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**

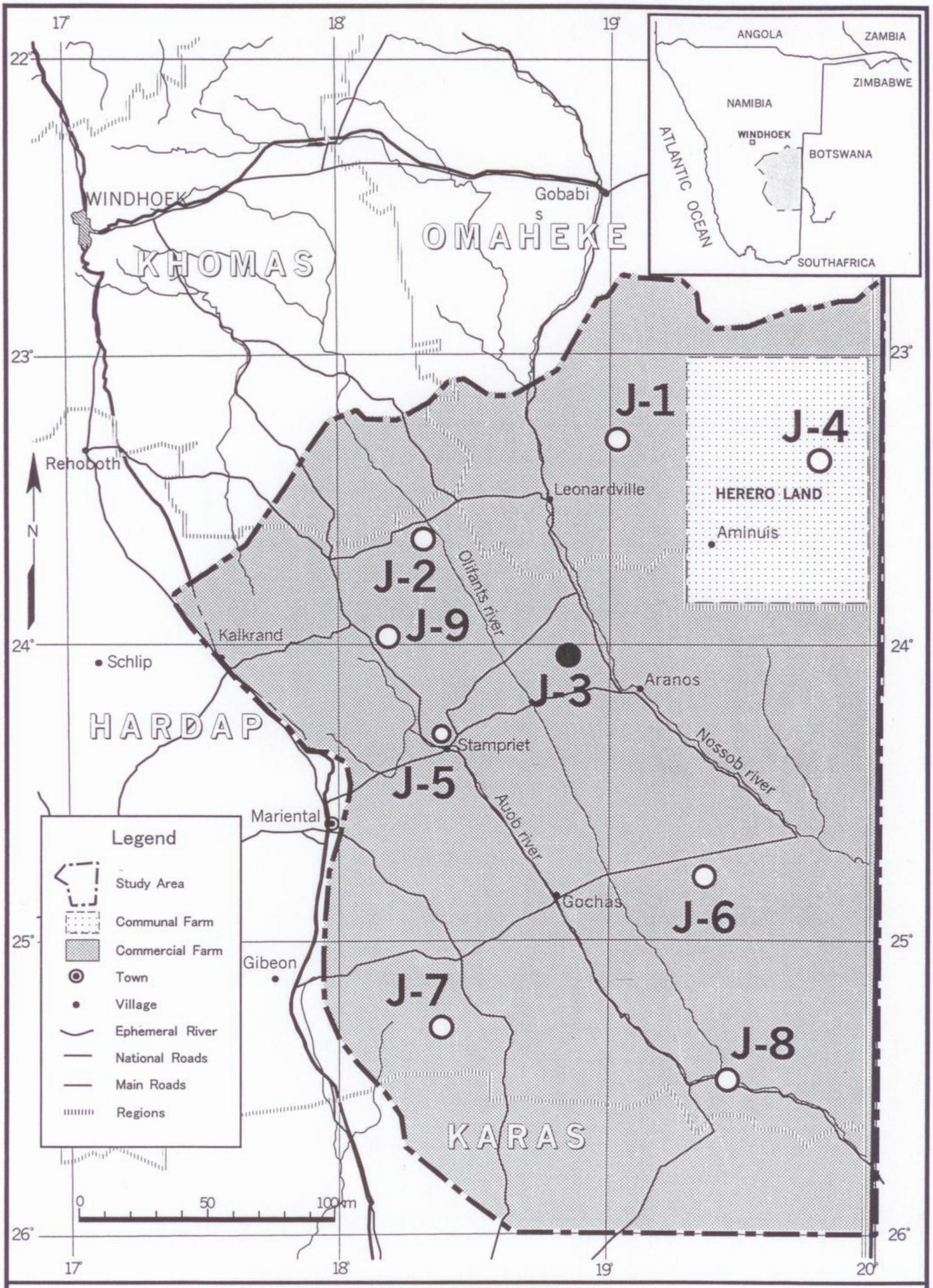
**J3-A (WW 39843)**

**Choroaoheib R 300**

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

# GEOLOGICAL BOREHOLE LOG

**Farm Choroaoheib R 300 (Ptn Steynsrus )** **WW 39843**
**Jica Reference: J - 3 -A** **S 24, 04792°**
**Date completed: 10 June 2000** **E 18, 79312°**
**(final casing installed)** **Collar elev.: 1205 m**

