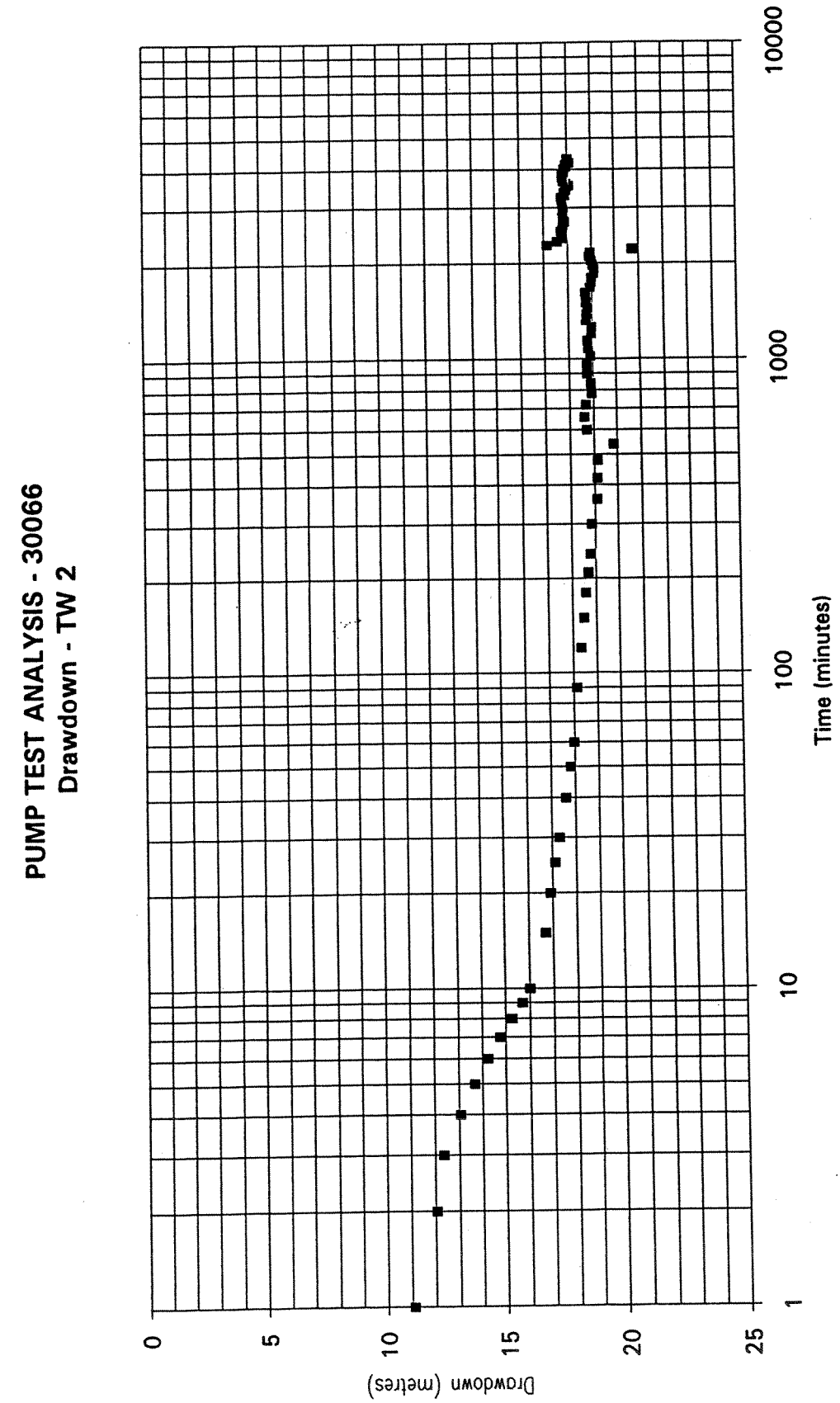
Figure 3-1


PUMP TEST ANALYSIS - 30066
Drawdown - TW 2
Drawdown (metres)
0
5
10
15
20
25
Time (minutes)
1
10
100
1000
10000

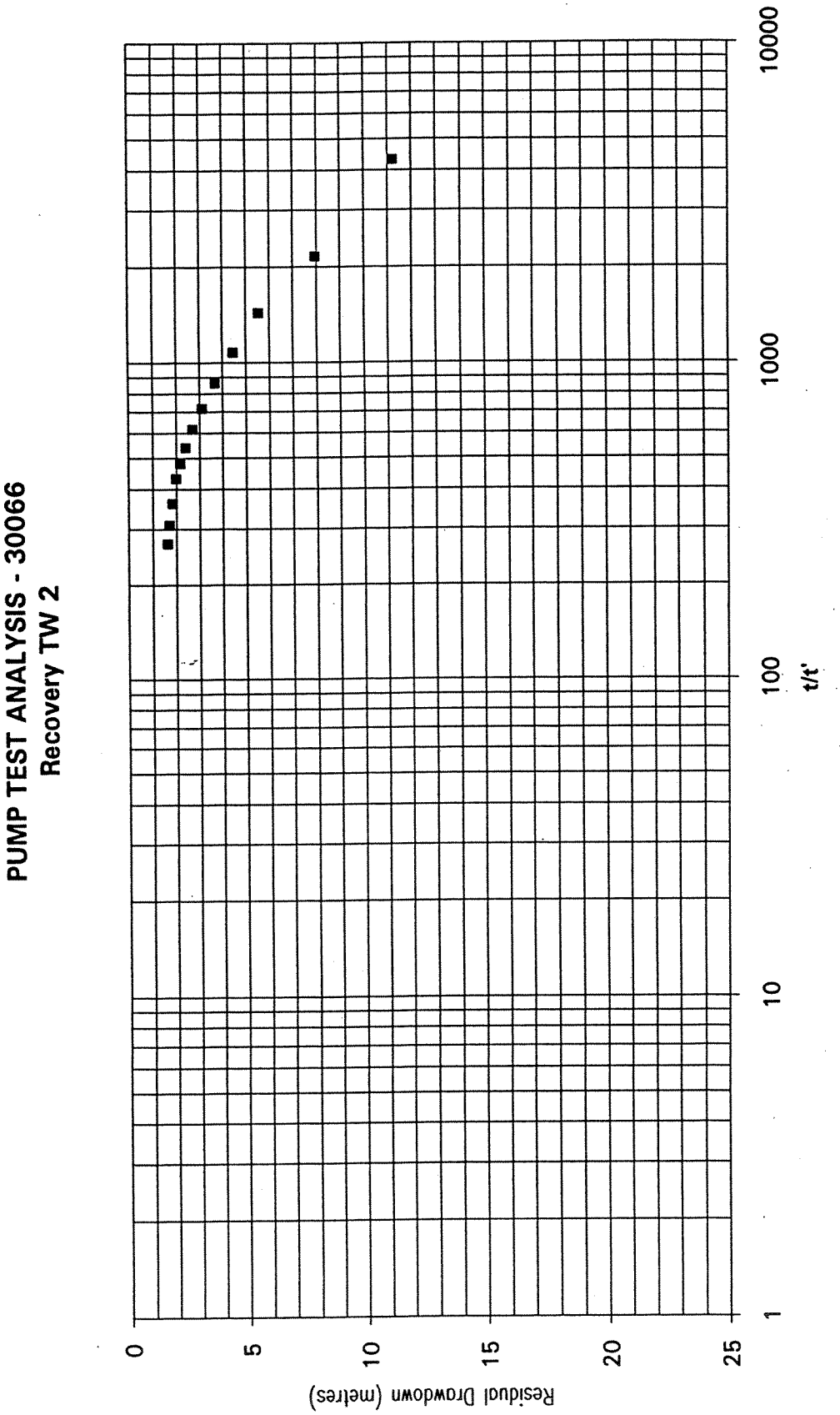

PUMP TEST ANALYSIS - 30066
Recovery TW 2
Residual Drawdown (meters)
0
5
10
15
20
25
1
10
100
1000
10000
t/t'

TABLE 3-4. FIELD PUMP TEST INFORMATION
Observation Well TW 1, Pumping TW 2

Well No:	TW 1	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 8, 1991	Static Water Level:	3.22 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
0		3.22	0.00			328
15		3.63	0.41			
33		3.95	0.73			
40		4.00	0.78			
75		4.12	0.90			
95		4.20	0.98			
135		4.28	1.06			
176		4.34	1.12			
236		4.40	1.18			
296		4.45	1.23			
356		4.48	1.26			
427		4.50	1.28			
487		4.53	1.31			
607		4.56	1.34			
727		4.58	1.36			
847		4.61	1.39			
967		4.63	1.41			
1087		4.65	1.43			
1207		4.67	1.45			
1327		4.70	1.48			
1447		4.72	1.50			
1567		4.73	1.51			
1687		4.74	1.52			
1807		4.76	1.54			
1927		4.77	1.55			
2047		4.79	1.57			
2167		4.80	1.58			
2287		4.78	1.56			
2407		4.80	1.58			
2527		4.80	1.58			
2647		4.81	1.59			
2767		4.83	1.61			
2887		4.83	1.61			
3007		4.84	1.62			
3127		4.85	1.63			
3247		4.87	1.65			
3367		4.87	1.65			
3487		4.87	1.65			

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TABLE 3-4. FIELD PUMP TEST INFORMATION (cont'd)
Observation Well TW 1, Pumping TW 2

Well No:	TW 1	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 8, 1991	Static Water Level:	3.22 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
3605		4.88	1.66			
3725		4.88	1.66			
3845		4.89	1.67			
3965		4.90	1.68			
4085		4.90	1.68			
4205		4.92	1.70			
4320		4.92	1.70			
4338	18	4.60		1.38	241	
4365	45	4.34		1.12	97	
4370	50	4.32		1.10	87	
4420	100	4.12		0.90	44	
4450	130	4.07		0.85	34	
4505	185	4.00		0.78	24	

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TABLE 3-5: PUMP TEST ANALYSIS
Observation Well TW 1, Pumping TW 2

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown (early)	0.79	327.50	1.70	-	75.99
Drawdown (late)	0.29	327.50	1.70	-	207.00

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
75.99	2.78E-03	145.50	2.25E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
75.99	25.00	1054.36	161.06

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PUMP TEST ANALYSIS - 30066
Drawdown TW 1, Pumping TW 2

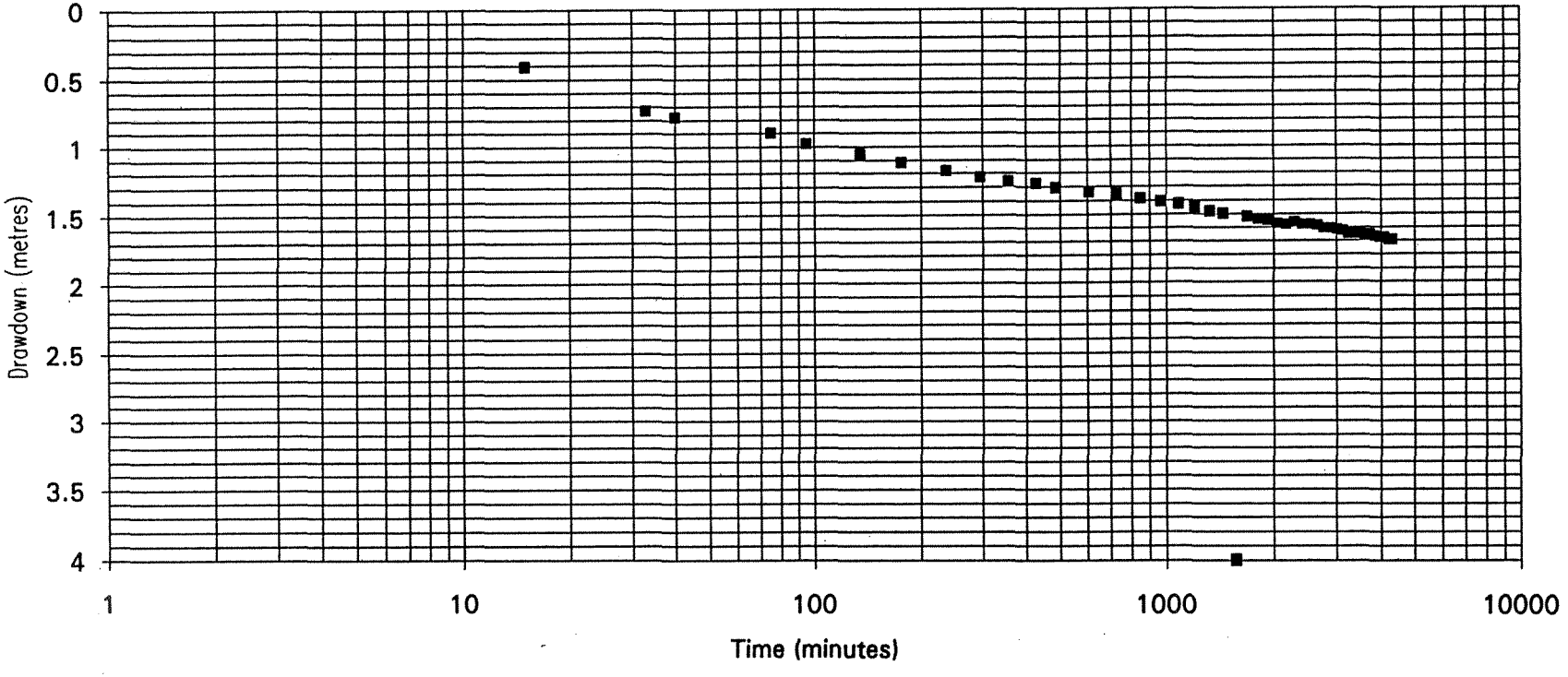

TABLE 3-6. FIELD PUMP TEST INFORMATION
Observation Well TW 3, Pumping TW 2

Well No:	TW 3	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 8, 1991	Static Water Level:	1.33 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
0		1.33	0.00			328
20		3.13	1.80			
60		3.96	2.63			
85		4.13	2.80			
125		4.32	2.99			
182		4.46	3.13			
242		4.56	3.23			
301		4.62	3.29			
362		4.68	3.35			
422		4.73	3.40			
482		4.75	3.42			
602		4.77	3.44			
722		4.79	3.46			
842		4.81	3.48			
962		4.82	3.49			
1082		4.84	3.51			
1202		4.87	3.54			
1322		4.87	3.54			
1442		4.90	3.57			
1562		4.91	3.58			
1682		4.91	3.58			
1802		4.93	4.00			
1922		4.96	3.63			
2042		4.98	3.65			
2162		4.99	3.66			
2282		4.83	3.50			
2402		4.89	3.56			
2522		4.89	3.56			
2642		4.90	3.57			
2762		4.92	3.59			
2882		4.92	3.59			
3002		4.93	3.60			
3122		4.94	3.61			
3242		4.95	3.62			
3362		4.96	3.63			
3482		4.97	3.64			
3602		4.98	3.65			
3722		4.97	3.64			

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TABLE 3-6. FIELD PUMP TEST INFORMATION (cont'd)
Observation Well TW 3, Pumping TW 2

Well No:	TW 3	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 8, 1991	Static Water Level:	1.33 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
3842		4.97	3.64			
3962		4.98	3.65			
4082		4.99	3.66			
4202		5.01	3.68			
4320		5.01	3.68			
4332	12	3.40		2.07	361	
4334	14	3.28		1.95	310	
4350	30	2.82		1.49	145	
4355	35	2.76		1.43	124	
4390	70	2.47		1.14	63	
4400	80	2.42		1.09	55	
4445	125	2.27		0.94	36	
4515	195	2.12		0.79	23	

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TABLE 3-7: PUMP TEST ANALYSIS
Observation Well TW 3, Pumping TW 2

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown (early)	1.64	327.50	3.68	-	36.60
Drawdown (late)	0.22	327.50	3.68	-	272.87

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
36.60	1.25E-03	72.80	1.94E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
36.60	25.00	507.83	77.58

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PUMP TEST ANALYSIS - 30066
Drawdown TW 3, Pumping TW 2

