STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN FOR THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN IN THE REPUBLIC OF NAMIBIA

Japan International Cooperation Agency

Pacific Consultants International

BOREHOLE FINAL REPORT

Borehole

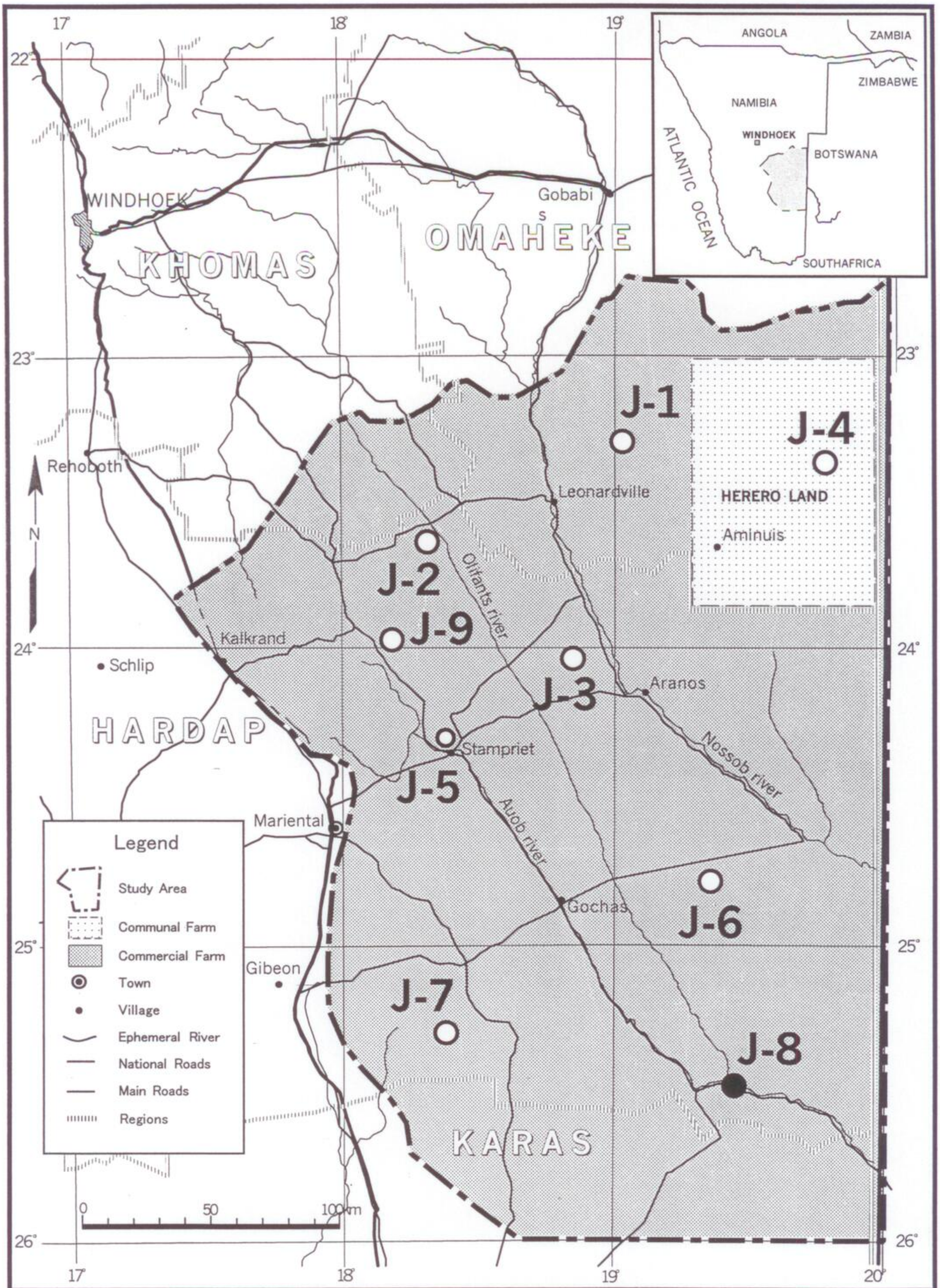
J8-K (WW 39854)

Twee Reviere R481

METZGER PM DRILLING
P.O.Box 11733
Windhoek
Namibia

Windhoek

October 2000



Location Map of Test Boreholes

THE STUDY ON THE GROUNDWATER IN THE STAMPRIET ARTESIAN BASIN | JICA

Contents per Chapter

1. Geological Borehole Log

THE STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN IN THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN

GEOLOGICAL BOREHOLE LOG

Farm Twee Reviere **WW 39854**
Jica Reference: J 8 K **S 25.46122°**
Date completed: 21 / 07 / 2000 **E 19.43266°**
Collar elev.: 1015 m

Depth below surface (m)	Section (m)	Lithology	Stratigraphy
0 - 3	3	**Calcrete**, moderately karsted. Shallow cover of pale orange sand. Karst cavities filled with orange to pale red sand.	
3 - 12	9	Pinkish calcretized **conglomerate**. Matrix is a fine to medium grained pinkish grey calcareous sandstone, with pebbles and boulders of grey and brown quartzite and sandstone.	
12 - 14	2	Very light grey to white sandy **calcrete**.	**KALAHARI**
14 - 19	5	Pale grey to pale brown sandy **calcrete**. Drill-cuttings recovered in a clayey mass. Saline encrustations on dry cuttings. (= sulphate ?)	
19 - 30	11	Pale grey to white sandy **calcrete** with minor clayey horizons at 23 & 28 m. At 21 m red sandstone pebbles in calcareous sandstone matrix.	
30 - 36	6	**Sandstone** very pale brown, mostly fine grained unsorted, calcareous. Grains sub-rounded. Saline coating on dry drill cuttings.	
36 – 129 EOH	105	**Sandstone**, generally pale reddish brown, gradually changing to reddish brown at depth. Grain-size unsorted, very fine to medium, and generally finer grained at 135 to 141 m. Aquifer (saline!) Collected drill cuttings when dried before washing all develope a white saline coating.	

REMARKS:

1. Screens from 84,60 m to 96,30 m and from 102.30 m to 114.0 m.
2. Gravel emplaced up to 12 m from ground level. Total length of gravelpack is 117 m.
3. This borehole was drilled by the mud-rotary method, resulting in a highly ground mass of drill-cuttings, which have to be carefully washed and interpreted.

This borehole was logged by F. Bockmuhl.

2. Penetration Record

	Penetration Record Borehole J 8 K WW 39854				
Depth (m)	Pen. Rate (min/m)	Time	Date	Remarks	
1		Time 12:30	Date 16/7/00	Drilling Air rotary 311mm	
5					
10					
	1.05				
	1.8				
	2.1				
	2.3				
	2.25				
	2.05				
	1.8				
	2.2				
20					
	2.6				
	3.25				
	2.15	Time 14:24			
	2.45				
	2.25				
	2.5				
	2.7				
	2.85				
	1.4				
30	2				
	2.2				
	2.2				
	2.7				
	2.45				
	2.6				
	2.35				
	2.35				
	2.3				
	2.3				
40	2.25				
	2.1				
	2.85				
	2.3	Time 15:25			
	2.1				
	1.85				
	1.6				
	1.7				
	2				
	1.75				
50	2.7				
	1.65				
	1.6				
	1.5				

	2.75				
	1.15				
	1.15				
	1.05				
	1.35				
	1.25				
60	1.2				
	1.65				
	1.1				
	1.6				
	1.15				
	0.95				
	0.85				
	0.95				
	1.05				
	1.05				
70	1.25				
	1.35				
	1.55				
	1.3				
	1.65				
	2.3				
	1.85				
	2.5				
	2.45	Time 16:47			
	2				
80	1.6				
	2.45				
	1.3				
	1.5				
	1.35				
	1.75				
	1.45				
	1.6				
	1.8				
	1.25				
90	1.4				
	1.4				
	0.9				
	1.3				
	1.65				
	1.1				
	0.9				
	0.95				
	1.25				
	1.25				
100	1.4				
	0.85				
	0.95				
	1.7				
	1.45				
	1.3				
	1.45				
	1.7				
	1.4				
	1.6				