| Depth below surface (m) | Section (m) | Lithology | Stratigraphy |
|---|---|---|---|
| 0 - 10 | 10 | Massive white to light grey sandy **calcrete**. A shallow cover of reddish brown medium to coarse sand. A conglomerate horizon, partially cemented by calcrete, was intersected at 4 to 8 m | |
| 10 - 12 | 2 | Sandy and gravelly **calcrete**. Washed sample dominated by coarse fraction. Pebbles well rounded. | |
| 12 - 25 | 13 | **Calcrete**. Sandy up to 16 m, coarsening to a conglomerate with increasing depth. | **KALAHARI** |
| 25 - 27 | 2 | Coarse **gravel** in a yellowish orange clayey matrix. | |
| 27 - 38 | 11 | Greyish-white massive **calcrete-conglomerate**: predominantly reworked red sandstone in a calcareous matrix. | |
| 38 - 48 | 10 | Quartz pebbles to small boulders, poorly cemented by calcrete to a **conglomerate**. Coarser fraction highly ground by drilling action. | |
| 48 - 59 | 11 | Reddish brown calcareous, fine to coarse grained unsorted **sandstone**. | |
| 59 - 73 | 14 | Pale reddish brown calcareous **sandstone**, fine to medium grained, progressing to a basal conglomerate at 73 m. | |
| 73 - 76 | 3 | Coarse **pebbles** in a pale reddish **sandstone** matrix. | **RIETMOND** |
| 76 - 111 | 35 | Light reddish to brownish fine to medium grained **sandstone** with frequent larger pebbles occurring throughout the sample. The drilled sample has a clayey appearance, indicating the presence of intercalated regular soft shale horizons | |
| 111- 121 | 10 | Reddish brown fine to medium grained sandstone. Abundant dispersed pebbles within sample. | |
| 121 - 122 | 1 | Medium to coarse grained reddish feldspathic **sandstone**. Calcareous. | |
| 122 - 126 | 4 | Medium grained white to pale grey **sandstone**. Calcareous in horizons. | **AUOB A5** |
| 126 - 145 | 19 | Coarse grained **sandstone**, light brown to white with disseminated white gypsum specs. Moderately calcareous in places. Below 129 m the samples collected are highly contaminated by coarse washout from upper Kalahari beds. | |

| | | | |
|---|---|---|---|
| 145 - 151 | 6 | Highly contaminated sample: Probably the same horizon as in J - 3 - N at 143 m to 149 m. | **AUOB A4 ??** |
| 151 - 157 | 6 | Medium to coarse grained reddish to grey calcareous **sandstone**. At 157 m the sample is purplish in colour and feldspathic. | |
| 157 - 159 | 2 | Pale reddish brown soft **shale**, **sandy**. | |
| 159 - 164 | 5 | Pale brownish grey **shale**. | |
| 164 - 170 | 6 | Grey **sandy shale**, slightly micaceous with **siltstone** intercalated at 167 to 170 m. Moderately calcareous. | **AUOB A3** |
| 170 -.177 | 7 | Light grey **sandy shale**, laminated with muscovite on laminations at places. Very thin very fine **sandstone** / **siltstone** horizons in laminae. | |
| 177 - 182 | 5 | Grey **shale** with minor sandy micaceous horizons. Clogging drill-bit. | |
| 182 - 226,5 | 44,5 | Grey **shale** moderately laminated. Non-calcareous. Colour gradually changing to dark grey and black with depth. | **AUOB A2** |
| 226,5 - 230 | 3,5 | Pale grey calcareous **sandstone** fine-grained, porous. | |
| 230 - 235 | 5 | Light grey fine-grained **sandstone**, calcareous and porous and intercalated with grey to dark grey shale. Sandstone well sorted. | **AUOB A1** |
| 235 - 246 | 11 | Light grey medium grained **sandstone**, moderately porous to porous in horizons, calcareous with white calcite specks disseminated throughout sample. | |
| 246 - 253 EOH | 7 | Light grey well laminated **shale** with minor horizons of lighter grey very fine sandstone. | **MUKOROB** |

**Remarks:**

1. The mud-rotary drilling method was employed, resulting in highly ground drill-cuttings through relative slow up-hole velocity.
2. Continuous wash-out from the poorly consolidated upper Kalahari horizons result in a contamination of samples collected from below.