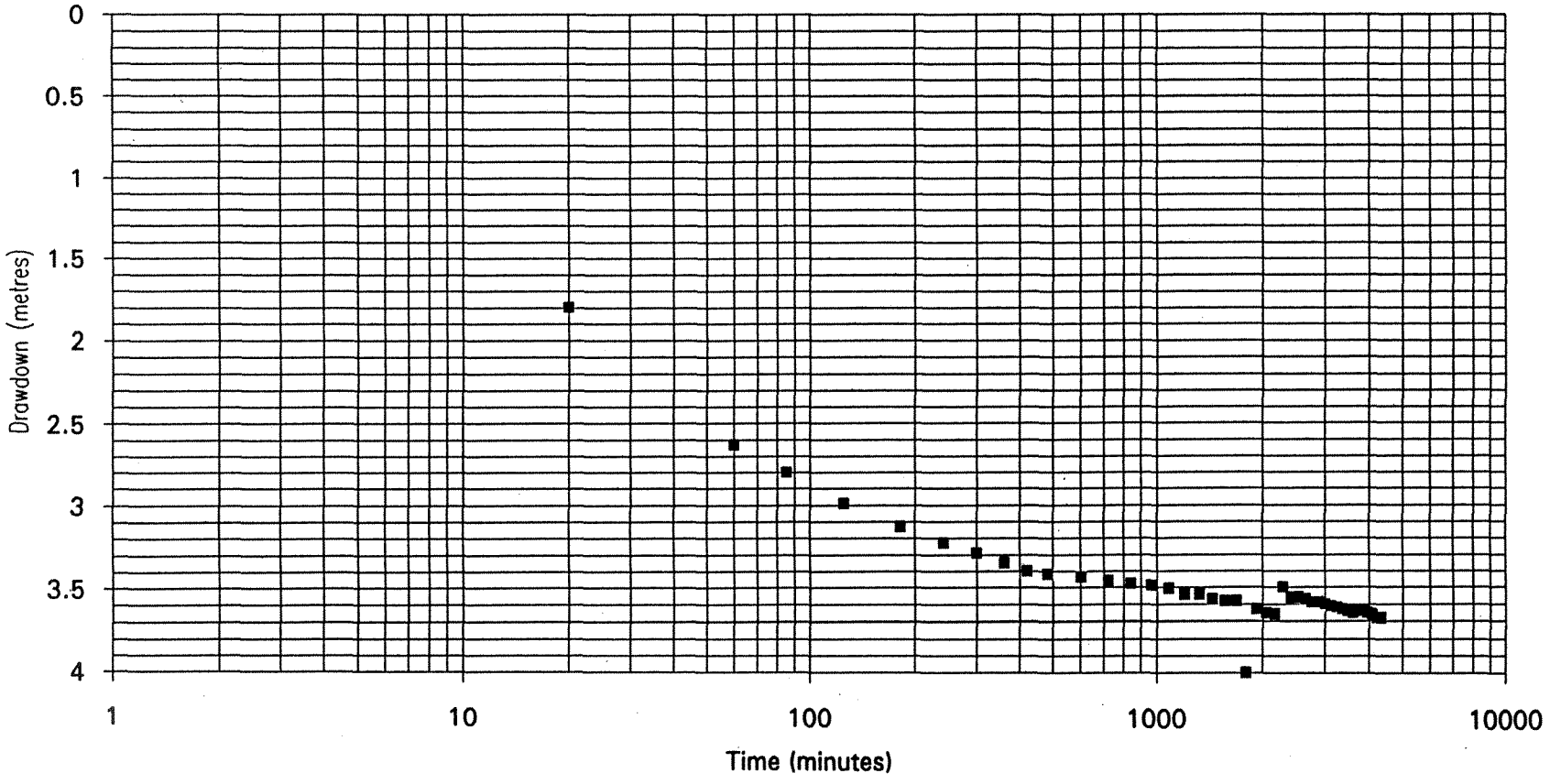

TABLE 3-8: FIELD PUMP TEST INFORMATION

Observation Well TW 4, Pumping TW 2

Well No:	TW 4	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 14, 1991	Static Water Level:	2.3 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
0		2.30	0.00			328
1		2.40	0.10			
2		2.49	0.19			
3		2.57	0.27			
4		2.65	0.35			
5		2.73	0.43			
6		2.79	0.49			
7		2.85	0.55			
8		2.91	0.61			
9		2.97	0.67			
10		3.02	0.72			
30		3.66	1.36			
65		3.95	1.65			
90		4.07	1.77			
130		4.20	1.90			
186		4.33	2.03			
246		4.41	2.11			
306		4.46	2.16			
366		4.50	2.20			
425		4.54	2.24			
485		4.58	2.28			
605		4.60	4.00			
725		4.62	2.32			
845		4.63	2.33			
965		4.65	2.35			
1085		4.67	2.37			
1205		4.70	2.40			
1325		4.73	2.43			
1445		4.74	2.44			
1565		4.75	2.45			
1685		4.75	2.45			
1805		4.77	2.47			
1925		4.79	2.49			
2045		4.82	2.52			
2165		4.82	2.52			
2285		4.75	2.45			
2405		4.78	2.48			
2525		4.78	2.48			
2645		4.79	2.49			

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TABLE 3-8: FIELD PUMP TEST INFORMATION (cont'd)
Observation Well TW 4, Pumping TW 2

Well No:	TW 4	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	26.8 m
Date:	August 14, 1991	Static Water Level:	2.3 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
2765		4.82	2.52			
2885		4.82	2.52			
3005		4.82	2.52			
3125		4.83	2.53			
3245		4.84	2.54			
3265		4.85	2.55			
3485		4.86	2.56			
3605		4.86	2.56			
3725		4.86	2.56			
3845		4.87	2.57			
3965		4.88	2.58			
4085		4.88	2.58			
4205		4.91	2.61			
4320		4.93	2.63			
4321	1	4.93		2.63	4321	
4322	2	4.89		2.59	2161	
4323	3	4.83		2.53	1441	
4324	4	4.74		2.44	1081	
4325	5	4.67		2.37	865	
4326	6	4.58		2.28	721	
4327	7	4.51		2.21	618	
4328	8	4.41		2.11	541	
4329	9	4.33		2.03	481	
4330	10	4.26		1.96	433	
4342	22	3.81		1.51	197	
4380	60	3.45		1.15	73	
4410	90	3.33		1.03	49	
4440	120	3.24		0.94	37	
4510	190	3.10		0.80	24	

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TABLE 3-9: PUMP TEST ANALYSIS
Observation Well TW 4, Pumping TW 2

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown (early)	1.09	327.50	2.61	-	55.07
Drawdown (late)	0.32	327.50	2.61	-	187.60

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
55.07	1.60E-03	71.50	3.87E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
55.07	25.00	764.10	116.72

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PUMP TEST ANALYSIS - 30066
Drawdown TW 4, Pumping TW 2

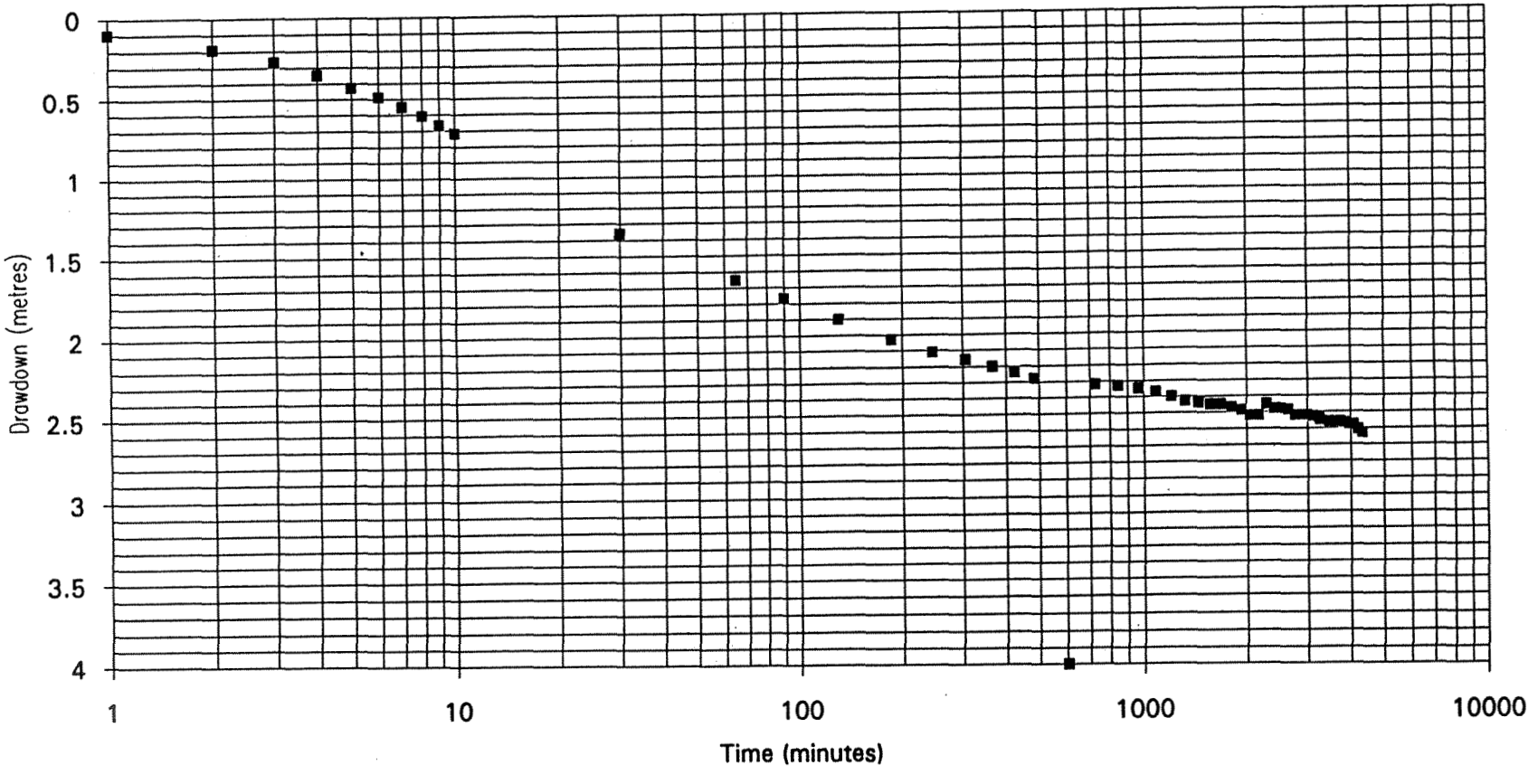

TABLE 3-10: SUMMARY OF AQUIFER PARAMETERS
Pumping TW 2

Transmissivity, Jacob Straight Line Method

TW 1	T=	76.0
TW 3	T=	36.6
TW 4	T=	55.1
	Avg T =	55.9 m2/day

Storativity , Jacob Straight Line Method

TW 1	S=	2.25E-05
TW 2	S=	1.94E-05
TW 4	S=	3.87E-05
	Avg S=	2.69E-05

20 Year Aquifer Safe Yield

		m3/day	igpm
TW 1	=	1054	161.0
TW 3	=	508	77.5
TW 4	=	764	116.7
Average	=	582	88.8

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TABLE 4-1: PUMPING TEST SUMMARY

TEST WELL TW 4 , MOOSE CREEK, ONTARIO

Test Conducted By:	Jacques, Whitford Limited
Pumping Began:	3:00 p.m., April 8, 1991
Pumping Ended:	3:00 p.m., April 11, 1991(72 hours)
Recovery Began:	3:00 p.m., April 11, 1991
Recovery Ended:	3:46 p.m., April 11, 1991 (> 95% recovery)

Well Data

Elevation:	83.0 m
Depth:	32.0 m
Casing Length:	16.2 m
Casing Stick-up	0.6 m
Diameter:	400 mm
Driller:	Olympic Drilling Ltd.
Pump Type:	40 hp Submersible
Pump Setting:	29.9 m
Static Water Level:	1.4 m
Available Drawdown:	24.2 m
Recorded Drawdown:	24.7 m
Pumping Rate (avg.):	327.5 m3/day

Lithology

0 - 0.6 m Topsoil
0.6 - 12.5 m Grey fluidized sand
12.5 - 16.2 m Fractured bedrock (shaly limestone)
16.2 - 32.0 m Dark Grey shaly limestone

Chemical Analyses

Table 4, Ontario Drinking Water Objectives (MOE) and bacteria at 72 hours

Observation Wells

TW 1: r = 169.5 m, depth = 30.5 m (1.19 m drawdown)
TW 2: r = 72 m, depth = 30.8 m (1.97 m drawdown)
TW 3: r = 115 m, depth = 31.4 m (1.82 m drawdown)

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TABLE 4-2: FIELD PUMP TEST INFORMATION
Pumping TW 4

Well No:	TW 4	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	29.9 m
Date:	April 8, 1991	Static Water Level:	1.41 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
0		1.41	0.00			
1.0		7.60	6.19			328
2		11.14	9.73			
3		11.50	10.09			
4		16.45	15.04			
5		18.86	17.45			
6		18.97	17.56			
7		20.42	19.01			
8		20.44	19.03			
10		22.31	20.90			
13		22.68	21.27			
14		22.75	21.34			
16		22.94	21.53			
18		23.06	21.65			
20		23.13	21.72			
25		23.24	21.83			
30		23.39	21.98			
35		23.50	22.09			
40		23.57	22.16			
50		23.78	22.37			
60		23.89	22.48			
70		23.99	22.58			
80		24.10	22.69			
90		24.17	22.76			
105		24.30	22.89			
120		24.38	22.97			
150		24.48	23.07			
180		24.65	23.24			
210		24.90	23.49			
240		25.10	23.69			
300		25.29	23.88			
360		25.45	24.04			
420		25.54	24.13			
480		25.64	24.23			
540		25.71	24.30			
600		25.80	24.39			
660		25.83	24.42			
720		25.85	24.44			

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TABLE 4-2: FIELD PUMP TEST INFORMATION(cont'd)

Pumping TW 4

Well No:	TW 4	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	29.9 m
Date:	April 8, 1991	Static Water Level:	1.41 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
840		25.91	24.50			
960		25.99	24.58			328
1080		26.18	24.77			
1200		26.20	24.79			
1320		26.25	24.84			
1440		26.28	24.87			
1560		26.32	24.91			
1680		26.34	24.93			
1800		26.47	25.06			
1920		26.40	24.99			
2040		26.38	24.97			
2160		26.35	24.94			
2280		26.33	24.92			
2400		26.30	24.89			
2520		26.18	24.77			
2640		26.24	24.83			
2760		26.24	24.83			
2880		26.40	24.99			
3000		26.52	25.11			
3120		26.70	25.29			
3240		26.87	25.46			
3360		26.79	25.38			
3480		26.70	25.29			
3600		26.54	25.13			
3720		26.41	25.00			
3840		26.20	24.79			
3960		26.10	24.69			
4080		26.08	24.67			
4200		26.07	24.66			
4320		26.10	24.69			

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TABLE 4-2: FIELD PUMP TEST INFORMATION(cont'd)
Pumping TW 4

Well No:	TW 4	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	29.9 m
Date:	April 8, 1991	Static Water Level:	1.41 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
4321	0.5			19.19	8642	
4321	1			15.89	4321	
4322	2			10.54	2161	
4323	3			5.99	1441	
4324	4			4.54	1081	
4325	5			3.50	865	
4326	6			2.82	721	
4327	7			2.41	618	
4328	8			2.15	541	
4330	10			1.80	433	
4332	12			1.62	361	
4334	14			1.50	310	
4336	16			1.41	271	
4338	18			1.34	241	
4340	20			1.28	217	
4345	25			1.17	174	
4350	30			1.10	145	
4355	35			1.03	124	
4360	40			0.97	109	
4363	43			0.95	101	
4366	46			0.90	95	

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TABLE 4-3: PUMP TEST ANALYSIS
Pumping TW 4

Calculation of Transmissivity from Pump Test Curves (Jacob Straight Line Method)

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown (early)	18.20	327.50	24.70	13.26	3.30
Drawdown (late)	1.90	327.50	24.70	13.26	31.60
Recovery (early)	16.30	327.50	-	-	3.68
Recovery (late)	1.20	327.50	-	-	50.03

Calculation of Safe Yields from Transmissivities

Transmissivity	T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
Average	22.15	24.20	297.50	45.45
Minimum	3.30	24.20	44.30	6.77

Calculation of Transmissivity and Storativity From Observation Well Data
(Jacob method,distance vs. drawdown at constant t)

Delta s (m)	Time (days)	r0 (meters)	Transmissivity (m2/day)	Storativity
1.44	0.069	640.00	83.24	3.18E-05

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Figure 4-1

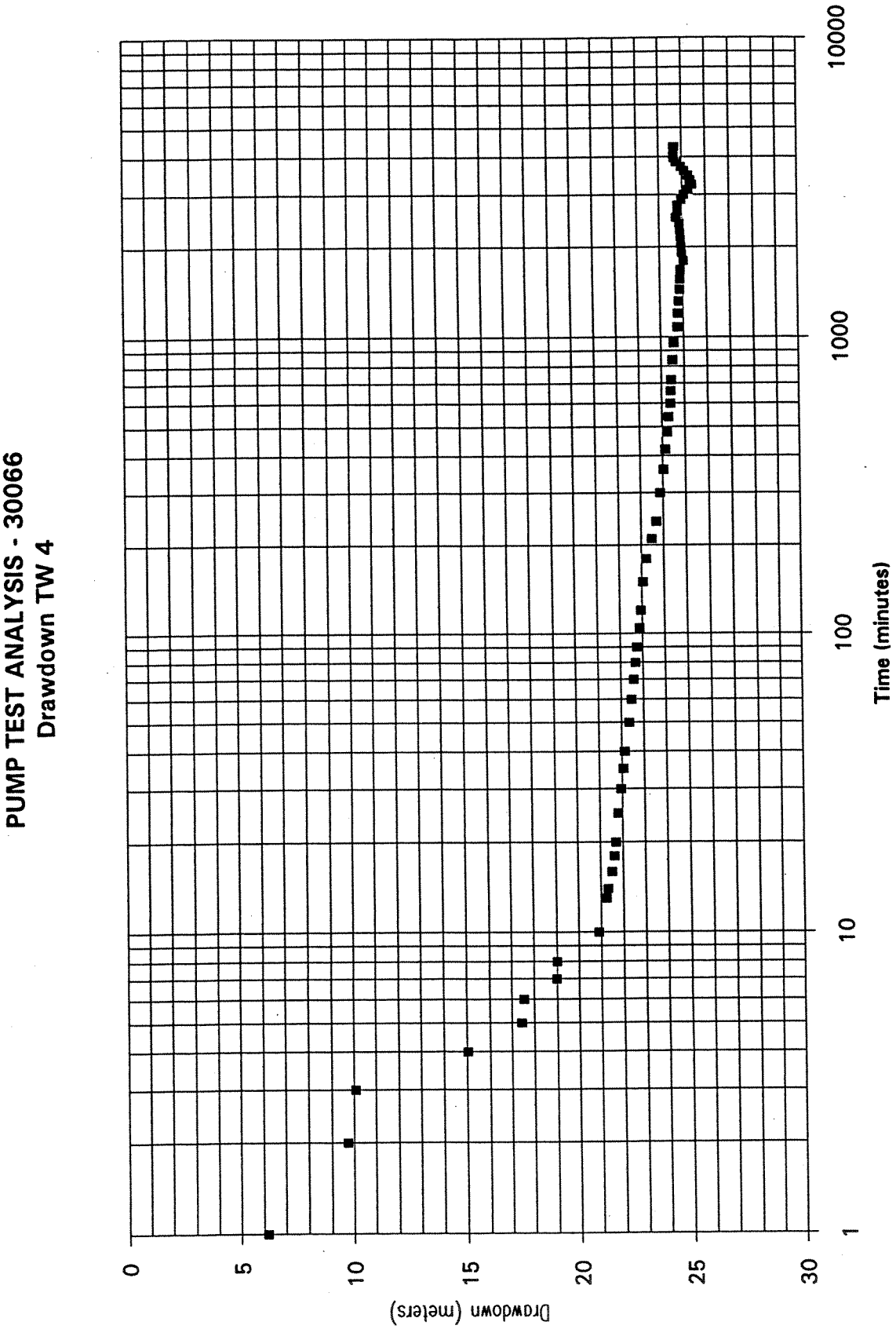
PUMP TEST ANALYSIS - 30066
Drawdown TW 4
Drawdown (meters)
0
5
10
15
20
25
30
1
10
100
1000
10000
Time (minutes)