110	1.5				
	1.5				
	1.7				
	1.7				
	1.1				
	1.4				
	1.55				
	1.55				
	1.3				
	1.85				
120	1.95				
	1.55				
	1.5				
	0.9				
	0.9				
	1.1				
	1.4				
	0.75				
	0.6			End of borehole	

j8kpen

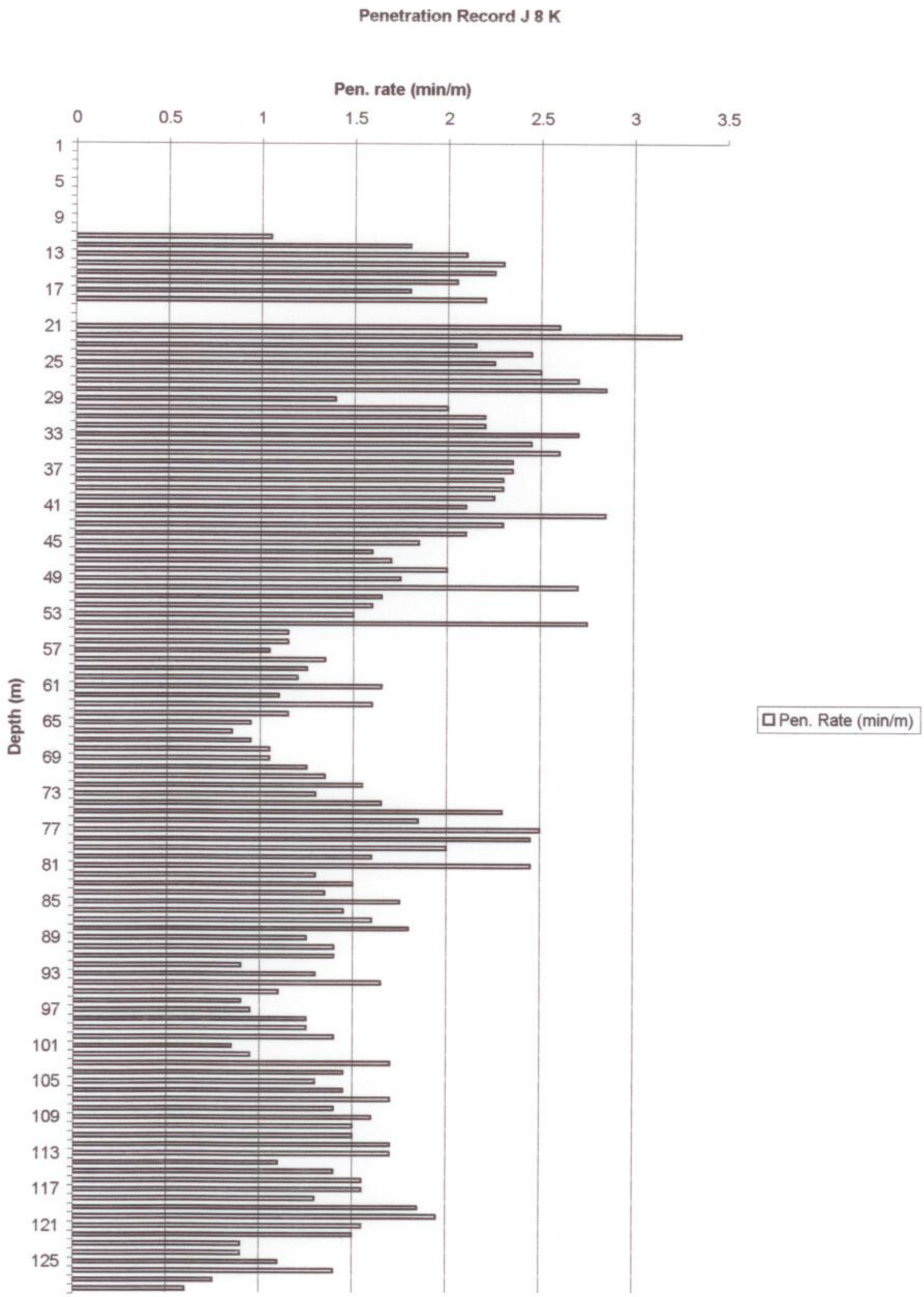


Chart2

3. Mud Rotary Drilling Log

THE STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN IN THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN

MUD ROTARY DRILLING LOG

JICA REFERENCE: J 8 K LOCALITY: Twee Reviere R 481 WW 39854 DATE: 17/07/00

TIME	DEPTH mbgl	MARSH FUNNEL TEST 1000 ml (sec)	MARSH FUNNEL TEST 500 ml (sec)	E. C. mS/cm	DENSITY	pH	TEMPERATURE ° C	COMMENT
16:47	78	28		7,25		9	21	Water used for air rotary drilling.
18:25	128	29		4,69		9	23	This borehole was drilled air rotary and filled with drillfluid as recorded.

This borehole was drilled by air rotary method, as better drill cuttings could be obtained.

4. Geophysical Log and Casing Design

Poseidon Geophysics

(Reg. No. 93550)

CO. Poseidon Geophysics
WELL..J8K WW 39854
PROJ.
LCN. Twee Riviere
STE. J 8
FILING No. J8K

CONSULTANT PACIFIC CONSULTANTS INTERNATIONAL

COMPANY METZGER PM DRILLING

PROJECT The Study on the Groundwater Potential Evaluation and Management Plan in the Southeast Kalahari (Stampriet) Artesian Basin

WELL ID J8K WW39854

LOCATION TWEE RIVIERE

COUNTRY REPUBLIC OF NAMIBIA

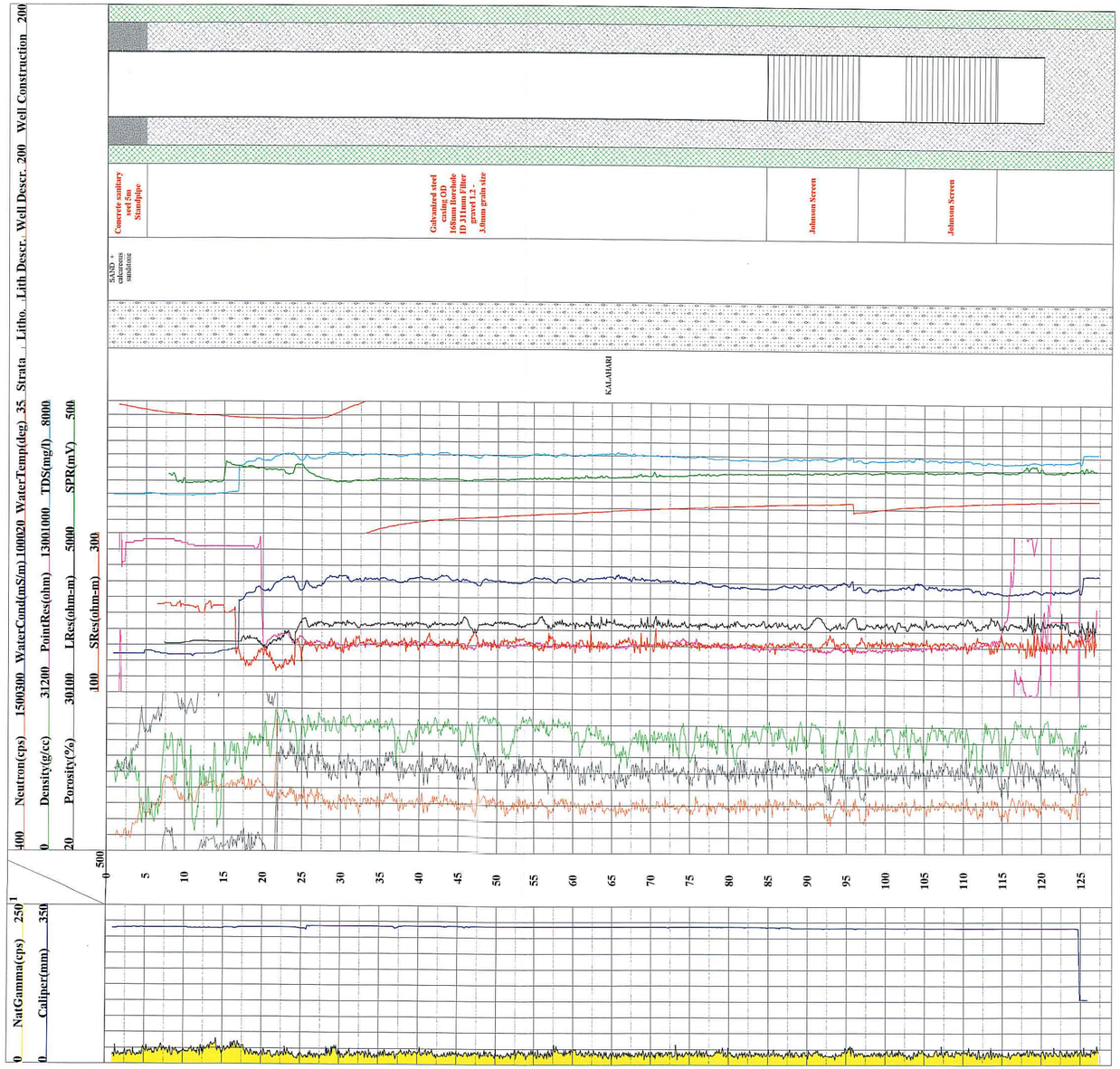
BH COORDINATES

COLLAR ELEVATION
LOG MEAS. FROM Groundlevel

DRILLING MEAS. FROM Groundlevel

DATE	18 July 2000
TYPE LOG	Physical Properties
DEPTH-DRILLER	129m
DEPTH-LOGGER	125.9
BTM LOGGED INTERVAL	125.9
TOP LOGGED INTERVAL	0.60m
PERMANENT DATUM	Groundlevel
RECORDED BY	Wimpie Coetzer
WITNESSED BY	Frank Bokmuhl

JAPAN INTERNATIONAL COOPERATION AGENCY



5. Borehole Development Data

THE STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN IN THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN

BOREHOLE DEVELOPMENT DATA

JICA REFERENCE: J 8 K LOCALITY: Twee Reviere R 481 WW 39854 DATE: 22/07/2000 (starting)