This borehole was logged by F. Bockmuhl.

| | | | |
|---|---|---|---|
| 145 - 151 | 6 | Highly contaminated sample: Probably the same horizon as in J - 3 - N at 143 m to 149 m. | **AUOB A4 ??** |
| 151 - 157 | 6 | Medium to coarse grained reddish to grey calcareous **sandstone**. At 157 m the sample is purplish in colour and feldspathic. | |
| 157 - 159 | 2 | Pale reddish brown soft **shale**, **sandy**. | |
| 159 - 164 | 5 | Pale brownish grey **shale**. | |
| 164 - 170 | 6 | Grey **sandy shale**, slightly micaceous with **siltstone** intercalated at 167 to 170 m. Moderately calcareous. | **AUOB A3** |
| 170 -.177 | 7 | Light grey **sandy shale**, laminated with muscovite on laminations at places. Very thin very fine **sandstone** / **siltstone** horizons in laminae. | |
| 177 - 182 | 5 | Grey **shale** with minor sandy micaceous horizons. Clogging drill-bit. | |
| 182 - 226,5 | 44,5 | Grey **shale** moderately laminated. Non-calcareous. Colour gradually changing to dark grey and black with depth. | **AUOB A2** |
| 226,5 - 230 | 3,5 | Pale grey calcareous **sandstone** fine-grained, porous. | |
| 230 - 235 | 5 | Light grey fine-grained **sandstone**, calcareous and porous and intercalated with grey to dark grey shale. Sandstone well sorted. | **AUOB A1** |
| 235 - 246 | 11 | Light grey medium grained **sandstone**, moderately porous to porous in horizons, calcareous with white calcite specks disseminated throughout sample. | |
| 246 - 253 EOH | 7 | Light grey well laminated **shale** with minor horizons of lighter grey very fine sandstone. | **MUKOROB** |

**Remarks:**

1. The mud-rotary drilling method was employed, resulting in highly ground drill-cuttings through relative slow up-hole velocity.
2. Continuous wash-out from the poorly consolidated upper Kalahari horizons result in a contamination of samples collected from below.

This borehole was logged by F. Bockmuhl.

# 2. Penetration Record

| Depth (m) | Pen. Rate (min/m) |
|---|---|
| 1 | |
| | |
| | |
| | |
| 5 | |
| | 0.7 |
| | 1.2 |
| | 2.8 |
| | 5.6 |
| 10 | 1.65 |
| | 2 |
| | 1.3 |
| | 1.8 |
| | 2.4 |
| | 4.75 |
| | 1.9 |
| | 2 |
| | 4.8 |
| | 1.9 |
| 20 | 2.6 |
| | 4.7 |
| | 5.25 |
| | 5.9 |
| | 2.5 |
| | 2.5 |
| | 3.2 |
| | 3.4 |
| | 5.4 |
| | 7.1 |
| 30 | 7 |
| | 6.75 |
| | 6.15 |
| | 5.75 |
| | 3.8 |
| | 3.7 |
| | 2.9 |
| | 3.3 |
| | 2.7 |
| | 2.45 |
| 40 | 2.6 |
| | 2.05 |
| | 1.7 |
| | 1.4 |
| | 3.1 |
| | 2.7 |
| | 4 |
| | 1.85 |
| | 3.5 |
| | 4.2 |
| 50 | 4.1 |
| | 3 |
| | 2.7 |
| | 2.35 |
| | 2.75 |
| | 3 |