Figure 4-2

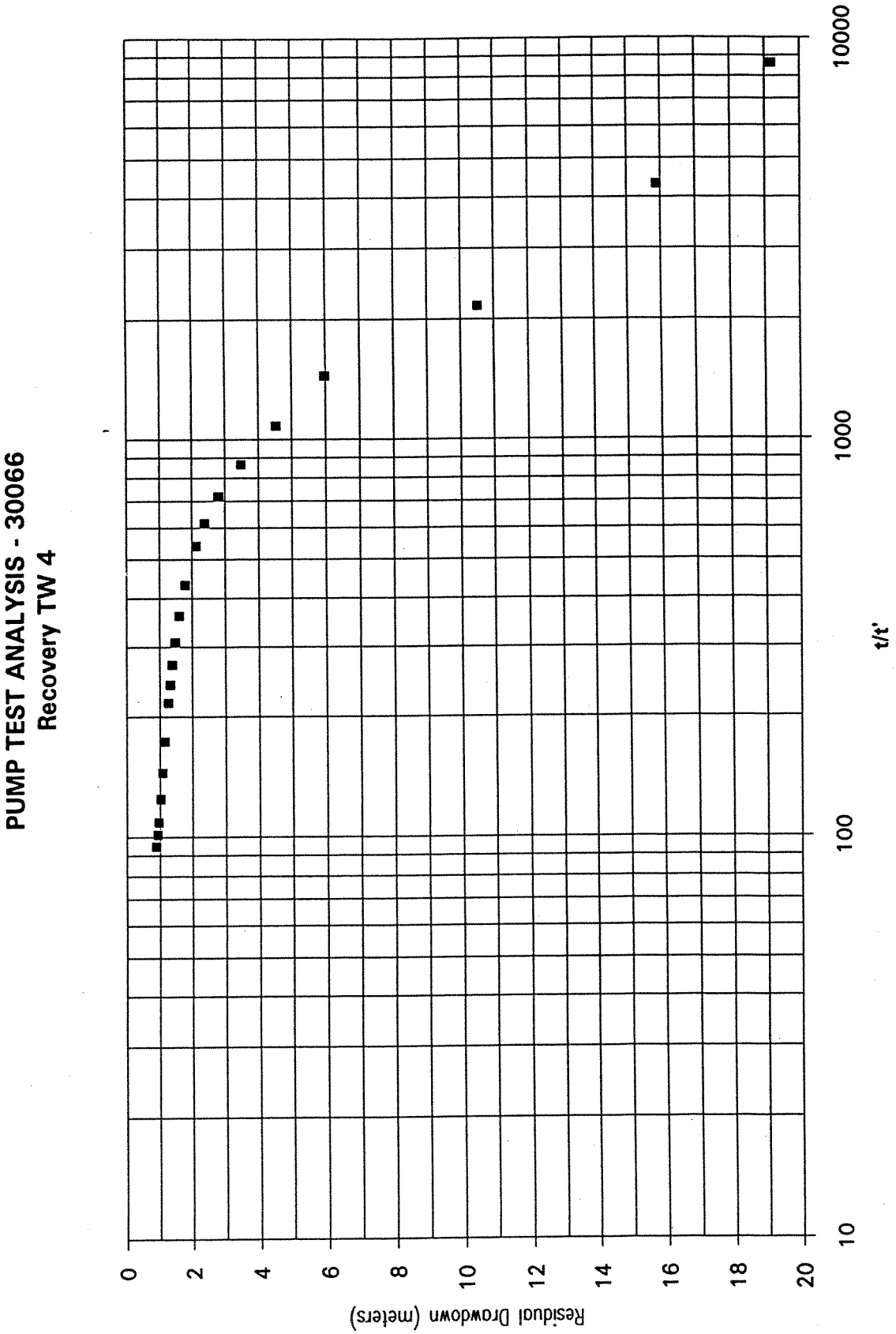
PUMP TEST ANALYSIS - 30066
Recovery TW 4
Residual Drawdown (meters)
0
2
4
6
8
10
12
14
16
18
20
10
100
1000
10000
t/t'

Figure 4-3

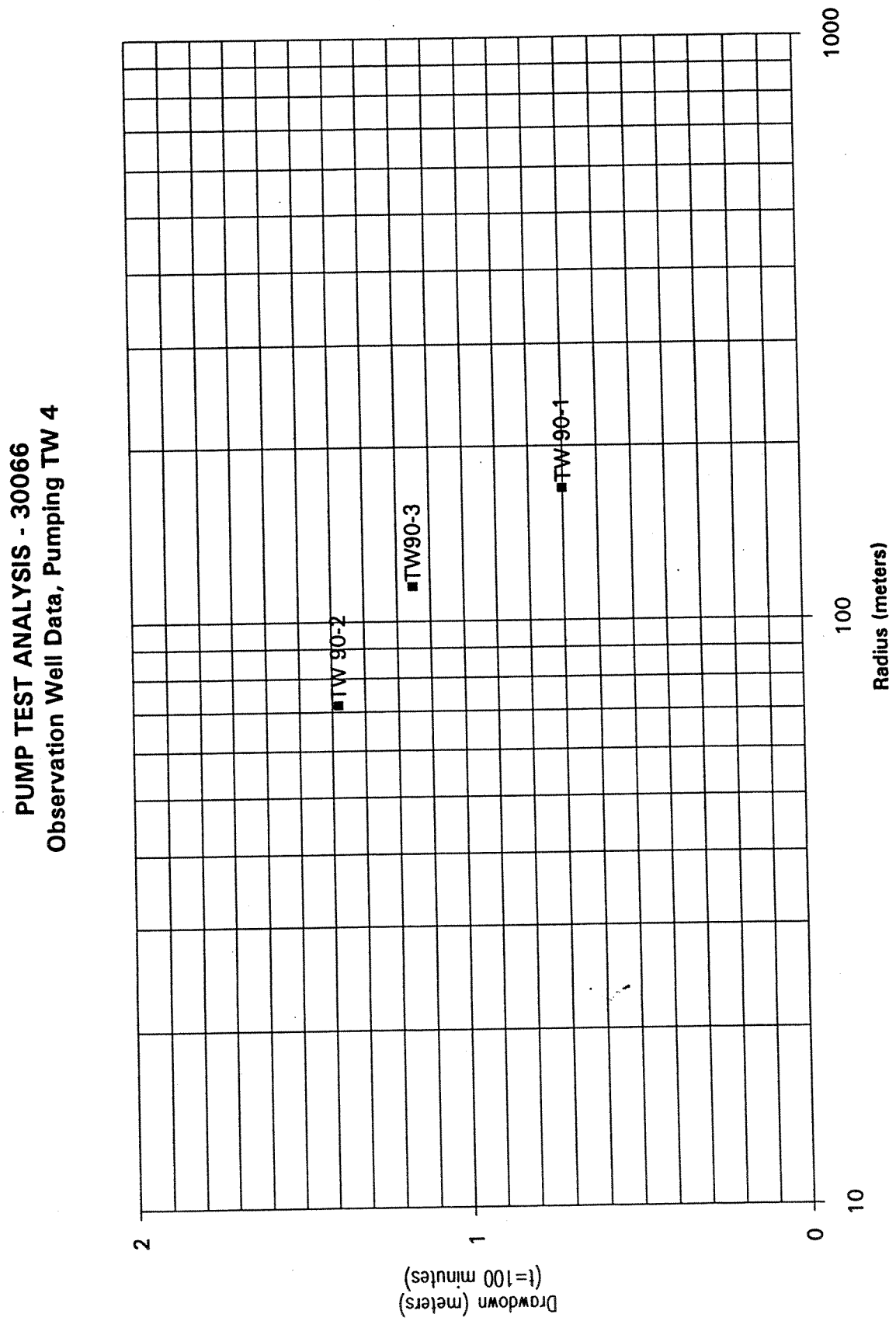
PUMP TEST ANALYSIS - 30066
Observation Well Data, Pumping TW 4
Drawdown (meters)
(t=100 minutes)
2
1
0
10
100
1000
Radius (meters)
TW 90-2
TW90-3
TW-90-1

TABLE 4-4: FIELD PUMP TEST INFORMATION
Observation Well TW 1, Pumping TW 4

Well No:	TW 1	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	29.9 m
Date:	April 8, 1991	Static Water Level:	2.17 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
0		2.17	0.00			
19		2.46	0.29			328
26		2.54	0.37			
35		2.61	0.44			
65		2.77	0.60			
98		2.87	0.70			
131		2.93	0.76			
160		2.95	0.78			
189		2.98	0.81			
220		3.03	0.86			
249		3.05	0.88			
310		3.07	0.90			
370		3.11	0.94			
430		3.14	0.97			
490		3.14	0.97			
550		3.14	0.97			
610		3.13	0.96			
670		3.13	0.96			
730		3.12	0.95			
850		3.11	0.94			
970		3.10	0.93			
1090		3.09	0.92			
1210		3.08	0.91			
1330		3.13	0.96			
1450		3.15	0.98			
1570		3.17	1.00			
1690		3.20	1.03			
1810		3.24	1.07			
1930		3.25	1.08			
2050		3.21	1.04			
2170		3.16	0.99			
2290		3.14	0.97			
2410		3.13	0.96			
2530		3.13	0.96			
2650		3.17	1.00			
2770		3.20	1.03			

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TABLE 4-4: FIELD PUMP TEST INFORMATION (cont'd)
Observation Well TW 1, Pumping TW 4

Well No:	TW 1	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	29.9 m
Date:	April 8, 1991	Static Water Level:	2.17 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
2890		3.22	1.05			
3010		3.25	1.08			
3130		3.26	1.09			
3250		3.27	1.10			
3370		3.29	1.12			
3490		3.29	1.12			
3610		3.30	1.13			
3730		3.30	1.13			
3850		3.31	1.14			
3970		3.32	1.15			
4090		3.35	1.18			
4210		3.36	1.19			
4320		3.36	1.19			

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TABLE 4-5: PUMP TEST ANALYSIS
Observation Well TW 1, Pumping TW 4

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown	0.49	327.50	1.19	-	122.51

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
122.51	3.47E-03	169.50	3.33E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
122.51	25.00	1699.85	259.67

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PUMP TEST ANALYSIS - 30066
Drawdown TW 1, Pumping TW 4

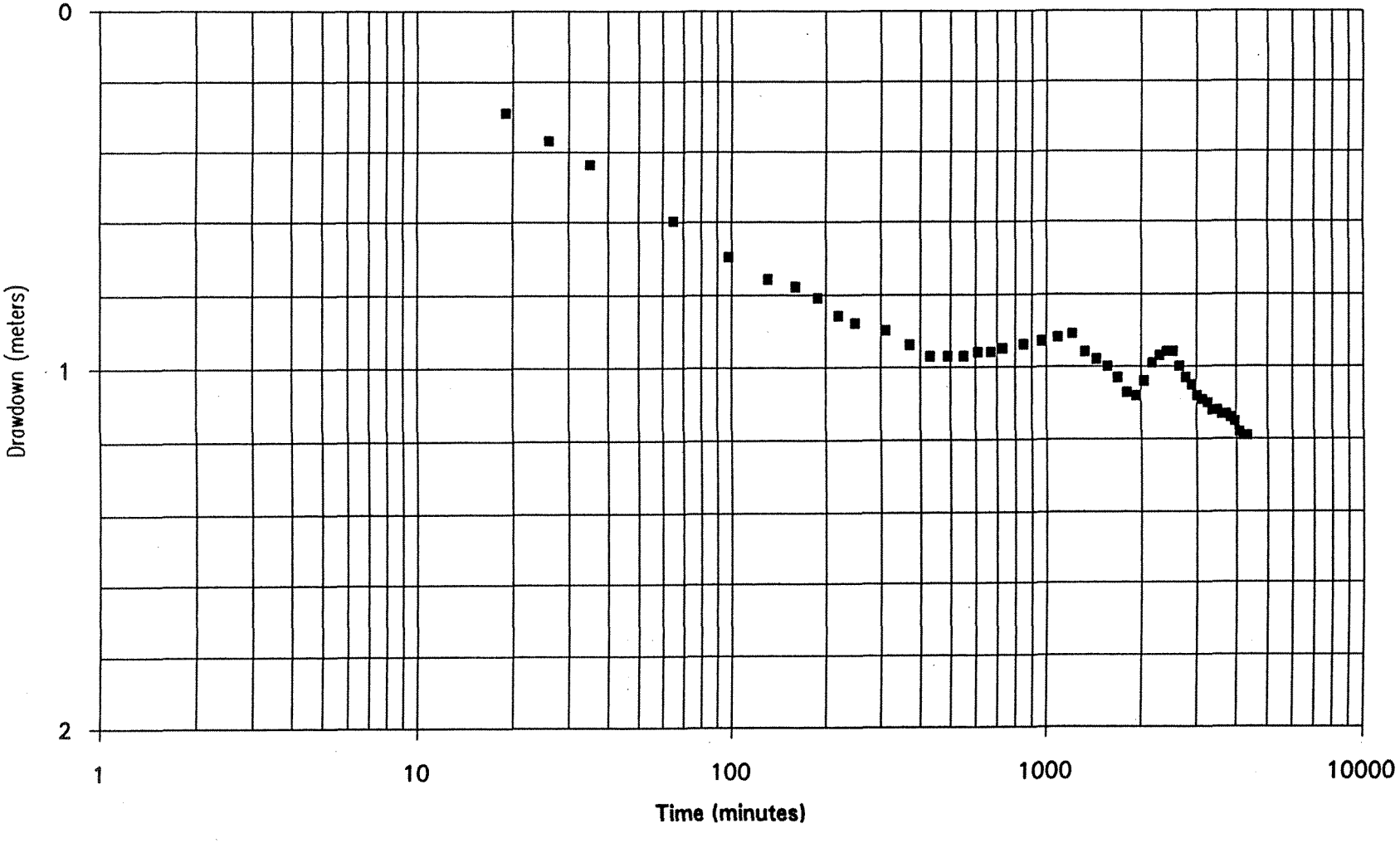

TABLE 4-6: FIELD PUMP TEST INFORMATION
Observation Well TW 2, Pumping TW 4

Well No:	TW 2	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	29.9 m
Date:	April 8, 1991	Static Water Level:	0.94 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
0		0.94	0.00			
15		1.63	0.69			328
21		1.76	0.82			
29		1.88	0.94			
37		1.97	1.03			
59		2.13	1.19			
68		2.18	1.24			
95		2.29	1.35			
127		2.36	1.42			
156		2.42	1.48			
185		2.46	1.52			
217		2.53	1.59			
246		2.55	1.61			
312		2.58	1.64			
372		2.63	1.69			
432		2.67	1.73			
492		2.67	1.73			
552		2.67	1.73			
612		2.66	1.72			
672		2.67	1.73			
732		2.66	1.72			
852		2.66	1.72			
972		2.66	1.72			
1092		2.67	1.73			
1212		2.67	1.73			
1332		2.69	1.75			
1452		2.70	1.76			
1572		2.72	1.78			
1692		2.76	1.82			
1812		2.78	1.84			
1932		2.80	1.86			
2052		2.76	1.82			
2172		2.74	1.80			
2292		2.72	1.78			
2412		2.69	1.75			
2532		2.70	1.76			

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TABLE 4-6: FIELD PUMP TEST INFORMATION (cont'd)
Observation Well TW 2, Pumping TW 4

Well No:	TW 2	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	29.9 m
Date:	April 8, 1991	Static Water Level:	0.94 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
2652		2.76	1.82			
2772		2.75	1.81			
2892		2.78	1.84			
3012		2.81	1.87			
3132		2.82	1.88			
3252		2.83	1.89			
3372		2.84	1.90			
3492		2.85	1.91			
3612		2.85	1.91			
3732		2.86	1.92			
3852		2.87	1.93			
3972		2.87	1.93			
4092		2.89	1.95			
4212		2.91	1.97			
4320		2.91	1.97			

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TABLE 4-7: PUMP TEST ANALYSIS
Observation Well TW 2, Pumping TW 4

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown	0.75	327.50	1.97	-	80.04

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
80.04	1.39E-03	72.00	4.83E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
80.04	25.00	1110.57	169.65

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PUMP TEST ANALYSIS - 30066
Drawdown TW 2, Pumping TW 4