TIME (actual)	P.I.D. (mbsu)	½ 90° V-Notch (mm)	Yield (m^3/h)	E.C. (mS/m)	Water Level (mbsu)	Remarks
10:00						Date 22/07/00. **Cable Tool.** Plunging for 7 hours
08:00					41	Date 23/07/00. Plunge for 8 hours, bail 1 hour.
08:00				546	56.4	Date 24/07/00. plunge 5 hours, bail 4 hours.
12:00				480	60.80	Date 25/07/00. Plunge 1 hour, bail 3 hours.
08:00					60,60	Date 26/07/00. Bailing for 9 hours.
09:45	83					Date 28/07/00: **Airlift**
10:00					63.32	
11:00		25	0.25		63.24	
12:00		25			73.36	
13:00		25			74.50	
14:00	95	60	2.16		87.40	
15:00		30	0.36		87.42	
16:00		28			87.55	
16:30		25	0.25		87.44	Pump through the night.
09:00	107	30	0.36		69.34	Date 29/07/00.
10:00		35			74.42	
11:00		30			74.43	
12:00		30			75.44	
16:00		25	0.25		79.44	
17:00		28			82.54	

TIME (actual)	P.I.D. (mbsu)	½ 90° V-Notch (mm)	Yield (m^3/h)	E.C. (mS/m)	Water Level (mbsu)	Remarks
19:00	107	28	0.3		84.31	Pump through the night.
07:00						Date 30/07/00. Add pipes.
10:00	116	60			74.36	
11:00		40			75.56	
16:00		30	0.36		78.52	
19:00		28			78.42	Pump through the night.
07:00		25			82.43	
09:00	116	30	0.36		83.36	Stop airlift.

Remarks:

1. This borehole was also developed by electrical submersible pump on 9/8/00. Data captured below.

TIME (actual)	Pump time (min)	Water Level (mbsu)	Yield (m^3/h)	E.C. (mS/m)	Remarks
07:01	1	81.10			
	2	83.74			
	3	82.30			
	4	80.24			
	5	79.28			
	6	78.10			
	7	78.05			
	8	77.40			
	9	77.62			
	10	77.85	1.029		

TIME (actual)	Pump time (min)	Water Level (mbsu)	Yield (m^3/h)	E.C. (mS/m)	Remarks
	12	78.39			
	14	78.98			
	16	79.47	0.975		
	18	80.08			
	20	80.70			
	23	81.74			
	26	82.75	0.915		
	30	84.63			
	35	86.30		351	
	40	87.93			
	45	89.98	0.912		
	50	91.67			
	55	93.25			
	60	95.12	0.902		
	70	99.72	0.876		
	80	104.32	0.821		
	90	106.24			Close gate valve a little
	95	105.24	0.660		
	100	105.30	0.450		
	105	105.06			
	110	104.68			
	115	104.15			
	120	103.97			
	130	103.98		413	
	160	103.98	0.440		
	180	104.14			
	200		0.39		Close gate valve a little

TIME (actual)	Pump time (min)	Water Level (mbsu)	Yield (m^3/h)	E.C. (mS/m)	Remarks
	205		0.213		
	210	103.78	0.209		
	215				
	220	102.84			
	230		0.195		
	240	100.02	0.301		Open gatevalve
	250				
	260	99.35			
	270	98.95			
	280	98.48			
	300		0.307		
	320	97.29		463	
	340				
	360	96.13			
	380				
	400	95.24	0.310		
	420	94.82			
	440				
	460	94.26			
	480		0.317		
	500	93.73			
	520			405	
16:00	540	93.41	0.320		Stop developing. Measure recovery.
16:18		91.24			

6. Evaluation of Pumping Test

1. PUMPING TEST ANALYSIS

J8-K (WW39854) - Pumping well

J8-A (WW39855) - Observation well

J8-N (WW39856) - Observation well

1.1. Well Efficiency (Step Drawdown Test) (Annex 1)

Well Efficiency could not be evaluated due to the very low abstraction rates and minimal differences of the individual steps. The step draw down curve is presented in **Annex 1**.

The abstraction rates and respective draw down are summarised in **Table 1** below.

Table 1: J8-K: Borehole efficiency at various pumping rates

Borehole number	Step	Abstraction Rate [m^3/h]	Draw Down* [m]
J6-K	1	0.1	2.98
	2	0.2	6.07
	3	0.3	11.54
	4	0.4	19.65
	5	0.5	31.79

* at cut-off time Δt, after which well bore storage has no affect on the well performance

1.2. Constant Discharge Test Analysis (Annex 2 - 4)

The abstraction rate of the constant discharge test was 0.25 m^3/h. The constant discharge draw down curve of abstraction borehole **J8-K** and the Lithology indicate unconfined phreatic conditions. However, confined conditions cannot be excluded. The Theis method with draw down and recovery data was used to calculate the hydraulic conductivity of the aquifer **(Annex 2 & 3)**.

The rapid recovery to levels higher than the original rest water level could be an indication for clogging and ongoing borehole development during pump testing. In case of confined conditions this behaviour could be attributed to changes in atmospheric pressure.

At very low abstraction rates the standard pumping test evaluation becomes somewhat unreliable and the results should be compared with the results from the proposed slug test.

The aquifer storativity had to be estimated due to the fact that the observation boreholes **J8-A** and **J8-N** do not penetrate the same aquifer as **J8-K**. During the duration of the constant discharge test, a rise in the water levels of observation boreholes **J8-A** and **J8-N** is observed. (See **Annex 4**).

The results of the constant discharge analysis are summarised in **Table 2** below.

Table 2: Aquifer Parameters calculated for J8-K; Kalahari

Borehole number	Analysis method	T	s	k	S	Comments
		[m^2/day]	[m]	[cm/sec]	[-]	
J8-K	Theis-draw down	0.132	30	5.1×10^{-6}	$*5 \times 10^{-3}$	*Storativity estimated - Observation boreholes are not located in the tested aquifer
	Theis-recovery	0.122	30	4.7×10^{-6}	$*5 \times 10^{-3}$	

The Phreatic as well as the confined model was used to simulate and verify the actual data and analysis approach of the constant discharge test.

The radius of influence (R) was estimated after SICHARDT (1928) using the equation:

$R = 3000 \times s \times K_f^{1/2}$

$R = 3000 \times 17.3 \times 2.2 \times 10^{-4} = \underline{12\ m}$

where

R = Radius of influence

s = Draw down in abstraction borehole at end of pumping

K_f = Permeability of the aquifer

The equation is approximately correct for unconfined aquifers. The 12 m are considered to be the minimum value. The distance of the observation boreholes is, however, far beyond the radius of influence (J8-A = 121.7m and J8-N = 61.4 m).

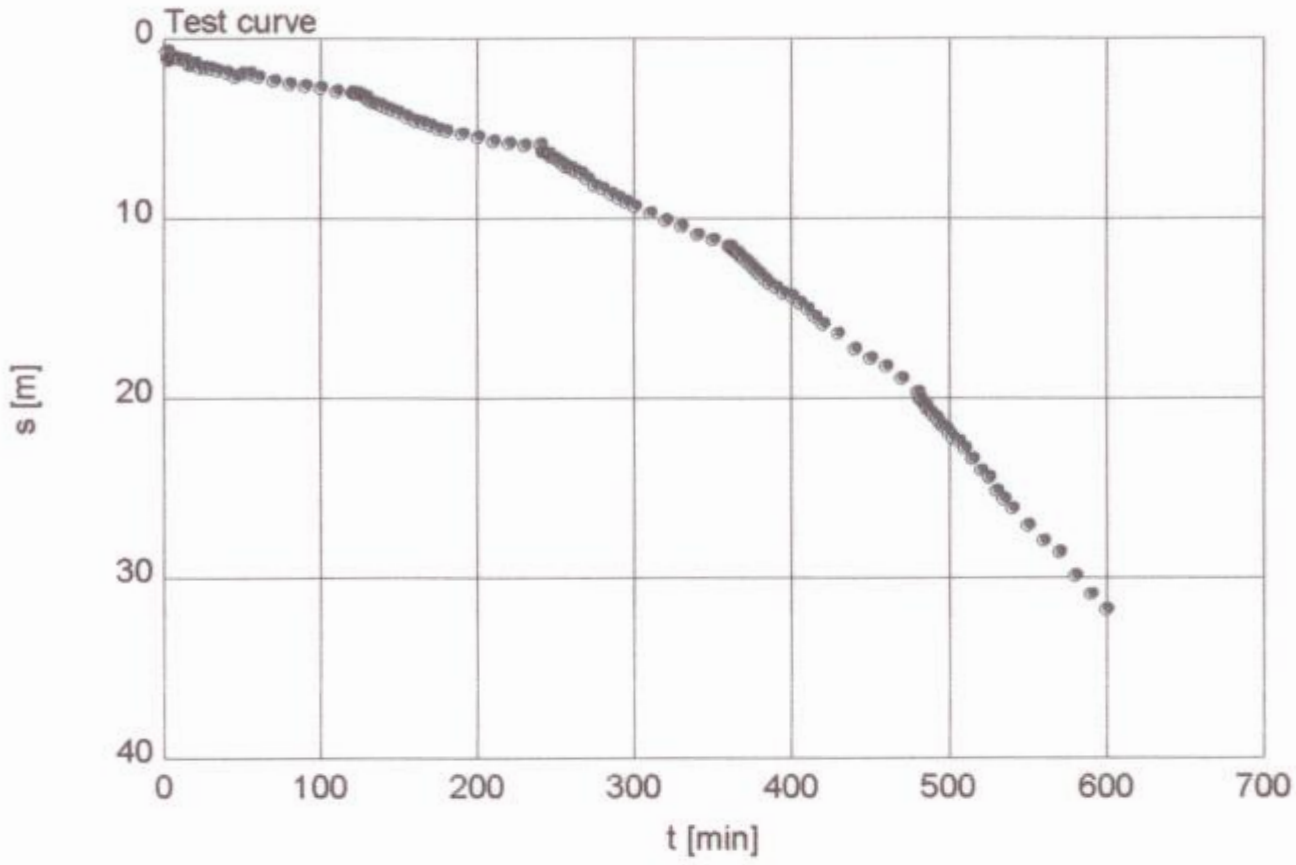
A proper evaluation of R (and storativity S) will only be possible once reliable data from observation wells, penetrating the same aquifer as the pumped well, are available.