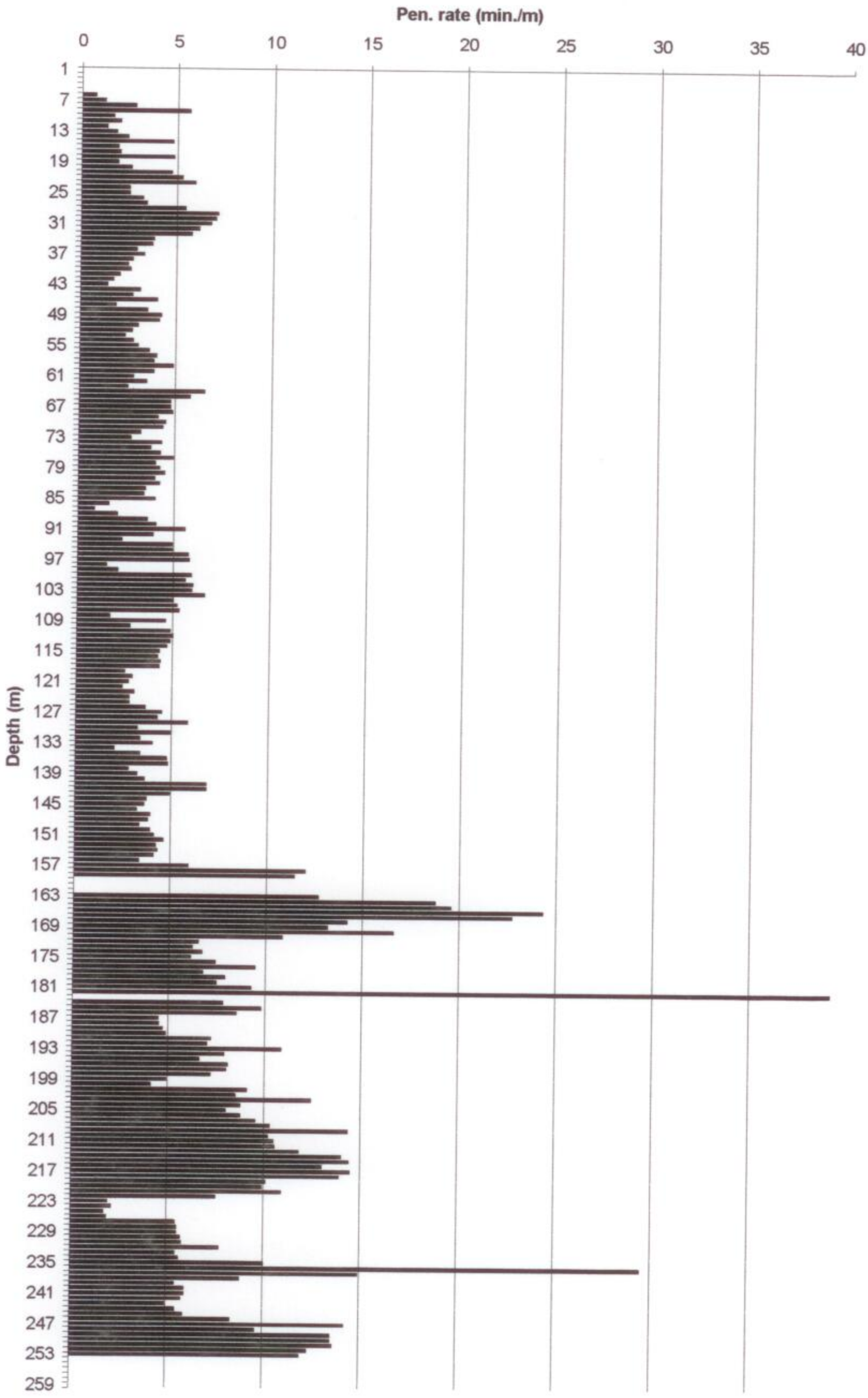
| | |
|---|---|
| | 3.6 |
| | 4 |
| | 3.85 |
| | 4.85 |
| 60 | 3.85 |
| | 2.8 |
| | 3.5 |
| | 2.5 |
| | 6.5 |
| | 5.75 |
| | 4.75 |
| | 4.75 |
| | 4.85 |
| | 4.1 |
| 70 | 4.5 |
| | 4.35 |
| | 3.2 |
| | 2.7 |
| | 4.3 |
| | 3.75 |
| | 4.25 |
| | 4.9 |
| | 4 |
| | 4.2 |
| 80 | 4.45 |
| | 3.95 |
| | 4.2 |
| | 3.5 |
| | 3.4 |
| | 4 |
| | 1.6 |
| | 0.85 |
| | 2.05 |
| | 3.6 |
| 90 | 4.05 |
| | 5.55 |
| | 3.9 |
| | 2.3 |
| | 4.9 |
| | 4.9 |
| | 5.75 |
| | 5.8 |
| | 1.5 |
| | 2.1 |
| 100 | 5.9 |
| | 5.6 |
| | 6 |
| | 5.95 |
| | 6.6 |
| | 5 |
| | 5.2 |
| | 5.3 |
| | 1.7 |
| | 4.6 |
| 110 | 2.75 |
| | 4.85 |