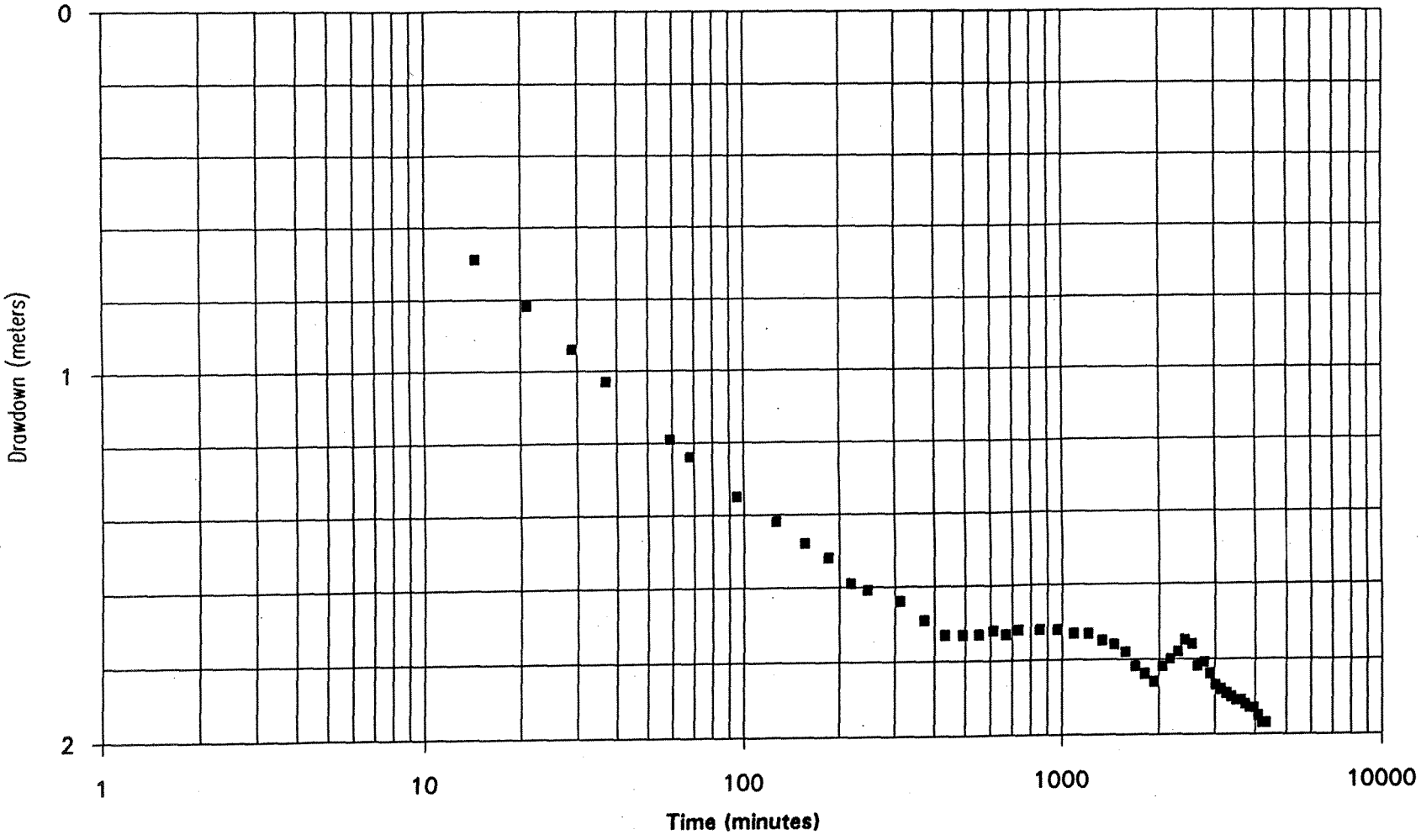

TABLE 4-8: FIELD PUMP TEST INFORMATION
Observation Well TW 3, Pumping TW 4

Well No:	TW 3	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	29.9 m
Date:	April 8, 1991	Static Water Level:	0.31 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
0		0.31	0.00			
16		0.78	0.47			328
23		0.91	0.60			
31		1.02	0.71			
39		1.12	0.81			
61		1.29	0.98			
93		1.43	1.12			
123		1.52	1.21			
153		1.59	1.28			
183		1.63	1.32			
213		1.69	1.38			
243		1.73	1.42			
314		1.76	1.45			
374		1.83	1.52			
434		1.88	1.57			
494		1.88	1.57			
554		1.89	1.58			
614		1.88	1.57			
674		1.89	1.58			
734		1.88	1.57			
854		1.89	1.58			
974		1.90	1.59			
1094		1.89	1.58			
1214		1.88	1.57			
1334		1.90	1.59			
1454		1.92	1.61			
1574		1.94	1.63			
1694		1.97	1.66			
1814		1.99	1.68			
1934		2.01	1.70			
2054		1.98	1.67			
2174		1.95	1.64			
2294		1.93	1.62			
2414		1.92	1.61			
2534		1.92	1.61			
2654		1.93	1.62			

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TABLE 4-8: FIELD PUMP TEST INFORMATION (cont'd)
Observation Well TW 3, Pumping TW 4

Well No:	TW 3	Pumping Rate:	327.5 m3/day
Well Loc.:	Moose Creek	Depth of Pump:	29.9 m
Date:	April 8, 1991	Static Water Level:	0.31 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Discharge Rate (m3/day)
2774		1.97	1.66			
2894		1.98	1.67			328
3014		2.20	1.89			
3134		2.04	1.73			
3254		2.06	1.75			
3374		2.08	1.77			
3494		2.10	1.79			
3614		2.10	1.79			
3734		2.11	1.80			
3854		2.11	1.80			
3974		2.10	1.79			
4094		2.12	1.81			
4214		2.13	1.82			
4320		2.13	1.82			

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TABLE 4-9: PUMP TEST ANALYSIS
Observation Well TW 3, Pumping TW 4

Calculation of Transmissivity from Pump Test Curves

Pump Test Portion	Delta s (m)	Q (m3/day)	Total Drawdown (m)	Specific Capacity (m2/day)	T (m2/day)
Drawdown	0.80	327.50	1.82	-	75.04

Calculation of Storativity from Pump Test Curves

T (m2/day)	t0 (days)	Radius (meters)	Storativity
75.04	2.78E-03	115.00	3.55E-05

Calculation of Safe Yields from Transmissivities

T (m2/day)	Available Drawdown (m)	20 Year Safe Yield (m3/day)	20 Year Safe Yield (igpm)
75.04	25.00	1041.16	159.05

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PUMP TEST ANALYSIS - 30066
Drawdown TW 3, Pumping TW 4

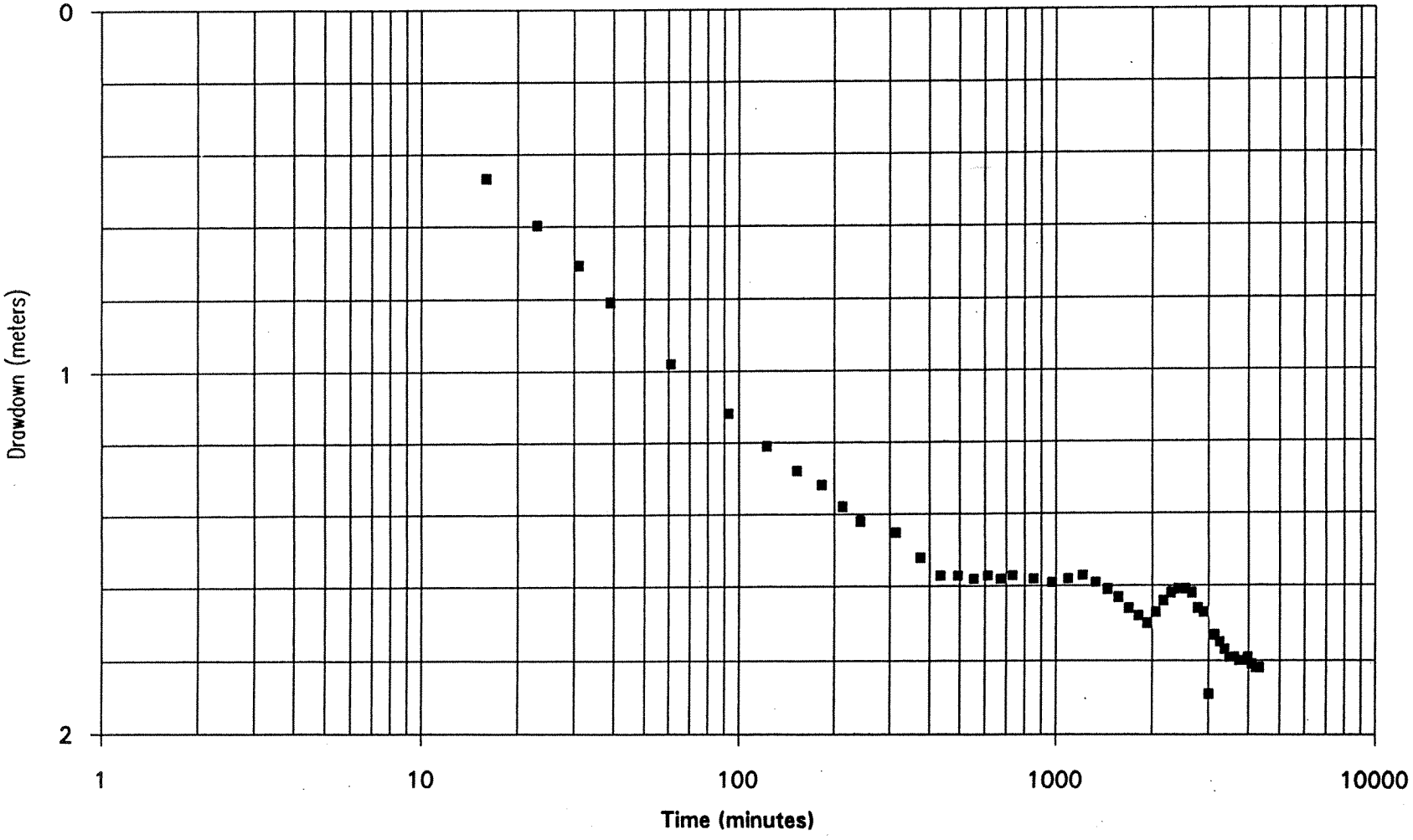

TABLE 4-10: SUMMARY OF AQUIFER PARAMETERS

Pumping TW 4

Transmissivity, Jacob Straight Line Method

TW 1	T =	122.5 m2/day
TW 2	T =	80.0 m2/day
TW 3	T =	75.0 m2/day
	Average T =	92.5 m2/day

Transmissivity, Theim Method

Between:

TW 1 & TW 2	T =	55.7 m2/day
TW 1 & TW 3	T =	32.1 m2/day
TW 2 & TW 3	T =	71.7 m2/day
	Average T =	53.2 m2/day

Average Transmissivity, Jacob Distance-Drawdown Method (at constant t)

Average T = 53.2 m2/day

Storativity, Jacob Straight Line Method

TW 1	S =	3.33E-05
TW 2	S =	4.82E-05
TW 3	S =	3.55E-05
	Average S =	3.90E-05

Average Storativity, Distance Drawdown Method

Average S = 3.18E-05

Average Aquifer Transmissivity =	66.3 m2/day
Average Aquifer Storativity =	3.54E-05
Average Aquifer 20 Year Safe Yield =	1283.9 m3/day
(assuming 25 m available drawdown)	196.0 igpm

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TABLE 5-1: 36 HOUR MULTIWELL TEST - TW 1

PART OF LOT 19, CONC. 6, TWP. OF ROXBOROUGH, ONTARIO

Test Conducted By:	Jacques Whitford Environment Limited
Pumping Began:	November 12, 1991 @ 2:30 p.m.
Pumping Ended:	November 14, 1991 @ 2:30 a.m. (36 hours)
Recovery Began:	November 14, 1991 @ 2:30 a.m.
Recovery Ended:	November 14, 1991 @ 2:30 p.m. (12 hours)

Well Data

Elevation (Estimated):	84 m (ASL)
Depth of hole:	30.5 m
Casing Length:	31.7 m
Annulus Diameter:	405 mm
Gravel Pack Gradation:	1/4 x 1/8 inch
Screen Slot Size:	80
Casing Diameter:	200 mm
Casing Stickup	1.2 m
Pump Type:	10 h.p. Submersible
Pump Setting:	25.9 m
Static Water Level (from TOC)):	4.1 m
Available Drawdown:	16.9 m
Recorded Drawdown (final):	13.5 m
Pumping Rate (final):	327.5 m3/day

Water Quality Parameters

Temperature, Electrical Conductivity, pH, Dissolved Oxygen, Hydrogen Sulphide
General analysis and bacteria: sampled October 16, 1991 @ 36 hours

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TABLE 5-2: FIELD INFORMATION - 36 HOUR MULTIWELL TEST

Pumping Well - TW 1

Well No:	TW 1	Pumping Rate (final):	327.5 m3/day
Well Loc.:	Moose Creek, Ont.	Depth of Pump:	25.9 m
Date:	November 12, 1991	Static Water Level:	4.1 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Q (m3/day)
0		4.10	0.00			360.0
1		8.05	3.95			
2		10.98	6.88			
3		12.82	8.72			
4		13.95	9.85			
6		15.22	11.12			
8		16.02	11.92			
10		16.54	12.44			
12		16.90	12.80			
14		17.15	13.05			
16		17.36	13.26			
18		17.10	13.00			
20		16.85	12.75			
26.5		14.60	10.50			327.5
30		15.60	11.50			
35		15.93	11.83			
40		16.05	11.95			
50		16.19	12.09			
60		16.32	12.22			
75		16.39	12.29			
105		16.53	12.43			
122		16.62	12.52			
150		16.72	12.62			
180		16.85	12.75			
240		16.78	12.68			
300		16.84	12.74			
360		16.92	12.82			
420		16.94	12.84			
480		16.96	12.86			
540		16.97	12.87			
600		17.10	13.00			
660		17.17	13.07			
720		17.19	13.09			
840		17.22	13.12			
960		17.23	13.13			
1080		17.24	13.14			
1200		17.25	13.15			

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TABLE 5-2: FIELD INFORMATION - 36 HOUR MULTIWELL TEST (cont'd.)
Pumping Well - TW 1

Well No:	TW 1	Pumping Rate (final):	327.5 m3/day
Well Loc.:	Moose Creek, Ont.	Depth of Pump:	25.9 m
Date:	November 12, 1991	Static Water Level:	4.1 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Q (m3/day)
1320		17.26	13.16			327.5
1440		17.29	13.19			
1560		17.35	13.25			
1680		17.38	13.28			
1800		17.41	13.31			
1920		17.48	13.38			
2040		17.53	13.43			
2160	0	17.58	13.48			
2161	1	12.85		8.75	2161	
2162	2	8.75		4.65	1081	
2163	3	7.68		3.58	721	
2164	4	7.27		3.17	541	
2165	5	6.83		2.73	433	
2166	6	6.76		2.66	361	
2167	7	6.73		2.63	310	
2168	8	6.70		2.60	271	
2170	10	6.64		2.54	217	
2172	12	6.58		2.48	181	
2174	14	6.53		2.43	155	
2176	16	6.49		2.39	136	
2178	18	6.45		2.35	121	
2180	20	6.39		2.29	109	
2185	25	6.30		2.20	87	
2190	30	6.24		2.14	73	
2195	35	6.19		2.09	63	
2200	40	6.13		2.03	55	
2205	45	6.09		1.99	49	
2210	50	6.03		1.93	44	
2215	55	6.00		1.90	40	
2220	60	5.92		1.82	37	
2230	70	5.90		1.80	32	
2250	90	5.86		1.76	25	
2310	150	5.72		1.62	15	
2370	210	5.68		1.58	11	
2430	270	5.62		1.52	9	
2490	330	5.52		1.42	8	
2550	390	5.40		1.30	7	
2610	450	5.31		1.21	6	
2670	510	5.19		1.09	5	
2760	600	5.05		0.95	5	
2880	720	4.95		0.85	4	

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Figure 5-1

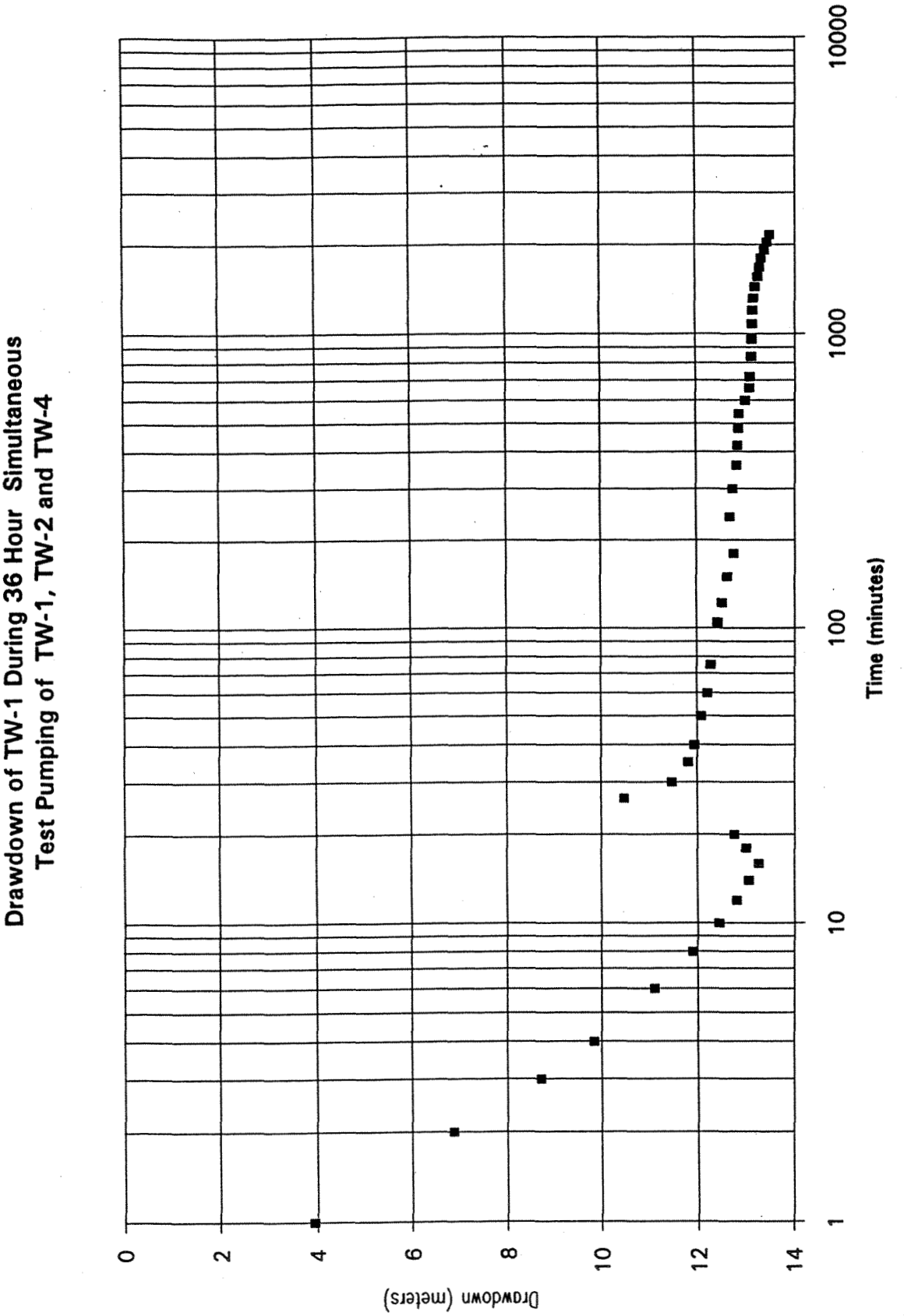
Drawdown of TW-1 During 36 Hour Simultaneous
Test Pumping of TW-1, TW-2 and TW-4
Drawdown (meters)
0
2
4
6
8
10
12
14
1
10
100
1000
10000
Time (minutes)