Groundwater Study in the Stampriet Artesian Basin

Evaluation of Test Pumping Data

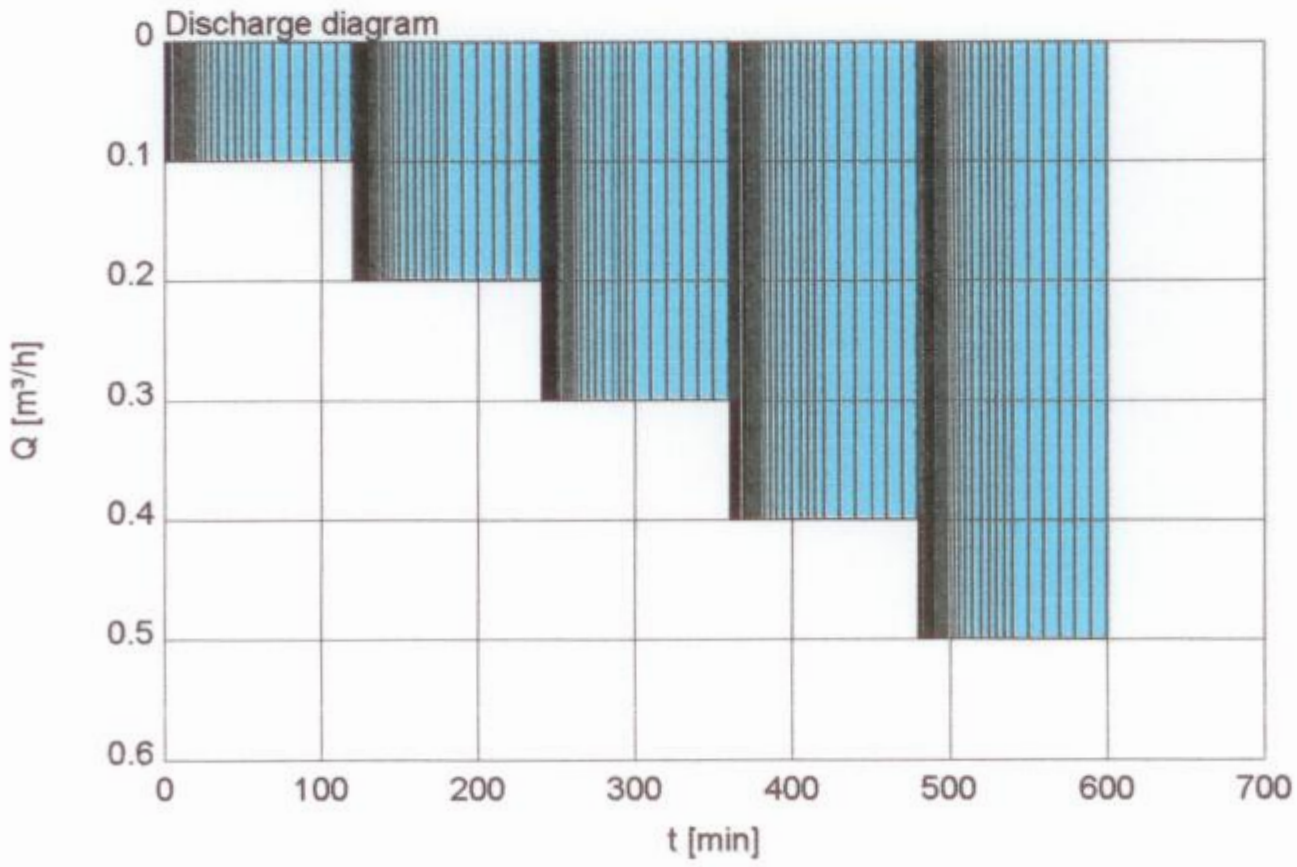
Test pumping diagnosis

Pumped well J8_K



Remarks

At these very low abstraction rates the well efficiency cannot be determined with the available evaluation methods



Discharge info

Dis.dur.:	600 [min]
tcorr:	314 [min]
Av.dis.:	0.30 [m³/h]
max.dis.:	0.50 [m³/h]
min.dis.:	0.10 [m³/h]
Qn:	0.50 [m³/h]
Dis.sum:	3.00 [m³]

Date 22/08/00 prepared by BIWAC

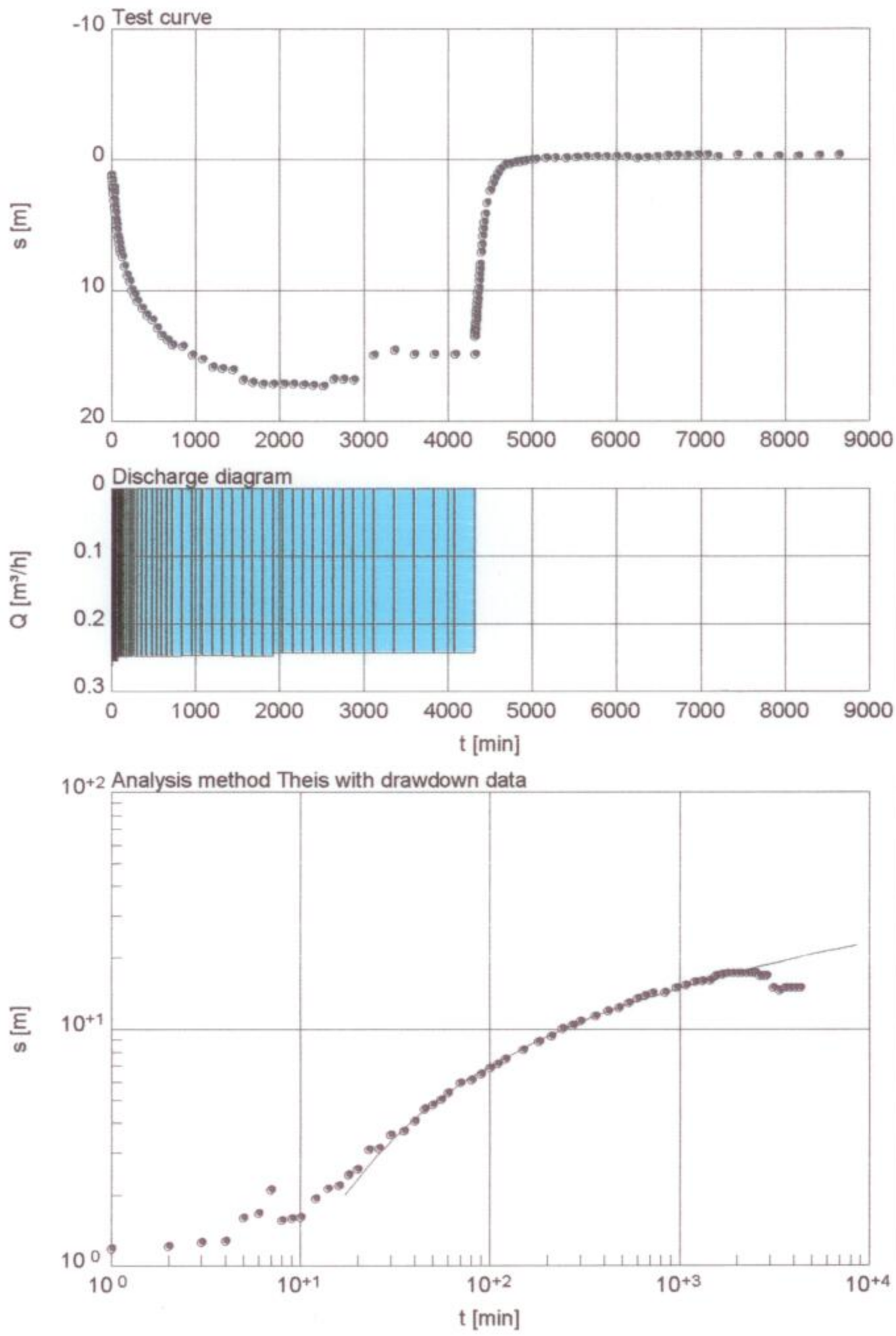
Annex 1

Groundwater Study in the Stampriet Artesian Basin

Evaluation of Test Pumping Data

Test pumping analysis

Pumped well J8_K



Borehole, well & aquifer

Drilled:	21.07.2000
Latitude:	25.46122
Longitude:	19.43266
Elevation:	1015 [m]
Depth:	129 [m]
Stick up:	0.60 [m]
Bh. radius:	0.1555 [m]
Casing radius:	0.084 [m]
RWL:	60.91 [m]
max.drawdown:	17.29 [m]
Aq.type:	confined
Aq.thickness:	30.00 [m]
Stratigraphy:	Kalahari
Lithology:	sandstone