Figure 5-2

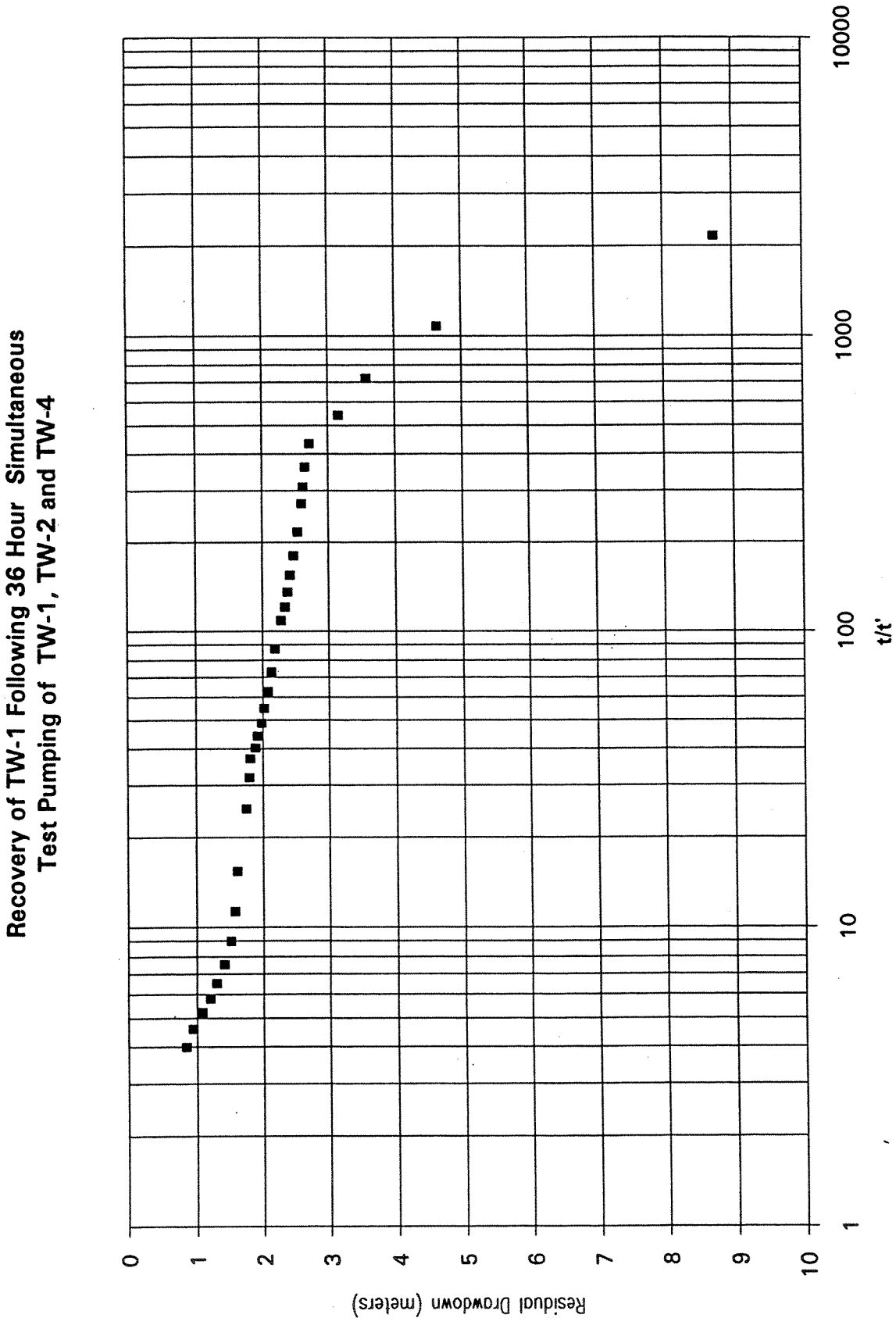
Recovery of TW-1 Following 36 Hour Simultaneous
Test Pumping of TW-1, TW-2 and TW-4
Residual Drawdown (meters)
0
1
2
3
4
5
6
7
8
9
10
1
10
100
1000
10000
t/t'

TABLE 5-3: 36 HOUR MULTIWELL TEST - TW 2

PART OF LOT 19, CONC. 6, TWP. OF ROXBOROUGH, ONTARIO

Test Conducted By:	Jacques Whitford Environment Limited
Pumping Began:	November 12, 1991 @ 2:30 p.m.
Pumping Ended:	November 14, 1991 @ 2:30 a.m. (36 hours)
Recovery Began:	November 14, 1991 @ 2:30 a.m.
Recovery Ended:	November 14, 1991 @ 2:30 p.m. (12 hours)

Well Data

Elevation (Estimated):	83 m (ASL)
Depth of hole:	30.8 m
Casing Length:	13.1 m
Annulus Diameter:	400 mm
Gravel Pack Gradation:	1/4 x 1/8 inch
Screen Slot Size:	80
Casing Diameter:	200 mm
Casing Stickup	0.9 m
Pump Type:	10 h.p. Submersible
Pump Setting:	25.9 m
Static Water Level (from TOC)):	2.3 m
Available Drawdown:	19.6 m
Recorded Drawdown (final):	17.1 m
Pumping Rate (final):	295 m3/day

Water Quality Parameters

Temperature, Electrical Conductivity, pH, Dissolved Oxygen, Hydrogen Sulphide
General analysis and bacteria: sampled October 16, 1991 @ 36 hours

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TABLE 5-4: FIELD INFORMATION - 36 HOUR MULTIWELL TEST

Pumping Well - TW 2

Well No:	TW 2	Pumping Rate (final):	295 m3/day
Well Loc.:	Moose Creek, Ont.	Depth of Pump:	25.9 m
Date:	November 12, 1991	Static Water Level:	2.27 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Q (m3/day)
0		2.27	0.00			229.0
1		5.25	2.98			
2		6.45	4.18			
3		7.20	4.93			
4		7.50	5.23			
5		7.80	5.53			
6		8.08	5.81			
7		8.28	6.01			
8		8.48	6.21			
9		8.63	6.36			
10		8.77	6.50			262.0
12		10.75	8.48			
14		12.43	10.16			
16		12.15	9.88			
18		12.37	10.10			
20		12.58	10.31			
29		12.83	10.56			
35		13.10	10.83			
40		13.34	11.07			
50		13.69	11.42			
61		13.80	11.53			
80		13.74	11.47			
93		13.71	11.44			
100		13.79	11.52			
120		13.85	11.58			295.0
167		17.94	15.67			
188		18.04	15.77			
252		18.23	15.96			
310		18.35	16.08			
370		18.54	16.27			
430		18.57	16.30			
490		18.60	16.33			
550		18.63	16.36			
610		18.66	16.39			
663		18.66	16.39			
720		18.69	16.42			
840		18.64	16.37			
960		18.70	16.43			
1080		18.90	16.63			

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TABLE 5-4: FIELD INFORMATION - 36 HOUR MULTIWELL TEST (cont'd.)

Pumping Well - TW 2

Well No:	TW 2	Pumping Rate (final):	295 m3/day
Well Loc.:	Moose Creek, Ont.	Depth of Pump:	25.9 m
Date:	November 12, 1991	Static Water Level:	2.27 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Q (m3/day)
1200		18.94	16.67			295
1327		18.98	16.71			
1447		19.37	17.10			
1567		19.30	17.03			
1687		19.32	17.05			
1807		19.34	17.07			
1827		19.37	17.10			
2047		19.41	17.14			
2160	0	19.40	17.13	17.13		
2161	1	10.63		8.36	2161	
2162	2	8.35		6.08	1081	
2163	3	7.77		5.50	721	
2164	4	7.20		4.93	541	
2165	5	6.61		4.34	433	
2166	6	6.28		4.01	361	
2167	7	6.00		3.73	310	
2168	8	5.81		3.54	271	
2169	9	5.67		3.40	241	
2170	10	5.55		3.28	217	
2179	19	4.95		2.68	115	
2185	25	4.74		2.47	87	
2195	35	4.67		2.40	63	
2255	95	4.15		1.88	24	
2314	154	3.91		1.64	15	
2448	288	3.73		1.46	9	
2670	510	3.40		1.13	5	
2760	600	3.21		0.94	5	
2880	720	3.12		0.85	4	

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Figure 5-3

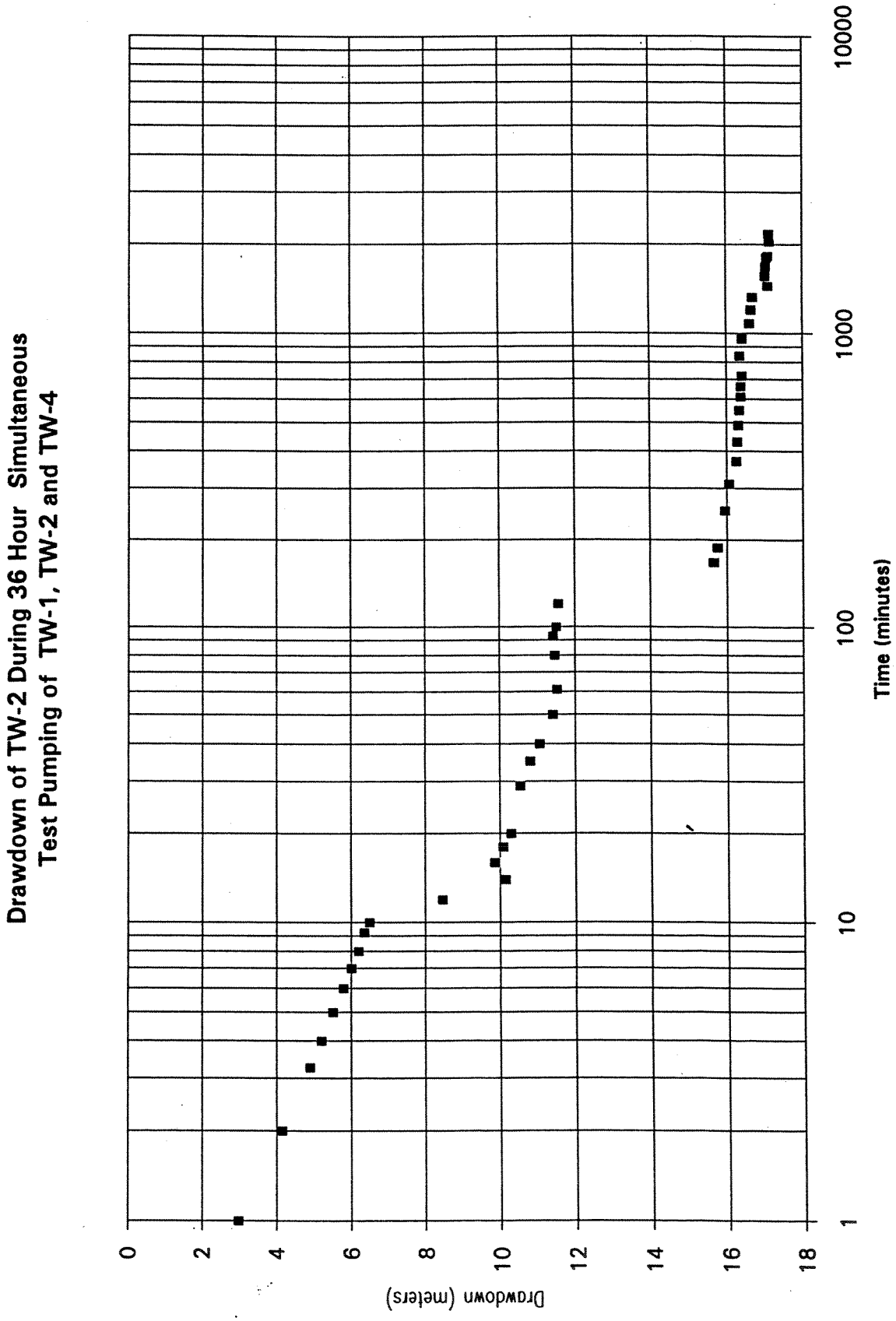
Drawdown of TW-2 During 36 Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4
Drawdown (meters)
0
2
4
6
8
10
12
14
16
18
Time (minutes)
1
10
100
1000
10000

Figure 5-4

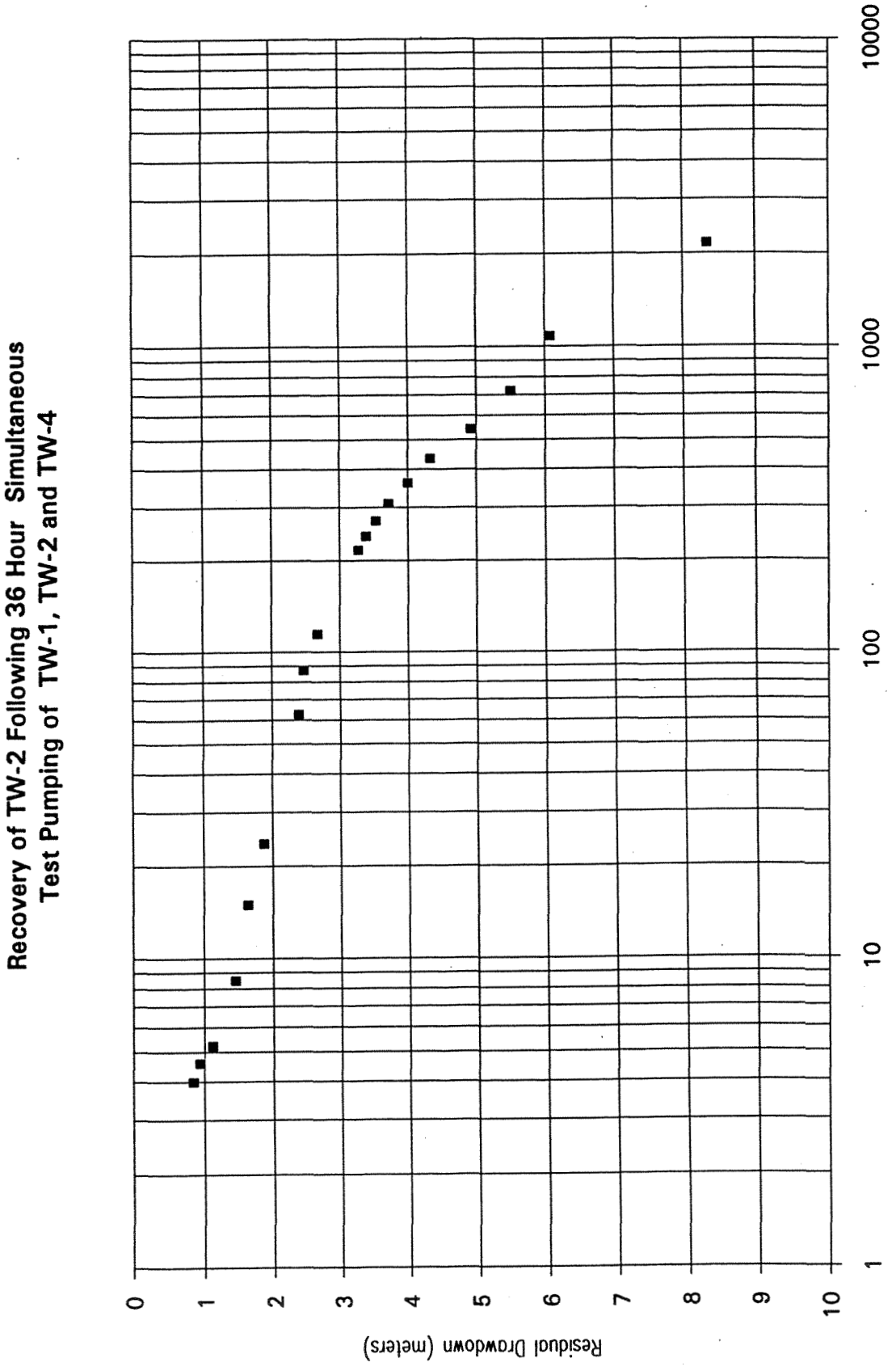
Recovery of TW-2 Following 36 Hour Simultaneous
Test Pumping of TW-1, TW-2 and TW-4
Residual Drawdown (meters)
0
1
2
3
4
5
6
7
8
9
10
1
10
100
1000
10000
t/t'

TABLE 5-5: 36 HOUR MULTIWELL TEST - TW 4

PART OF LOT 19, CONC. 6, TWP. OF ROXBOROUGH, ONTARIO

Test Conducted By:	Jacques Whitford Environment Limited
Pumping Began:	November 12, 1991 @ 2:30 p.m.
Pumping Ended:	November 14, 1991 @ 2:30 a.m. (36 hours)
Recovery Began:	November 14, 1991 @ 2:30 a.m.
Recovery Ended:	November 14, 1991 @ 2:30 p.m. (12 hours)

Well Data

Elevation (Estimated):	83 m (ASL)
Depth of hole:	32.0 m
Casing Length:	16.2 m
Annulus Diameter:	400 mm
Gravel Pack Gradation:	1/4 x 1/8 inch
Screen Slot Size:	80
Casing Diameter:	200 mm
Casing Stickup	0.6 m
Pump Type:	10 h.p. Submersible
Pump Setting:	25.9 m
Static Water Level (from TOC)):	2.2 m
Available Drawdown:	23.6 m
Recorded Drawdown (final):	15.7 m
Pumping Rate (final):	295 m3/day

Water Quality Parameters

Temperature, Electrical Conductivity, pH, Dissolved Oxygen, Hydrogen Sulphide

General analysis and bacteria: sampled October 16, 1991 @ 36 hours

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TABLE 5-6: FIELD INFORMATION - 36 HOUR MULTIWELL TEST
Pumping Well - TW 4

Well No:	TW 4	Pumping Rate (final):	295 m3/day
Well Loc.:	Moose Creek, Ont.	Depth of Pump:	25.9 m
Date:	November 12, 1991	Static Water Level:	2.22 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Q (m3/day)
0		2.22	0.00			
1		9.80	7.58			295
2		14.87	12.65			
3		14.96	12.74			
4		13.34	11.12			
6		13.14	10.92			360
8		15.48	13.26			
10		18.46	16.24			
12		19.73	17.51			
14		20.40	18.18			
16		20.71	18.49			
18		21.55	19.33			
20		22.00	19.78			
25		22.42	20.20			
30		22.57	20.35			
37		22.71	20.49			
43		22.77	20.55			
50		22.76	20.54			295
60		18.77	16.55			
82		18.04	15.82			
102		18.16	15.94			
121		18.05	15.83			
159		17.94	15.72			
194		17.10	14.88			
245		17.20	14.98			
305		17.26	15.04			
365		17.30	15.08			
425		17.34	15.12			
485		17.39	15.17			
545		17.42	15.20			
605		17.48	15.26			
668		17.48	15.26			
728		17.55	15.33			
848		17.53	15.31			
968		16.67	14.45			
1098		17.59	15.37			
1208		17.64	15.42			
1329		17.66	15.44			
1443		17.70	15.48			

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TABLE 5-6: FIELD INFORMATION - 36 HOUR MULTIWELL TEST (cont'd)
Pumping Well - TW 4

Well No:	TW 4	Pumping Rate (final):	295 m3/day
Well Loc.:	Moose Creek, Ont.	Depth of Pump:	25.9 m
Date:	November 12, 1991	Static Water Level:	2.22 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Q (m3/day)
1563		17.72	15.50			295
1683		17.73	15.51			
1803		17.75	15.53			
1923		17.76	15.54			
2043		17.79	15.57			
2100		17.81	15.59			
2160	0	17.93	15.71	15.71		
2184	24	5.43		3.21	91	
2191	31	4.67		2.45	71	
2261	101	4.37		2.15	22	
2320	160	3.85		1.63	15	
2356	196	3.69		1.47	12	
2670	510	3.65		1.43	5	
2760	600	3.16		0.94	5	
2880	720	3.01		0.79	4	

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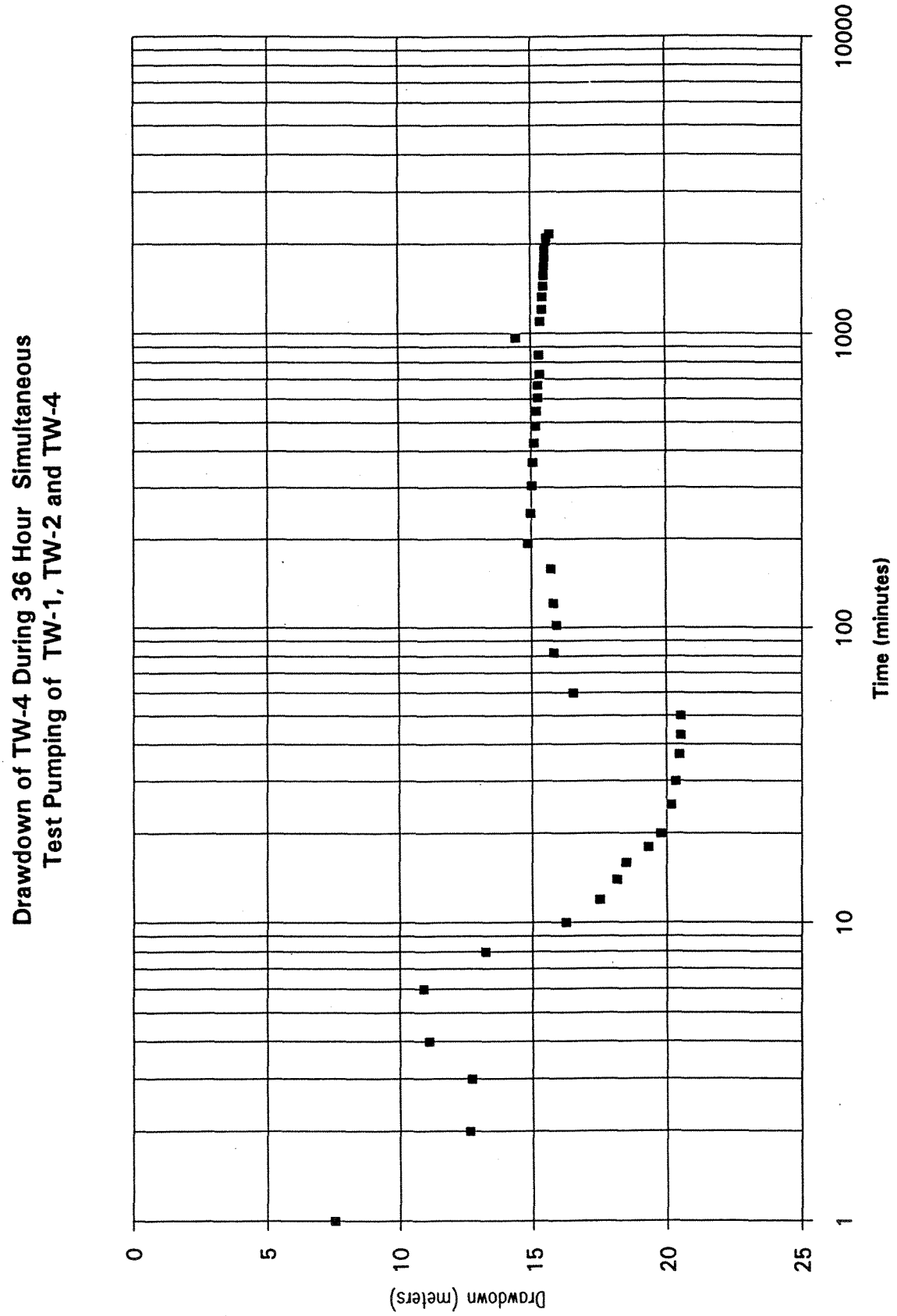
Drawdown of TW-4 During 36 Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4
Drawdown (meters)
0
5
10
15
20
25
1
10
100
1000
10000
Time (minutes)

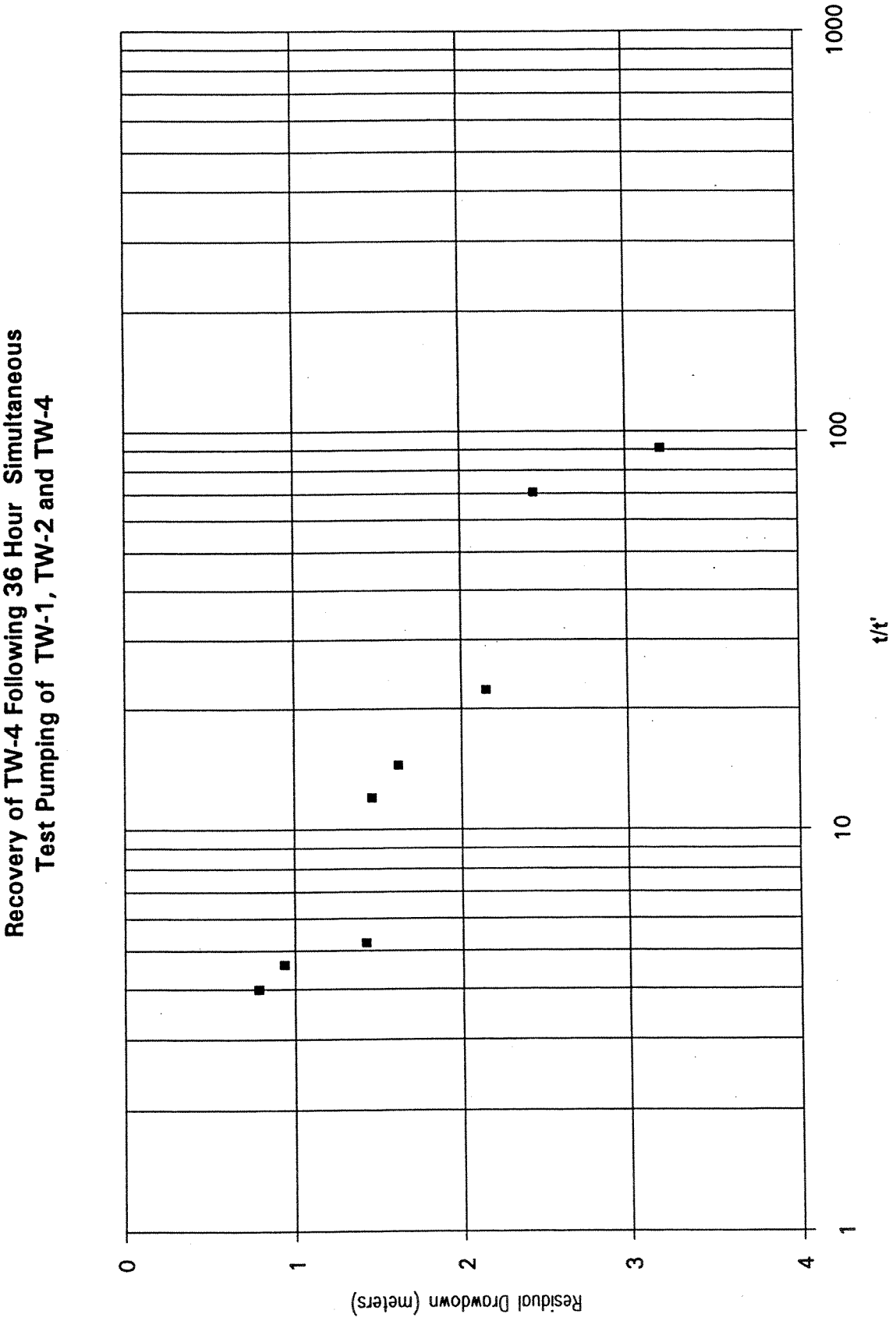
Recovery of TW-4 Following 36 Hour Simultaneous
Test Pumping of TW-1, TW-2 and TW-4
Residual Drawdown (meters)
0
1
2
3
4
1
10
100
1000
t/t'

TABLE 5-7: FIELD INFORMATION - 36 HOUR MULTIWELL TEST
Observation Well - TW 3

Well No:	TW 3	Pumping Rate (total):	917 m3/day
Well Loc.:	Moose Creek, Ont.	Depth of Pump:	25.9 m
Date:	November 12, 1991	Static Water Level:	1.08 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Q (m3/day)
0		1.08	0.00			
20		3.10	2.02			
34		3.51	2.43			
42		3.74	2.66			
52		3.99	2.91			
60		4.28	3.20			
101		4.52	3.44			
120		4.64	3.56			
162		5.18	4.10			
200		5.35	4.27			
247		5.57	4.49			
307		5.68	4.60			
367		5.80	4.72			
427		5.91	4.83			
487		5.94	4.86			
547		5.99	4.91			
607		6.08	5.00			
669		6.10	5.02			
725		6.14	5.06			
845		6.18	5.10			
965		6.24	5.16			
1085		6.28	5.20			
1205		6.31	5.23			
1327		6.34	5.26			
1448		6.36	5.28			
1568		6.41	5.33			
1688		6.42	5.34			
1808		6.43	5.35			
1928		6.46	5.38			
2048		6.49	5.41			
2160	0	6.51	5.43	5.43		
2196	36	4.91		3.83	61	
2257	97	3.00		1.92	23	
2336	176	2.75		1.67	13	
2380	220	2.57		1.49	11	
2670	510	2.16		1.08	5	
2760	600	2.04		0.96	5	
2880	720	1.93		0.85	4	

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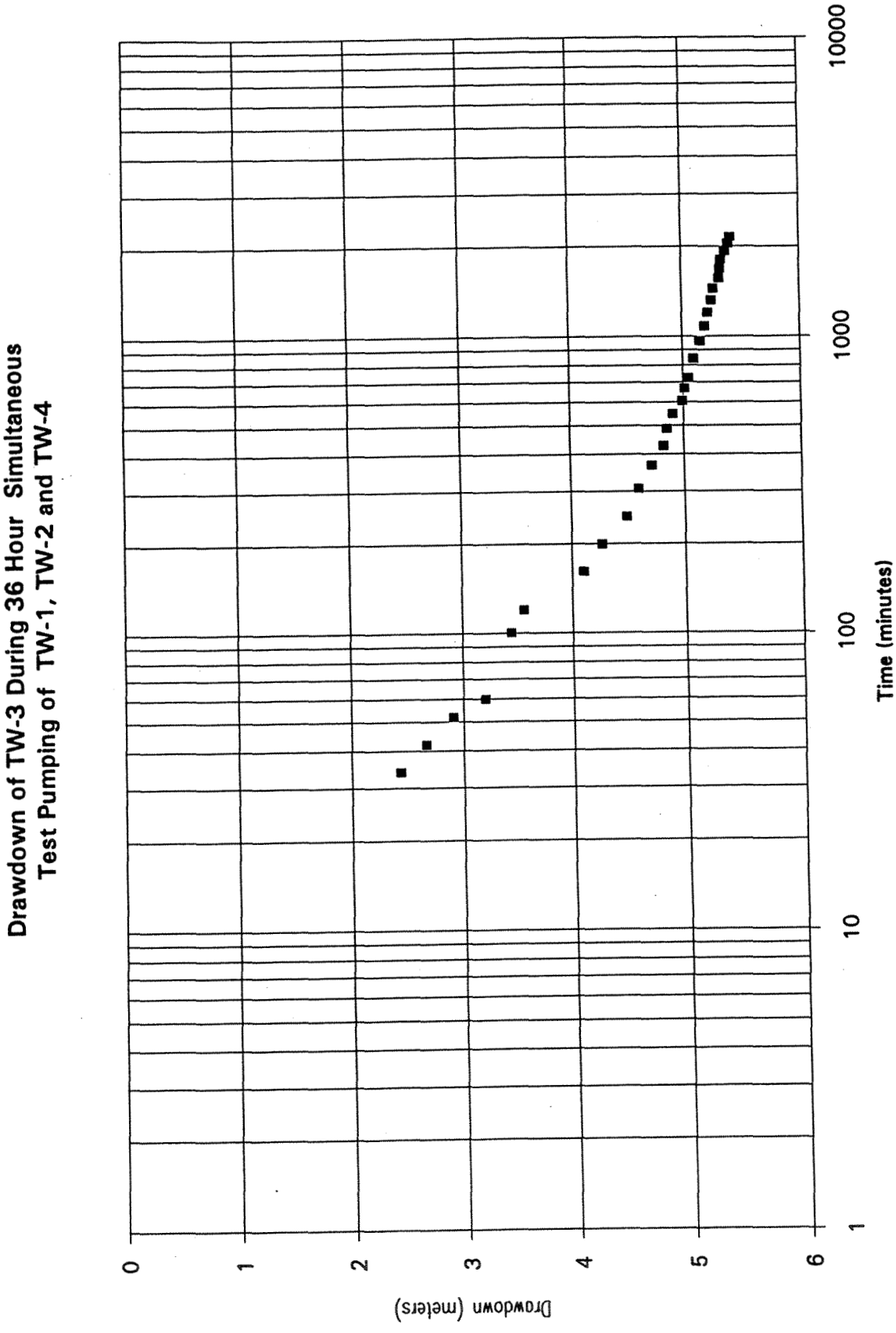
Figure 5-7


Drawdown of TW-3 During 36 Hour Simultaneous
Test Pumping of TW-1, TW-2 and TW-4
Drawdown (meters)
0
1
2
3
4
5
6
1
10
100
1000
10000
Time (minutes)

Recovery of TW-3 Following 36 Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4