Test running

Start:13/08/2000 07:01:00	
Dis.dur.:	4320 [min]
Av.dis.:	0.246 [m³/h]
Max.dis.:	0.267 [m³/h]
Min.dis.:	0.244 [m³/h]
Total dis.:	17.7 [m³]
Crew:	Metzger_PM
Supervisor:	PCI

Results

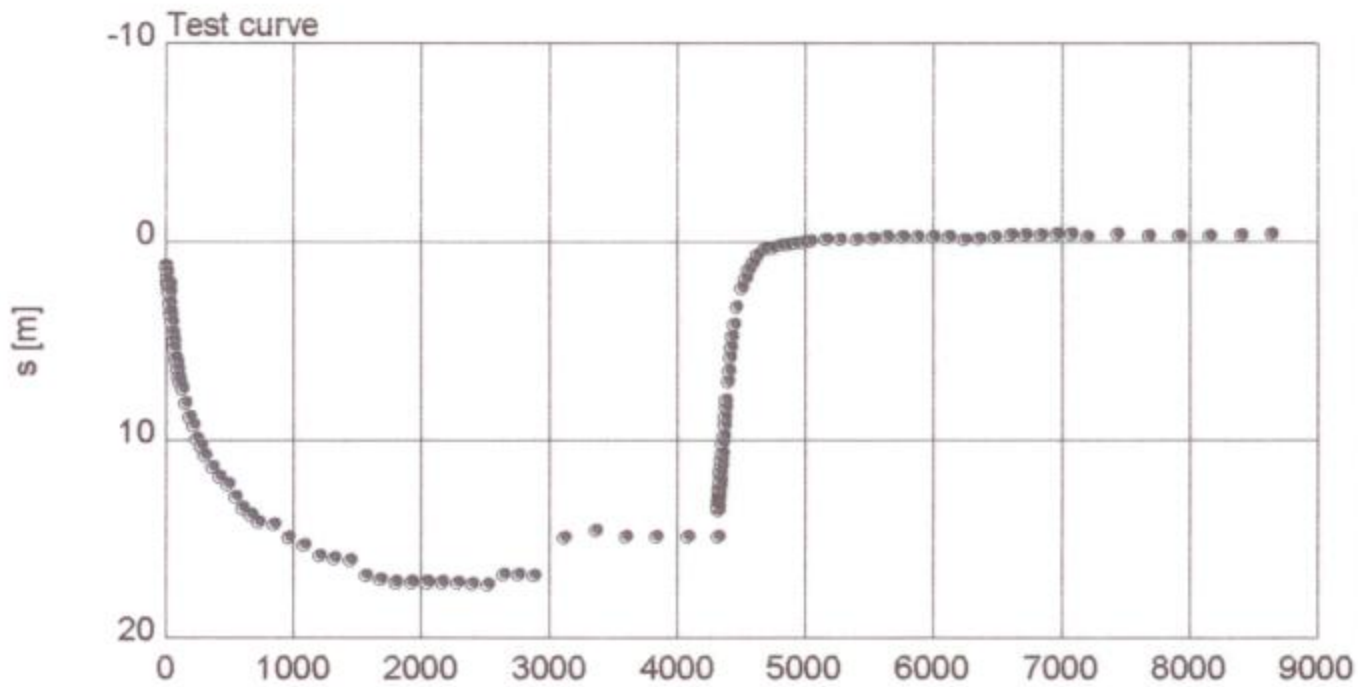
Match parameter:	
Q:	0.246 [m³/h]
t:	686 [min]
s:	13.4 [m]
1/u:	80.4 [-]
W(u):	3.78 [-]
Aquifer parameter:	
T:	0.132 [m²/d]
k:	0.0044 [m/d]

Groundwater Study in the Stampriet Artesian Basin

Evaluation of Test Pumping Data

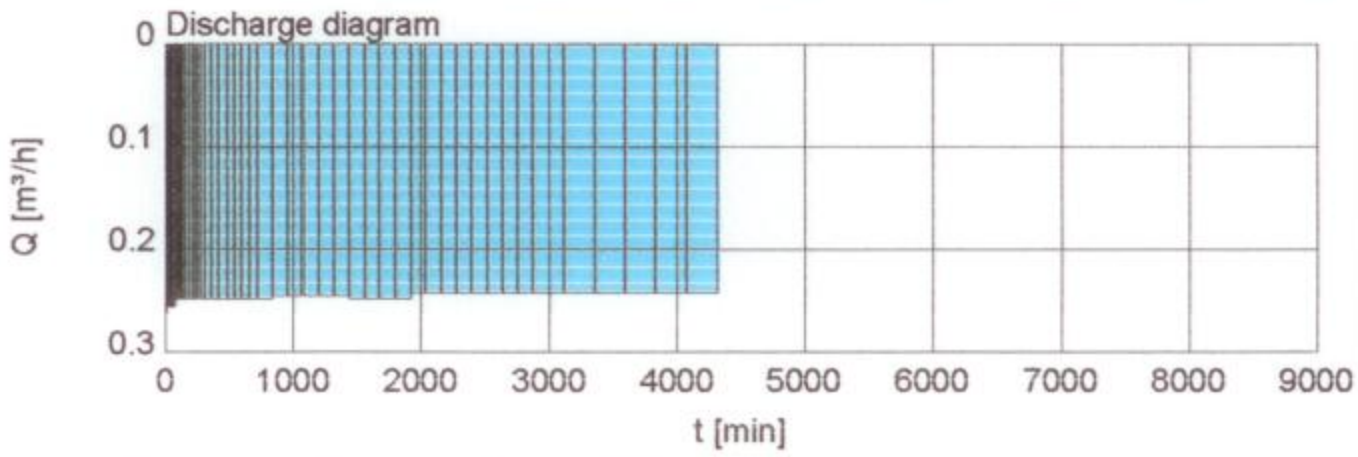
Test pumping analysis

Pumped well J8_K



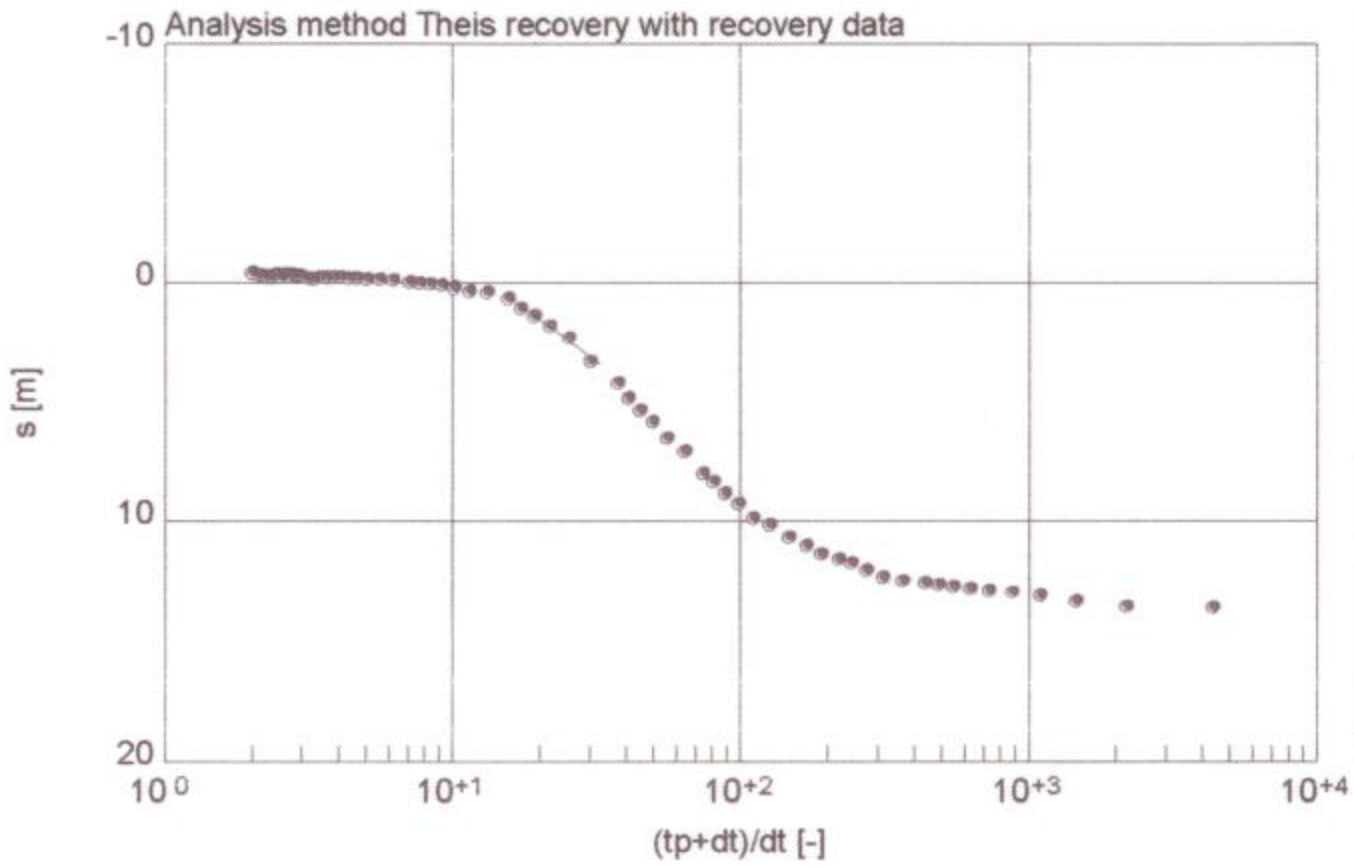
Borehole, well & aquifer

Drilled:	21.07.2000
Latitude:	25.46122
Longitude:	19.43266
Elevation:	1015 [m]
Depth:	129 [m]
Stick up:	0.60 [m]
Bh. radius:	0.1555 [m]
Casing radius:	0.084 [m]
RWL:	60.91 [m]
max.drawdown:	17.29 [m]
Aq.type:	confined
Aq.thickness:	30.00 [m]
Stratigraphy:	Kalahari
Lithology:	sandstone



Test running

Start:13/08/2000 07:01:00	
Dis.dur.:	4320 [min]
Av.dis.:	0.246 [m³/h]
Max.dis.:	0.267 [m³/h]
Min.dis.:	0.244 [m³/h]
Total dis.:	17.7 [m³]
Crew:	Metzger_PM
Supervisor:	PCI



Results

Match parameter:	
Q:	0.244 [m³/h]
b:	8.77 [m]
tcorr:	4372 [min]
to:	13.4 [-]
Aquifer parameter:	
T:	0.122 [m²/d]
k:	0.00408 [m/d]
est.S:	0.005 [-]

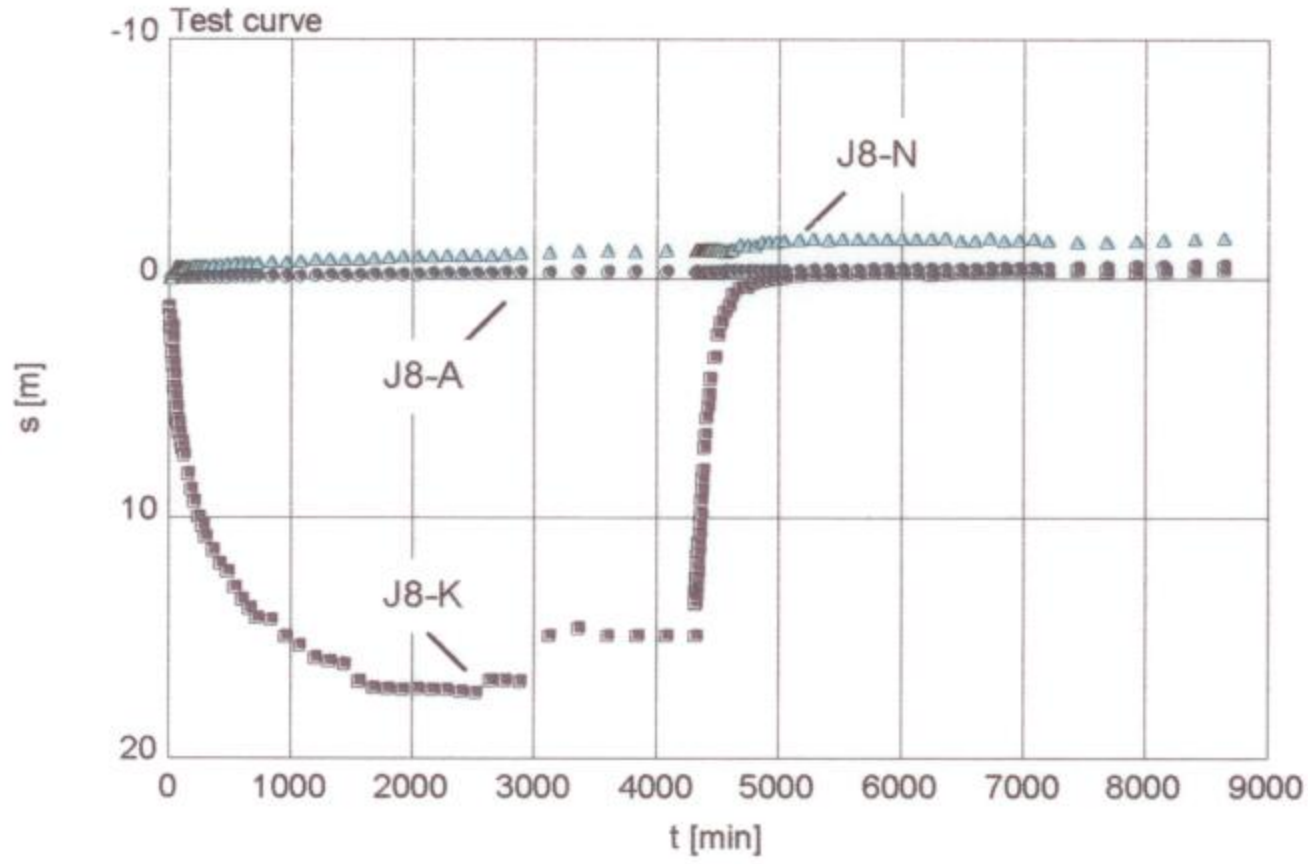
Date 22/08/00 prepared by BIWAC Annex 3

Groundwater Study in the Stampriet Artesian Basin

Evaluation of Test Pumping Data

Test pumping diagnosis

Pumped well J8_K

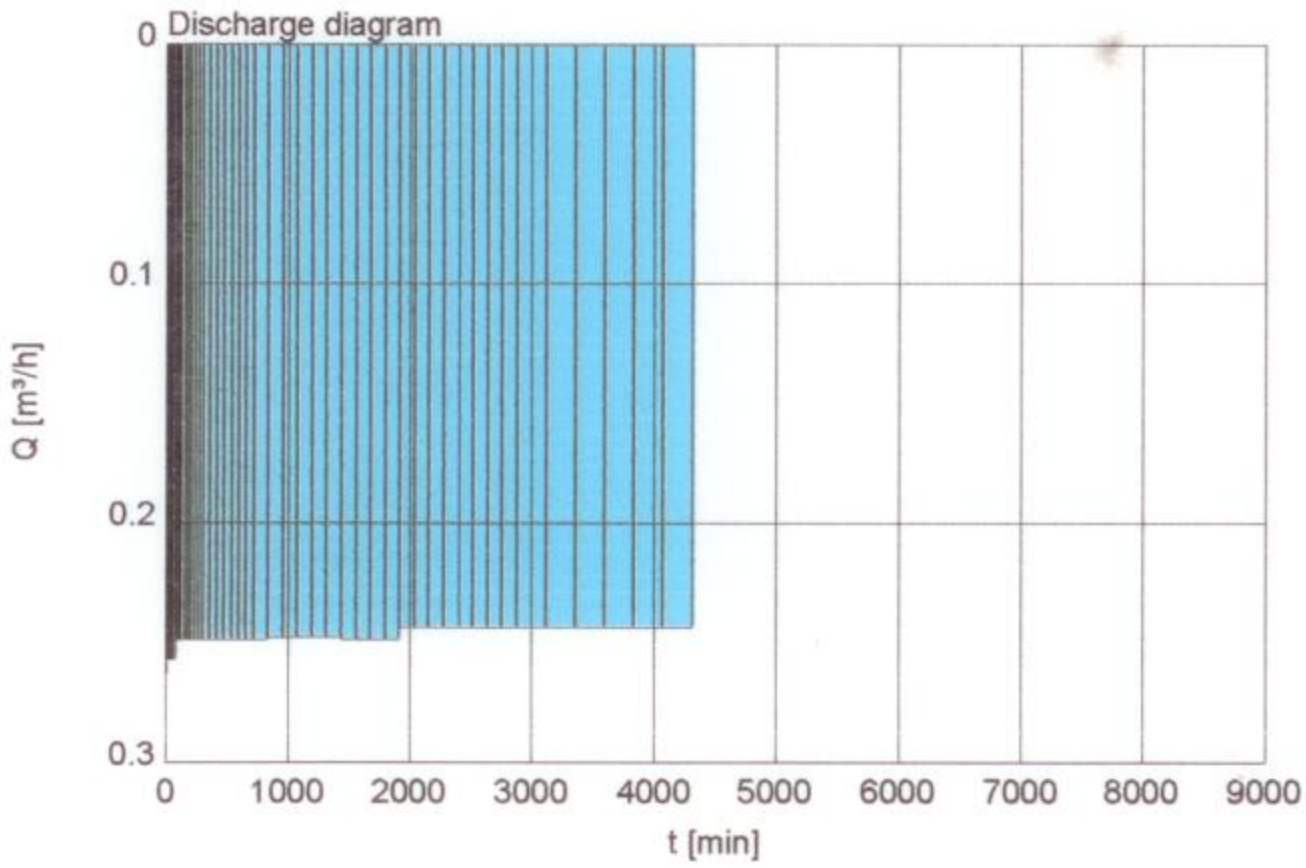


Remarks

Merged data from abstraction borehole J8_K and observation boreholes J8_A and J8_N.