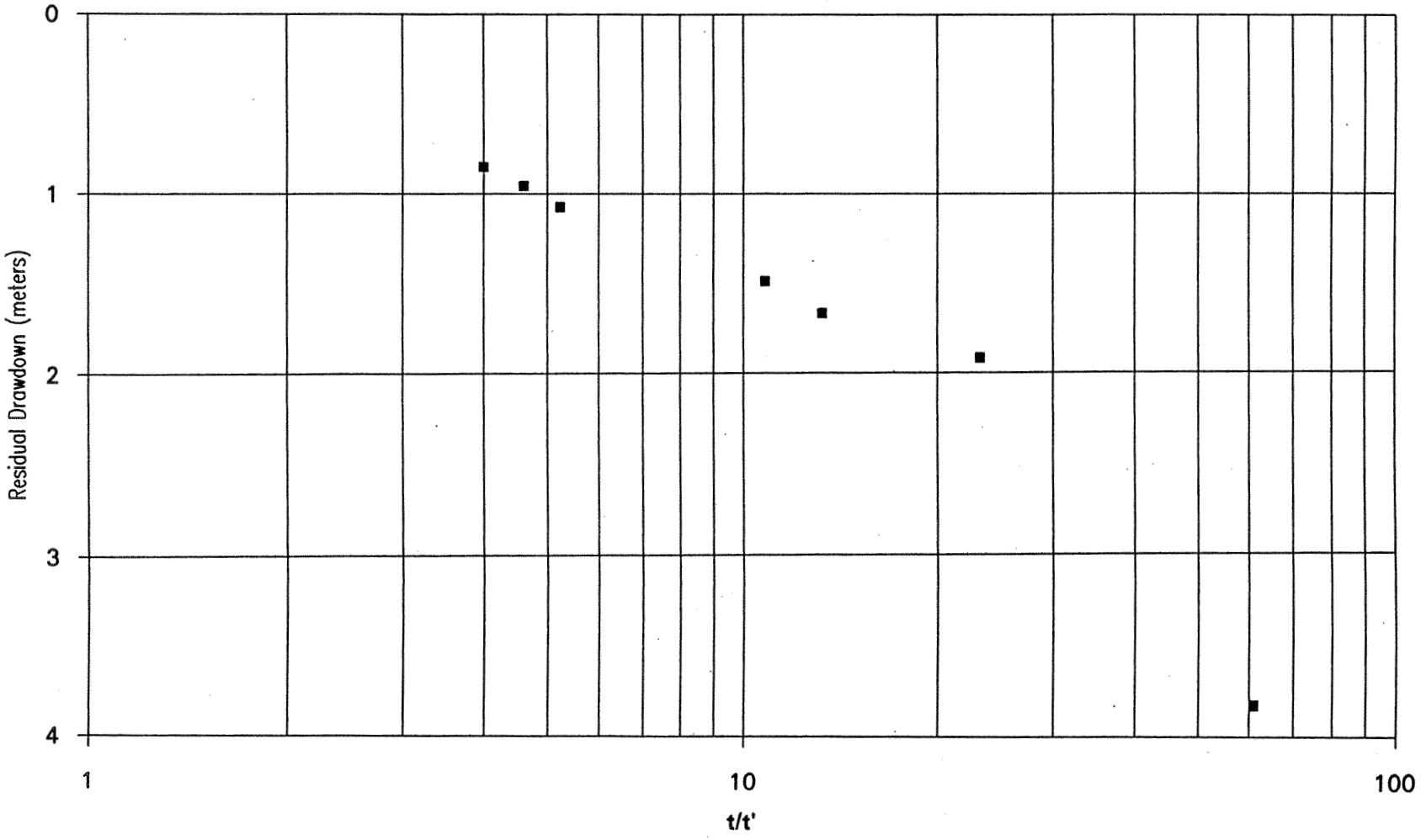


Figure 5-8

Figure 5-9

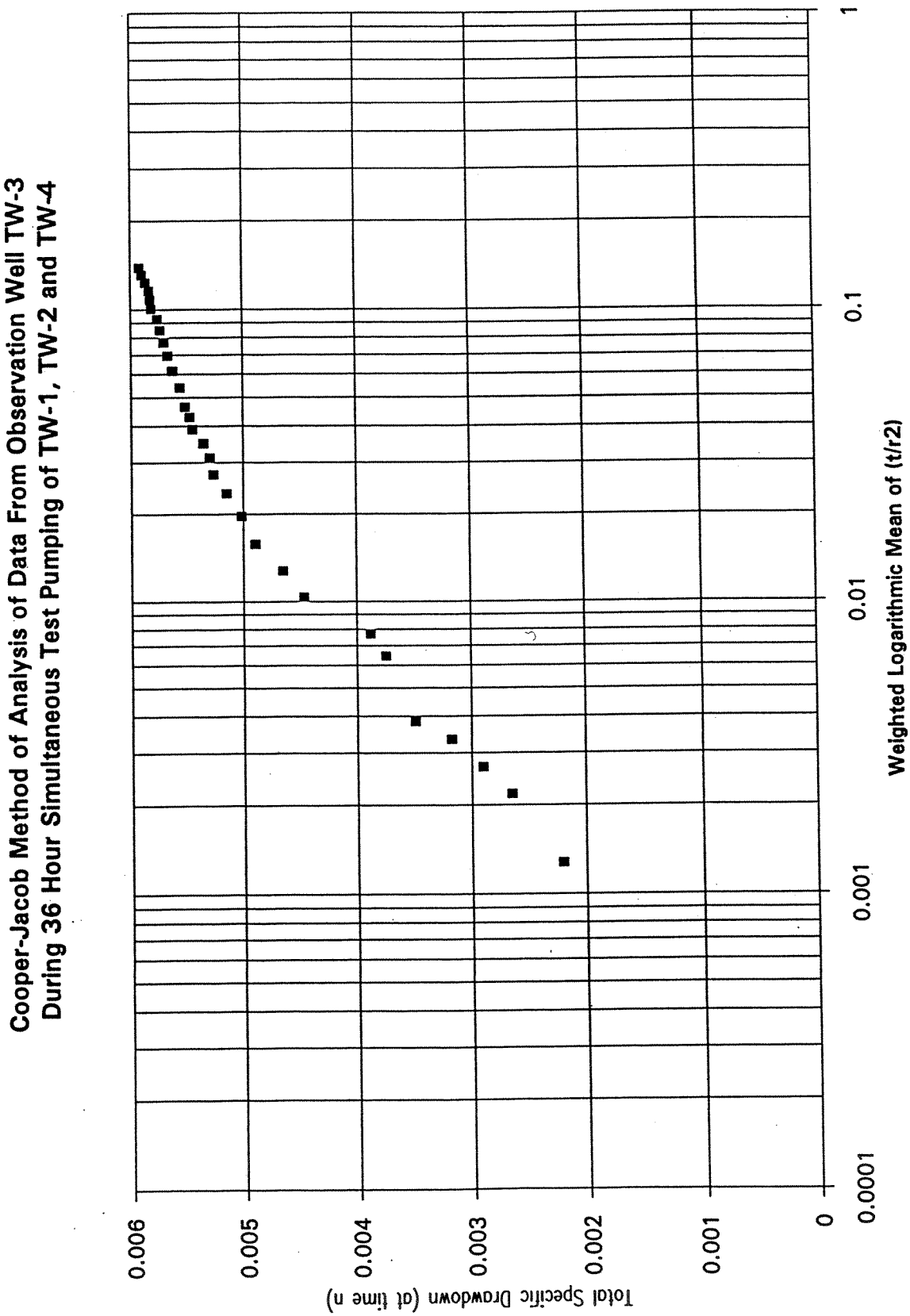

Cooper-Jacob Method of Analysis of Data From Observation Well TW-3
During 36 Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4
Total Specific Drawdown (at time n)
0.006
0.005
0.004
0.003
0.002
0.001
0
0.0001
0.001
0.01
0.1
1
Weighted Logarithmic Mean of (t/r2)

TABLE 5-8: FIELD INFORMATION - 36 HOUR MULTIWELL TEST
Observation Well - OW -1

Well No:	OW-1	Pumping Rate (total):	917 m3/day
Well Loc.:	Moose Creek, Ont.	Depth of Pump:	25.9 m
Date:	November 12, 1991	Static Water Level:	2.58 m

Time (min)	t'	W.L. (m)	Drawdown (m)	Residual Drawdown (m)	t/t'	Q (m3/day)
0		2.58	0.00			
20		4.23	1.65			
30		4.71	2.13			
35		4.99	2.41			
40		5.15	2.57			
50		5.20	2.62			
155		5.40	2.82			
197		5.53	2.95			
242		5.63	3.05			
302		5.69	3.11			
362		5.78	3.20			
602		5.98	3.40			
670		6.01	3.43			
730		6.04	3.46			
850		6.08	3.50			
970		6.11	3.53			
1099		6.13	3.55			
1210		6.15	3.57			
1322		6.13	3.55			
1441		6.18	3.60			
1561		6.20	3.62			
1681		6.20	3.62			
1801		6.21	3.63			
1921		6.24	3.66			
2041		6.24	3.66			
2161	0	6.29	3.71	3.71		
2265	105	4.37		1.79	22	
2325	165	4.16		1.58	14	
2372	212	4.05		1.47	11	
2670	510	3.65		1.07	5	
2760	600	3.53		0.95	5	
2880	720	3.41		0.83	4	

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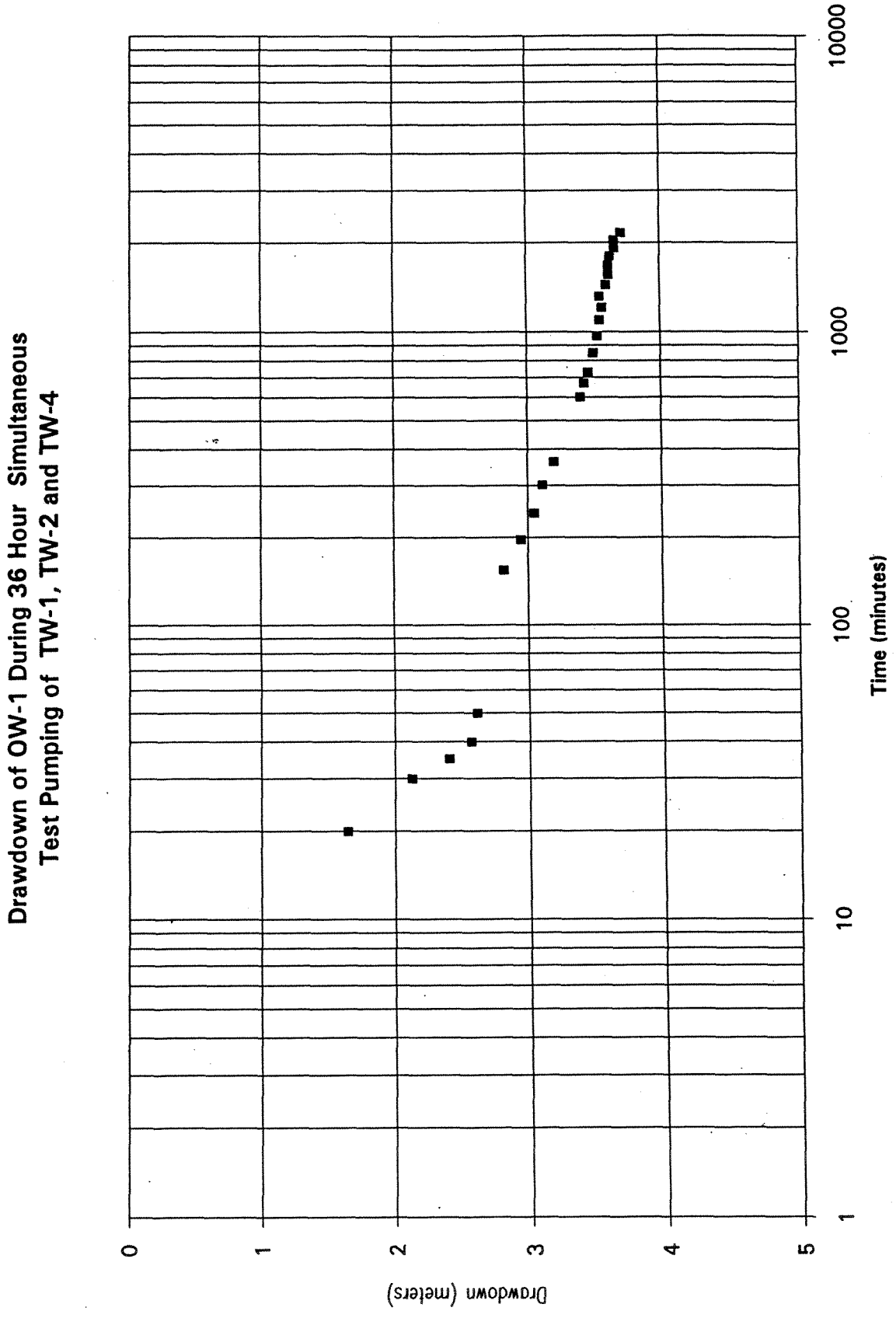
Figure 5-10


Drawdown of OW-1 During 36 Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4
Drawdown (meters)
0
1
2
3
4
5
Time (minutes)
1
10
100
1000
10000

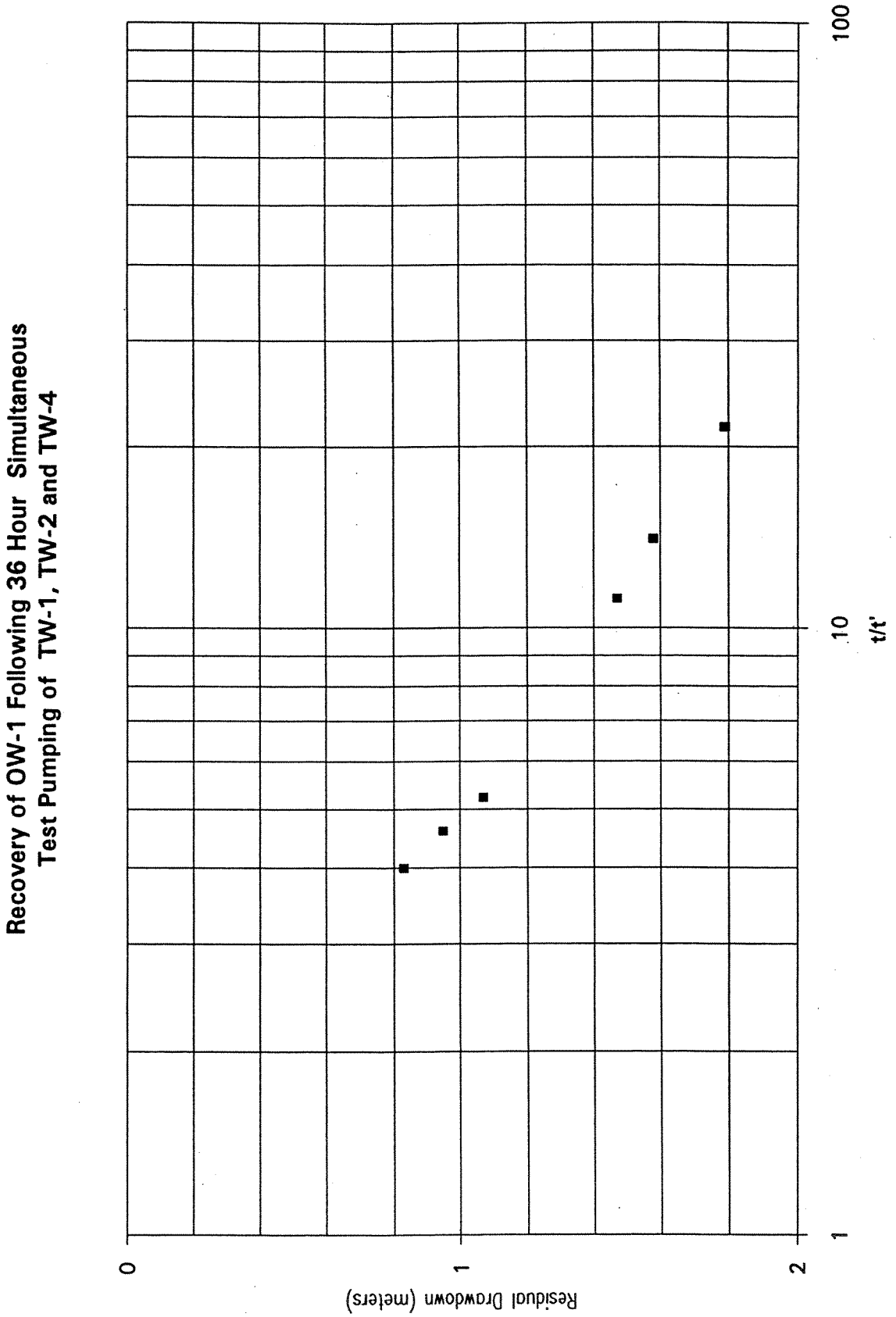

Recovery of OW-1 Following 36 Hour Simultaneous
Test Pumping of TW-1, TW-2 and TW-4
Residual Drawdown (meters)
0
1
2
1
10
100
t/t'

Figure 5-12

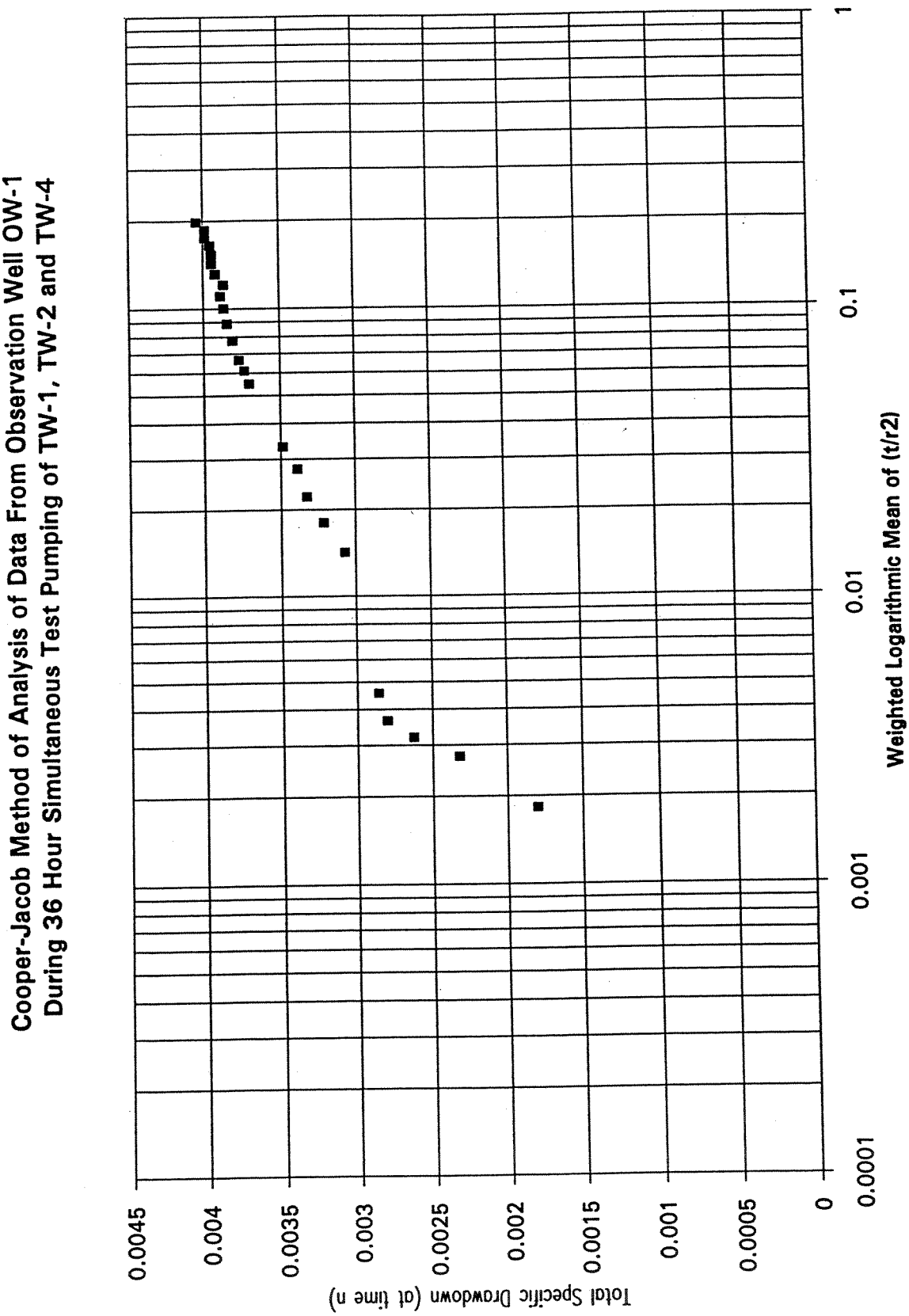

Cooper-Jacob Method of Analysis of Data From Observation Well OW-1
During 36 Hour Simultaneous Test Pumping of TW-1, TW-2 and TW-4
Total Specific Drawdown (at time n)
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
0.0001
0.001
0.01
0.1
1
Weighted Logarithmic Mean of (t/r2)

TABLE 5-9: SUMMARY OF AQUIFER PARAMETERS
Observation Well Data

Transmissivity, Cooper-Jacob Method

Northern Portion of Aquifer at:	OW 1	T=	215 m2/day
Southern Portion of Aquifer at:	TW 3	T=	129 m2/day

Storativity , Cooper-Jacob Method

Northern Portion of Aquifer at:	OW 1	S=	1.74E-03 *
Southern Portion of Aquifer at:	TW 3	S=	0.032 *

20 Year Aquifer Safe Yield		m3/day	igpm
Northern Portion of Aquifer at:	OW 1 =	2929	447
Southern Portion of aquifer at:	TW 3 =	1758	268

* This method may produce erroneously high storage coefficients. It will suffice to say that the northern portion of the aquifer displays a higher storativity by about one order of magnitude than the southern portion.