The water levels of observation boreholes are rising during the test.

Although pumping at a very low rate the draw down and recovery curves of J8_K are reasonably good and the data were evaluated for T and kf.



Discharge info

Dis.dur.:600 [min]
tcorr: 314 [min]

Av.dis.: 0.30 [m³/h]
max.dis.:0.50 [m³/h]
min.dis.:0.10 [m³/h]
Qn: 0.50 [m³/h]

Dis.sum: 3.00 [m³]

Distance of observation boreholes: J8-A = 121.7 m; J8-N = 61.4 m

Date 22/08/00 prepared by BIWAC

Annex 4

1. EVALUATION OF SLUG TEST

Borehole **J8-K** was tested using a 3 m long slug. The first test was done after the slug was lowered (**See Figures 1 and 2**), while the second test was done after the slug was pulled out of the borehole (**See Figures 3 and 4**).

The Cooper Bredenhoeft-Papadopulos (type curve) and Bouwer-Rice (straight line) solutions for confined aquifers were used to evaluate the transmissivity and hydraulic conductivity of the aquifer (**See Table 1**). Borehole J8-K was also pump tested and the results of the Theis draw down and recovery solutions were 0.132 m^2/day and 0.122 m^2/day respectively.

Table 1: Solutions for slug test J8-K (confined Kalahari aquifer)

Test	Solution	T [m^2/day]	K [cm/sec]	Y_0 [m]	S* [--]
Lower Slug	Cooper-Bredehoeft-Papadopulos	0.27			1.6×10^{-10}
	Bouwer-Rice		7.1×10^{-6}	1.06	
Pull Slug	Cooper-Bredehoeft-Papadopulos	0.31			1.0×10^{-10}
	Bouwer-Rice		8.3×10^{-6}	1.00	
Pumping test (for comparison)	Theis draw down	0.132			
Pumping test (for comparison)	Theis recovery	0.122			

* estimated

T = transmissivity [m^2/day]
K = hydraulic conductivity [cm/sec]
Y_0 = original displacement [m]
S* = estimated storativity [--]