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TABLE 6-1: WATER QUALITY ANALYSES

72 - HOUR PUMPING TEST, COLLECTED AT 3 HOURS

PARAMETER	UNITS	TW-1	ODWO
		HEALTH-RELATED PARAMETERS	
Sodium	mg/L	9.8	20
Fluoride	mg/L	< 0.1	2.4
Ammonia	mg/L	< 0.03	
Nitrite	mg/L	< 0.1	1
Nitrate	mg/L	< 0.1	10
Turbidity	FTU	3.9	1
		AESTHETIC PARAMETERS	
Colour	TCU	17	1
Hardness	mg/L	238	
Alkalinity	mg/L	203	
Conductivity	µS/cm	510	
TDS	mg/L	319	500
pH		7.32	
Chloride	mg/L	6.6	250
Sulphate	mg/L	35.7	500
Calcium	mg/L	69.3	
Magnesium	mg/L	15.8	
Potassium	mg/L	1.6	
TKN	mg/L	0.3	
Iron	mg/L	0.23	0.3
Manganese	mg/L	< 0.005	0.05
Hydrog. Sulphide	mg/L	< 0.01	0.05
Phenols	mg/L	< 0.002	0.002
Tannin/Lignin	mg/L	0.1	
Silicon	mg/L	6.64	
TOC	mg/L	2	5
		HEALTH-RELATED BACTERIOLOGICAL PARAMETERS	
Total Coliform	/100 mL	0	5
Fecal Coliform	/100 mL	0	1
Fecal Strep.	/100 mL	0	

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TABLE 6-2: WATER QUALITY ANALYSES - "TABLE 4", ODWO 72 - HOUR PUMPING TEST

TABLE 4A
HEALTH-RELATED PARAMETERS (MAC)

PARAMETER	UNIT	TW 1	MOE GUIDELINE
Arsenic	mg/L	< 0.01	0.05
Barium	mg/L	0.17	1
Boron	mg/L	0.04	5
Cadmium	mg/L	< 0.004	0.005
Chromium	mg/L	< 0.01	0.05
Cyanide	mg/L	< 0.02	0.2
Fluoride	mg/L	< 0.1	2.4
Lead	mg/L	< 0.04	0.05
Mercury	mg/L	< 0.001	0.001
Nitrate	mg/L	< 0.1	10
Nitrite	mg/L	< 0.1	1
NTA	mg/L	< 0.2	0.05
Selenium	mg/L	< 0.01	0.01
Silver	mg/L	< 0.01	0.05
Turbidity	FTU	1.3	1
Pesticides			
Aldrin	ug/L	< 0.1	0.7
Dieldrin	ug/L	< 0.05	0.7
Carbaryl	ug/L	< 0.1	70
Chlordane	ug/L	< 0.4	7
DDT	ug/L	< 0.03	30
Diazinon	ug/L	< 0.4	14
Endrin	ug/L	< 0.02	0.2
Heptachlor	ug/L	< 0.1	3
Hep. epoxide	ug/L	< 0.1	3
Lindane	ug/L	< 0.01	4
Methoxychlor	ug/L	< 0.2	100
Methyl Parathion	ug/L	< 0.2	7
Parathion	ug/L	< 0.3	35
Toxaphene	ug/L	< 1	5
2,4-D	ug/L	< 0.3	100
2,4,5-TP	ug/L	< 0.2	10

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TABLE 6-2: WATER QUALITY ANALYSES - "TABLE 4"(con't)
72 - HOUR PUMPING TEST

TABLE 4A
HEALTH-RELATED PARAMETERS (MAC)

PARAMETER	UNIT	TW 1	MOE GUIDELINE
Radionuclides			
Tritium	beq/L	< 100	40000
Cobalt-60	beq/L	< 1	
Strontium-90	beq/L	< 1	10
Iodine-131	beq/L	< 1	10
Cesium-134	beq/L	< 1	
Cesium-137	beq/L	< 1	50
Radium-226	beq/L	< 0.1	1
Trihalomethanes			
Chloroform	mg/L	< 0.001	0.35
Dichlorobromometha	mg/L	< 0.001	0.35
Chlorobromomethane	mg/L	< 0.001	0.35
Bromoform	mg/L	< 0.001	0.35

TABLE 4B
HEALTH-RELATED PARAMETERS (IMAC)

PCB's	ug/L	< 0.1	3
Uranium	ug/L	< 0.1	20

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TABLE 6-2: WATER QUALITY ANALYSES - "TABLE 4" (con't)
72 - HOUR PUMPING TEST

TABLE 4C
AESTHETIC PARAMETERS (MDC)

PARAMETER	UNIT	TW 1	MOE GUIDELINE
Chloride	mg/L	7.0	250
Colour	TCU	< 1	5
Copper	mg/L	< 0.01	1
Iron	mg/L	0.96	0.3
Manganese	mg/L	0.037	0.05
Methane	L/m3	< 0.01	3
Odour			inofffensive
Organic Nitrogen	mg/L	0.08	0.15
Phenols	mg/L	< 0.002	0.002
Sulphate	mg/L	42.5	500
Sulphide	mg/L	< 0.01	< 0.01
Taste			inoffensive
TDS	mg/L	310	500
TOC	mg/L	3	5
Zinc	mg/L	0.13	5

TABLE 4D
HEALTH-RELATED BACTERIOLOGICAL PARAMETERS

Total Coliform	/100 mL	0	10
Fecal Coliform	/100 mL	0	0
Fecal Strep.	/100 mL	0	

OTE: MAC = Maximum Allowable Concentration
IMAC = Interim Maximum Allowable Concentration
MDC = Maximum Desirable Concentration

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TABLE 6-3: WATER QUALITY ANALYSES - "TABLE 4", ODWO
72 - HOUR PUMPING TEST

TABLE 4A
HEALTH-RELATED PARAMETERS (MAC)

PARAMETER	UNIT	TW 2	MOE GUIDELINE
Arsenic	mg/L	< 0.01	0.05
Barium	mg/L	0.33	1
Boron	mg/L	0.11	5
Cadmium	mg/L	<0.004	0.005
Chromium	mg/L	< 0.01	0.05
Cyanide	mg/L	< 0.02	0.2
Fluoride	mg/L	< 0.1	2.4
Lead	mg/L	< 0.04	0.05
Mercury	mg/L	< 0.001	0.001
Nitrate	mg/L	<0.1	10
Nitrite	mg/L	<0.1	1
NTA	mg/L	< 0.02	0.05
Selenium	mg/L	< 0.01	0.01
Silver	mg/L	< 0.01	0.05
Turbidity	FTU	< 1	1
Pesticides			
Aldrin	ug/L	< 0.1	0.7
Dieldrin	ug/L	< 0.05	0.7
Carbaryl	ug/L	< 0.1	70
Chlordane	ug/L	< 0.4	7
DDT	ug/L	< 0.03	30
Diazinon	ug/L	< 0.4	14
Endrin	ug/L	< 0.02	0.2
Heptachlor	ug/L	< 0.1	3
Hep. epoxide	ug/L	< 0.1	3
Lindane	ug/L	< 0.01	4
Methoxychlor	ug/L	< 0.2	100
Methyl Parathion	ug/L	< 0.2	7
Parathion	ug/L	< 0.3	35
Toxaphene	ug/L	< 1	5
2,4-D	ug/L	< 0.3	100
2,4,5-TP	ug/L	< 0.2	10

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TABLE 6-3: WATER QUALITY ANALYSES - "TABLE 4"(con't)
72 - HOUR PUMPING TEST

TABLE 4A
HEALTH-RELATED PARAMETERS (MAC)

PARAMETER	UNIT	TW 2	MOE GUIDELINE
Radionuclides			
Tritium	beq/L	< 100	40000
Cobalt-60	beq/L	< 1	
Strontium-90	beq/L	< 1	10
Iodine-131	beq/L	< 1	10
Cesium-134	beq/L	< 1	
Cesium-137	beq/L	< 1	50
Radium-226	beq/L	< 0.1	1
Trihalomethanes			
Chloroform	mg/L	< 0.001	0.35
Dichlorobromometha	mg/L	< 0.001	0.35
Chlorobromomethane	mg/L	< 0.001	0.35
Bromoform	mg/L	< 0.001	0.35

TABLE 4B
HEALTH-RELATED PARAMETERS (IMAC)

PCB's	ug/L	< 0.1	3
Uranium	ug/L	< 0.1	20

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TABLE 6-3: WATER QUALITY ANALYSES - "TABLE 4" (con't)
72 - HOUR PUMPING TEST

TABLE 4C
AESTHETIC PARAMETERS (MDC)

PARAMETER	UNIT	TW 2	MOE GUIDELINE
Chloride	mg/L	11.5	250
Colour	TCU	1	5
Copper	mg/L	<0.01	1
Iron	mg/L	0.1	0.3
Manganese	mg/L	0.008	0.05
Methane	L/m3	< 0.01	3
Odour		Inoff.	inoffensive
Organic Nitrogen	mg/L	0.09	0.15
Phenols	mg/L	< 0.002	0.002
Sulphate	mg/L	39.9	500
Sulphide	mg/L	< 0.001	< 0.01
Taste		inoff.	inoffensive
TDS	mg/L	300	500
TOC	mg/L	3	5
Zinc	mg/L	0.01	5

TABLE 4D
HEALTH-RELATED BACTERIOLOGICAL PARAMETERS

Total Coliform	/100 mL	0	10
Fecal Coliform	/100 mL	0	0
Fecal Strep.	/100 mL	0	

OTE: MAC = Maximum Allowable Concentration
IMAC = Interim Maximum Allowable Concentration
MDC = Maximum Desirable Concentration

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TABLE 6-4: WATER QUALITY ANALYSES - "TABLE 4", ODWO
72 - HOUR PUMPING TEST

TABLE 4A
HEALTH-RELATED PARAMETERS (MAC)

PARAMETER	UNIT	TW 4	MOE GUIDELINE
Arsenic	mg/L	< 0.005	0.05
Barium	mg/L	0.433	1
Boron	mg/L	0.072	5
Cadmium	mg/L	< 0.004	0.005
Chromium	mg/L	< 0.005	0.05
Cyanide	mg/L	< 0.02	0.2
Fluoride	mg/L	< 0.1	2.4
Lead	mg/L	< 0.03	0.05
Mercury	mg/L	< 0.001	0.001
Nitrate	mg/L	<0.1	10
Nitrite	mg/L	<0.1	1
NTA	mg/L	< 0.02	0.05
Selenium	mg/L	< 0.005	0.01
Silver	mg/L	< 0.005	0.05
Turbidity	FTU	< 1	1
Pesticides			
Aldrin	ug/L	< 0.1	0.7
Dieldrin	ug/L	< 0.05	0.7
Carbaryl	ug/L	< 0.02	70
Chlordane	ug/L	< 0.4	7
DDT	ug/L	< 0.03	30
Diazinon	ug/L	< 0.4	14
Endrin	ug/L	< 0.02	0.2
Heptachlor	ug/L	< 0.1	3
Hep. epoxide	ug/L	< 0.1	3
Lindane	ug/L	< 0.001	4
Methoxychlor	ug/L	< 0.02	100
Methyl Parathion	ug/L	< 0.2	7
Parathion	ug/L	< 0.3	35
Toxaphene	ug/L	< 5	5
2,4-D	ug/L	< 0.3	100
2,4,5-TP	ug/L	< 0.2	10

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TABLE 6-4: WATER QUALITY ANALYSES - "TABLE 4"(con't)
72 - HOUR PUMPING TEST

TABLE 4A
HEALTH-RELATED PARAMETERS (MAC)

PARAMETER	UNIT	TW 4	MOE GUIDELINE
Radionuclides			
Tritium	beq/L	< 100	40000
Cobalt-60	beq/L	< 1	
Strontium-90	beq/L	< 1	10
Iodine-131	beq/L	< 1	10
Cesium-134	beq/L	< 1	
Cesium-137	beq/L	< 1	50
Radium-226	beq/L	< 0.1	1
Trihalomethanes			
Chloroform	mg/L	< 0.002	0.35
Dichlorobromometha	mg/L	< 0.002	0.35
Chlorobromomethane	mg/L	< 0.002	0.35
Bromoform	mg/L	< 0.002	0.35

TABLE 4B
HEALTH-RELATED PARAMETERS (IMAC)

PCB's	ug/L	< 1	3
Uranium	ug/L	< 0.10	20

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TABLE 6-4: WATER QUALITY ANALYSES - "TABLE 4" (con't)
72 - HOUR PUMPING TEST

TABLE 4C
AESTHETIC PARAMETERS (MDC)

PARAMETER	UNIT	TW 4	MOE GUIDELINE
Chloride	mg/L	11.9	250
Colour	TCU	< 1	5
Copper	mg/L	<0.01	1
Iron	mg/L	0.06	0.3
Manganese	mg/L	0.005	0.05
Methane	L/m3	< 0.001	3
Odour		Inoff.	inoffensive
Organic Nitrogen	mg/L	< 0.68	0.15
Phenols	mg/L	0.002	0.002
Sulphate	mg/L	32.9	500
Sulphide	mg/L	< 0.01	< 0.01
Taste		inoff.	inoffensive
TDS	mg/L	319	500
TOC	mg/L	3	5
Zinc	mg/L	<0.01	5

TABLE 4D
HEALTH-RELATED BACTERIOLOGICAL PARAMETERS

Total Coliform	/100 mL	0	10
Fecal Coliform	/100 mL	0	0
Fecal Strep.	/100 mL	0	

OTE: MAC = Maximum Allowable Concentration
IMAC = Interim Maximum Allowable Concentration
MDC = Maximum Desirable Concentration

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TABLE 6-5: WATER QUALITY ANALYSES
36 - HOUR MULTIWELL PUMPING TEST

PARAMETER	UNITS	TW-1	TW-2	TW-4	ODWO
		HEALTH-RELATED PARAMETERS			
Sodium	mg/L	8.0	19.1	21.7	20
Fluoride	mg/L	< 0.1	< 0.1	< 0.1	2.4
Ammonia	mg/L	0.04	0.17	0.22	
Nitrite	mg/L	< 0.1	< 0.1	< 0.1	1
Nitrate	mg/L	< 0.1	< 0.1	< 0.1	10
Turbidity	FTU	0.8	0.7	0.7	1
		AESTHETIC PARAMETERS			
Colour	TCU	1	< 1	< 1	1
Hardness	mg/L	276	224	205	
Alkalinity	mg/L	206	188	205	
Conductivity	µS/cm	560	520	500	
TDS	mg/L	350	326	312	500
pH		7.10	7.25	7.30	
Chloride	mg/L	5.7	12.1	16.1	250
Sulphate	mg/L	43.7	39.6	32.1	500
Calcium	mg/L	81.3	51.5	41.0	
Magnesium	mg/L	17.8	23.2	25.0	
Potassium	mg/L	2.2	4.4	4.9	
TKN	mg/L	1.2	0.6	0.6	
Iron	mg/L	0.22	0.08	0.15	0.3
Manganese	mg/L	0.045	0.016	0.005	0.05
Hydrog. Sulphide	mg/L	< 0.01	< 0.01	< 0.01	0.05
Phenols	mg/L	0.002	0.003	0.003	0.002
Tannin/Lignin	mg/L	< 0.1	< 0.1	< 0.1	
Silicon	mg/L	8.68	8.70	8.61	
TOC	mg/L	4	3	3	5
		HEALTH-RELATED BACTERIOLOGICAL PARAMETERS			
Total Coliform	/100 mL	0	0	0	5
Fecal Coliform	/100 mL	0	0	0	1
Fecal Strep.	/100 mL	0	0	0	

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