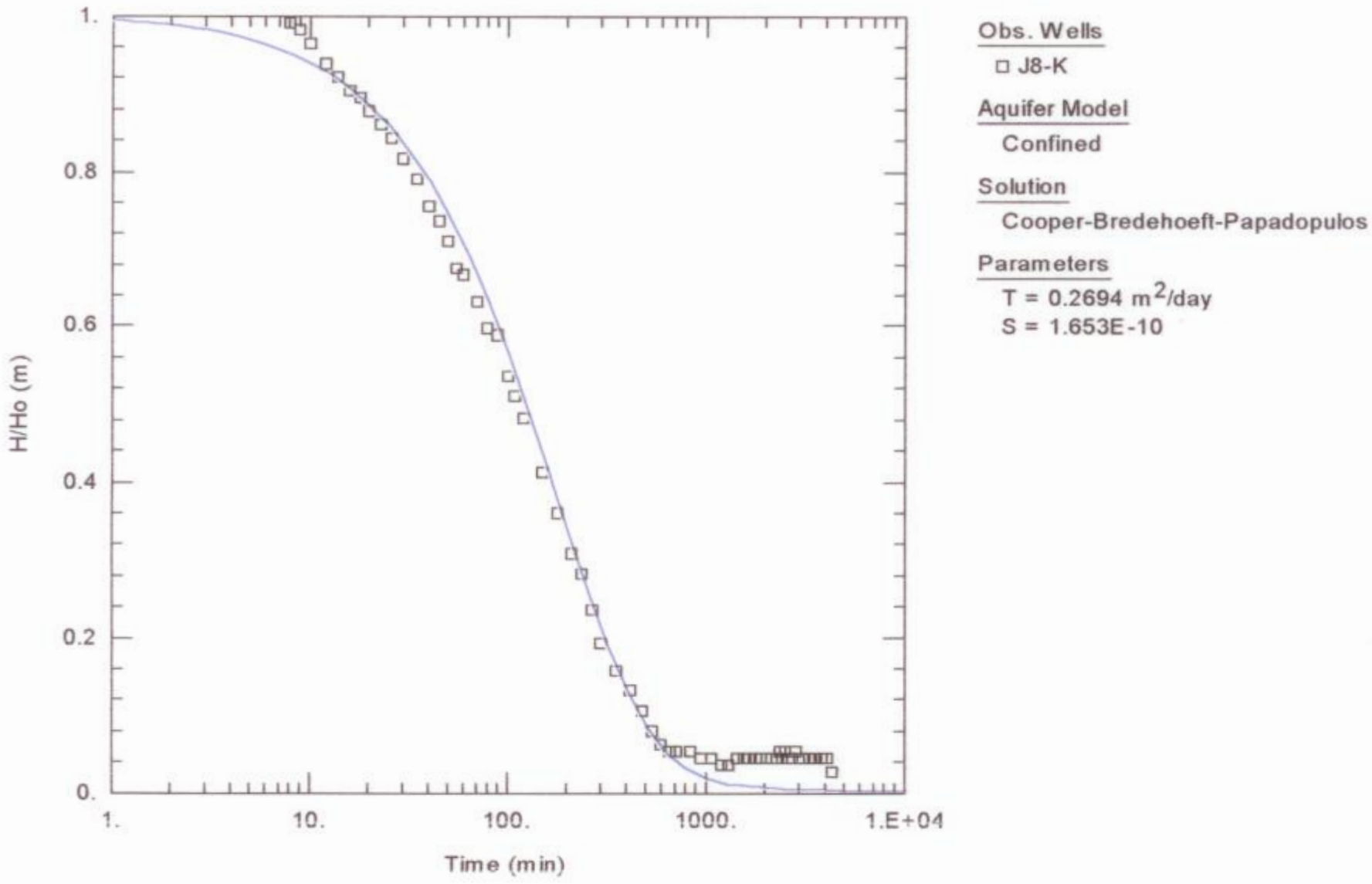


Figure 1: Lower slug; Cooper-Bredehoeft-Papadopulos Solution

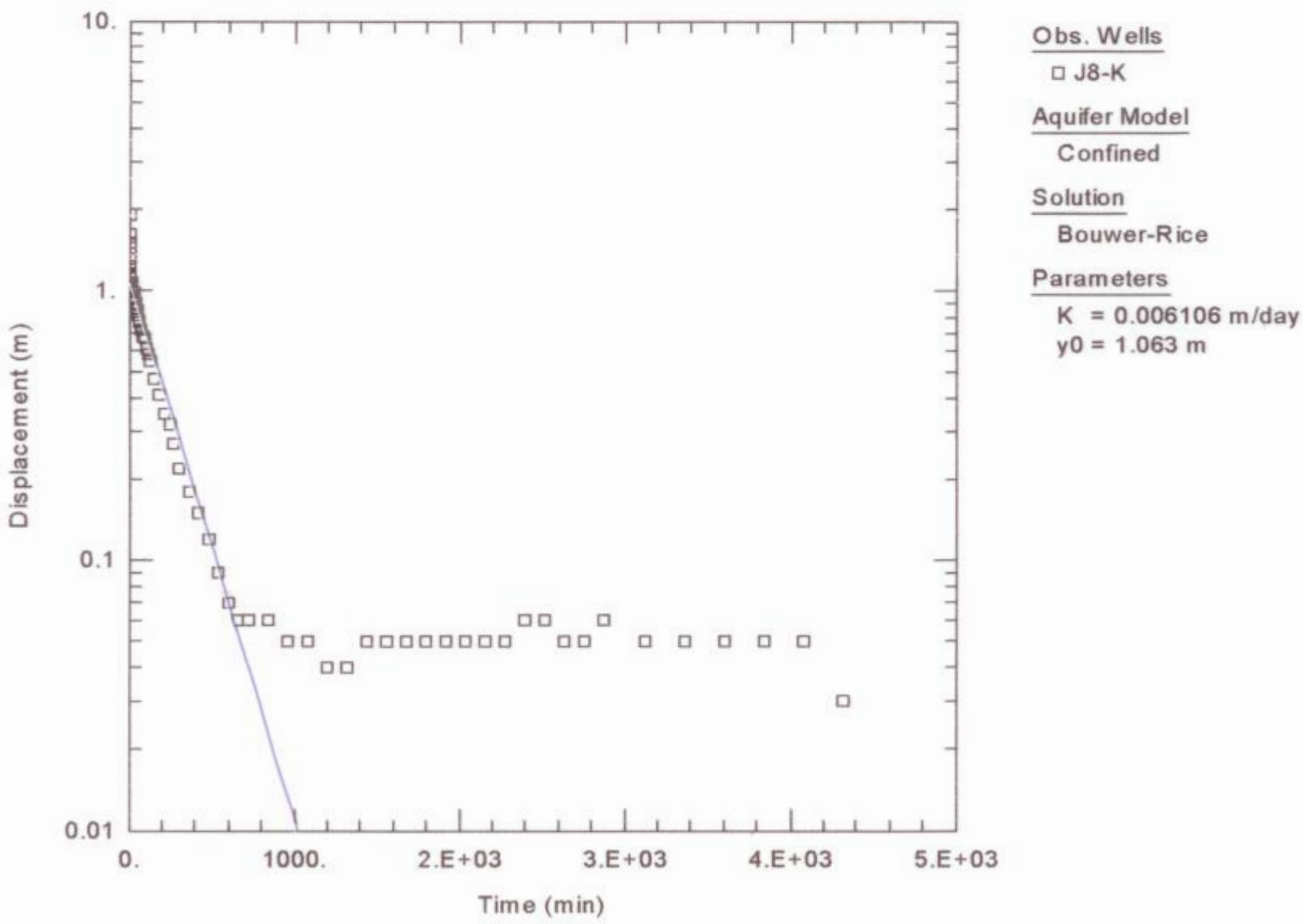


Figure 2: Lower slug; Bouwer-Rice Solution

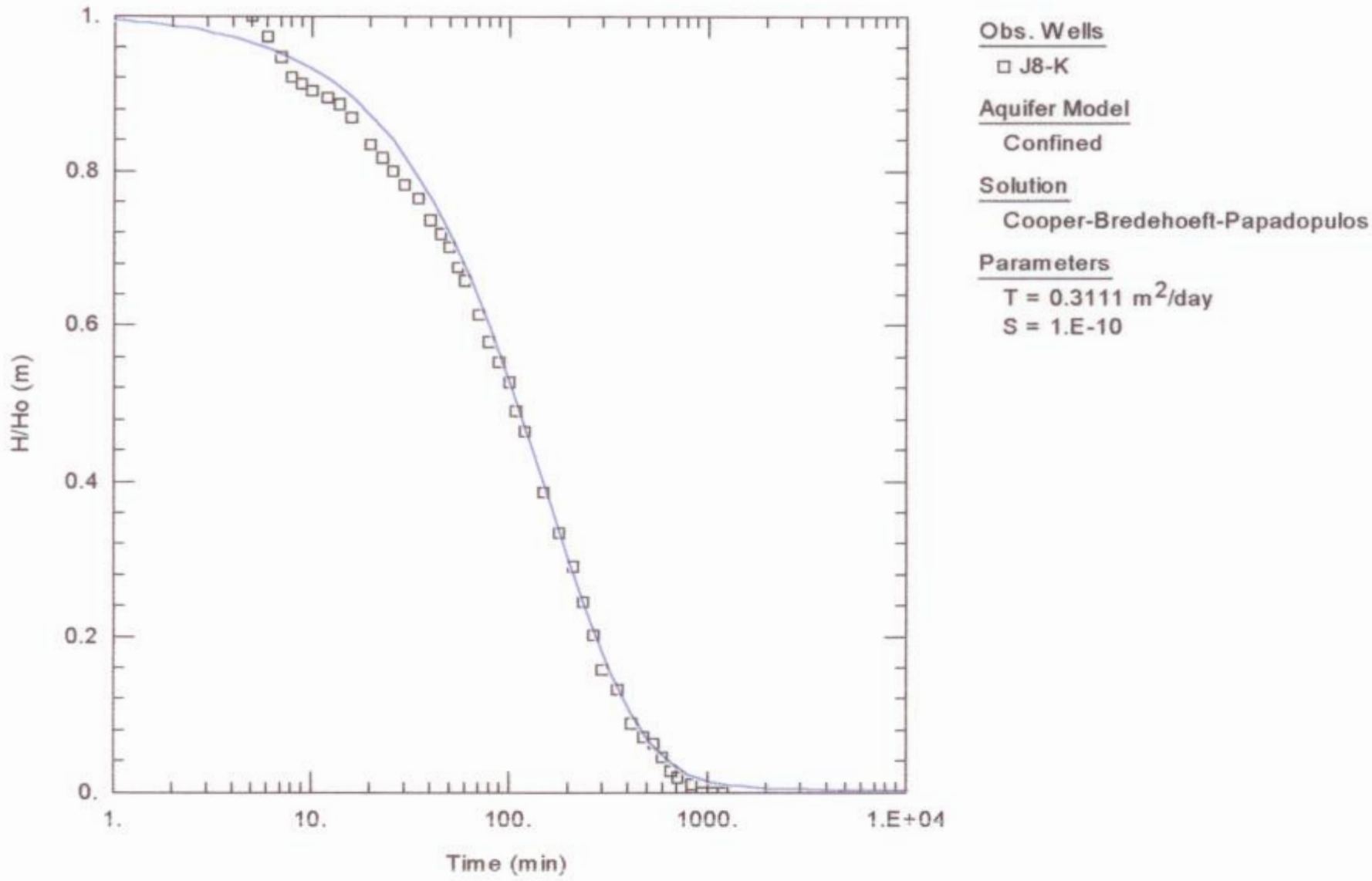


Figure 3: Pull slug; Cooper-Bredehoeft-Papadopulos Solution

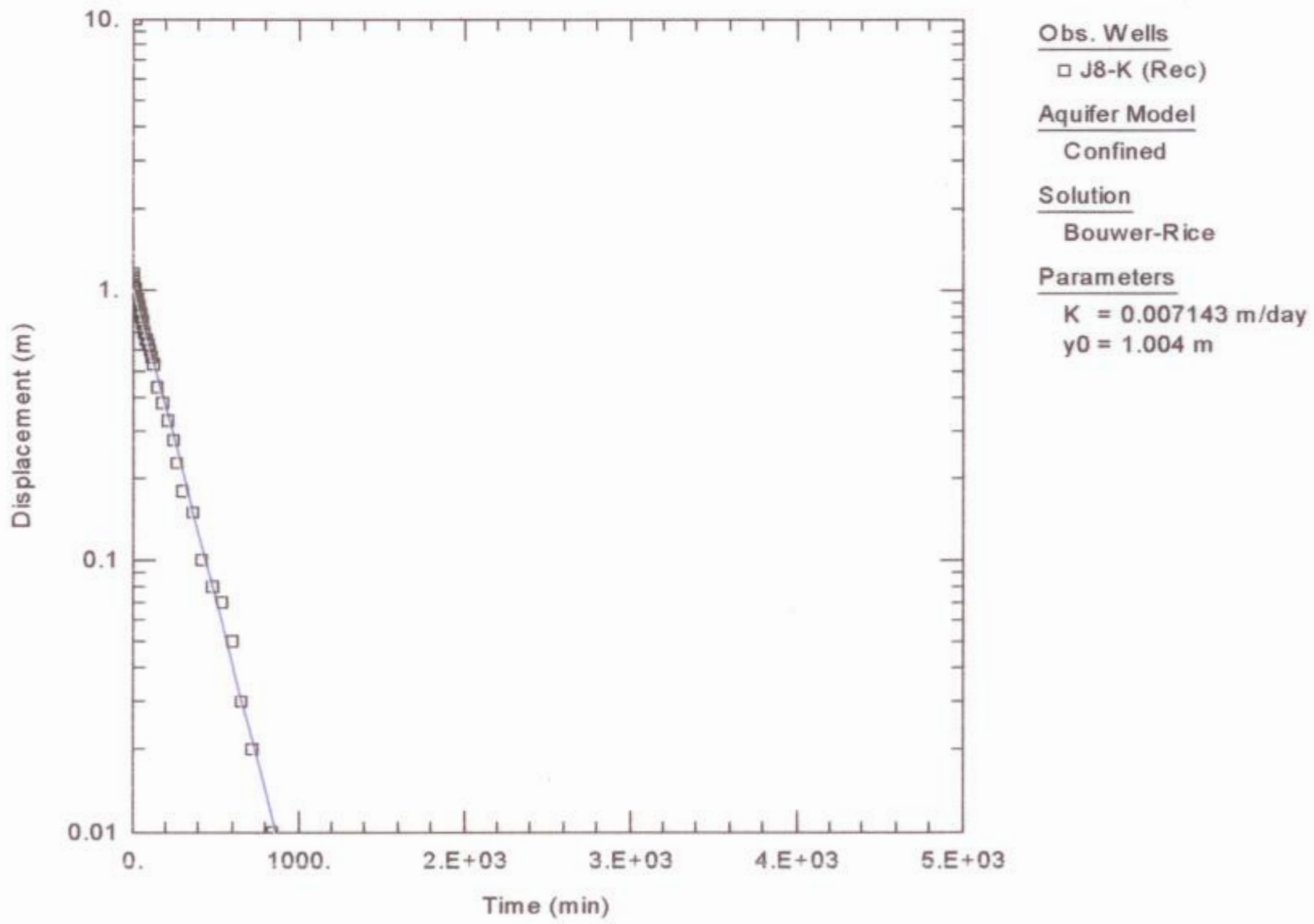


Figure 4: Pull slug; Bouwer-Rice Solution

7. Water Level Recorder Installation

THE STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN IN THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN

INSTALLATION OF SEBA FLOATERS

JICA REFERENCE: J 8 K LOCALITY: Twee Reviere R 481

WW 39854

1. **Serial Number of floater**: 4548
2. **Date installed**: 04/10/00
3. **Rest Water Level when installed**: 61.06 mbsu
4. **Distance from stick-up to logger**: 55.0 m
5. **Distance from logger to water level**: 6.06 m
6. **Cut off**: 55.0 m (0.91 + 54.11)