| | |
|---|---|
| | 5 |
| | 4.85 |
| | 4.7 |
| | 4.3 |
| | 4.2 |
| | 4.35 |
| | 4.3 |
| | 2.5 |
| 120 | 2.9 |
| | 2.7 |
| | 2.4 |
| | 3 |
| | 2.75 |
| | 2.75 |
| | 3.6 |
| | 4.45 |
| | 4.25 |
| | 5.8 |
| 130 | 3.2 |
| | 4.9 |
| | 3.35 |
| | 4 |
| | 2 |
| | 3.35 |
| | 4.75 |
| | 4.8 |
| | 2.75 |
| | 3.2 |
| 140 | 3.6 |
| | 6.8 |
| | 6.8 |
| | 4.9 |
| | 3.7 |
| | 3.6 |
| | 3.2 |
| | 3.9 |
| | 3.8 |
| | 3.35 |
| 150 | 3.9 |
| | 4.1 |
| | 4.6 |
| | 4.2 |
| | 4.3 |
| | 4.1 |
| | 3.35 |
| | 5.9 |
| | 12 |
| | 11.45 |
| 160 | |
| | 12.7 |
| | 18.75 |
| | 19.55 |
| | 24.3 |
| | 22.7 |

| | |
|---|---|
| | 14.2 |
| | 13.2 |
| 170 | 16.6 |
| | 10.85 |
| | 6.5 |
| | 6.2 |
| | 6.7 |
| | 6.1 |
| | 7.4 |
| | 9.45 |
| | 6.75 |
| | 7.9 |
| 180 | 7.45 |
| | 9.25 |
| | 39.2 |
| | 7.8 |
| | 9.8 |
| | 8.5 |
| | 4.45 |
| | 4.5 |
| | 4.7 |
| 190 | 4.85 |
| | 7.2 |
| | 7 |
| | 10.85 |
| | 7.9 |
| | 6.6 |
| | 8.1 |
| | 8 |
| | 7.2 |
| | 4.9 |
| 200 | 4.1 |
| | 9.1 |
| | 8.5 |
| | 12.4 |
| | 8.75 |
| | 8 |
| | 8.75 |
| | 9.55 |
| | 10.3 |
| | 14.35 |
| 210 | 10.2 |
| | 10.5 |
| | 10.55 |
| | 11.8 |
| | 14 |
| | 14.4 |
| | 13 |
| | 14.45 |
| | 13.9 |
| | 10.1 |
| 220 | 9.9 |
| | 10.9 |
| | 7.5 |
| | 1.9 |

| | |
|---|---|
| | 2.1 |
| | 1.7 |
| | 1.85 |
| | 5.4 |
| | 5.5 |
| | 5.5 |
| 230 | 5.7 |
| | 5.75 |
| | 7.7 |
| | 5.4 |
| | 5.6 |
| | 10 |
| | 29.45 |
| | 14.9 |
| | 8.8 |
| | 5.4 |
| 240 | 5.9 |
| | 5.9 |
| | 5.75 |
| | 4.9 |
| | 5.45 |
| | 5.85 |
| | 8.3 |
| | 14.2 |
| | 9.6 |
| | 13.5 |
| 250 | 13.5 |
| | 13.6 |
| | 12.3 |
| | 11.9 |

## Penetration Record J 3 A



# 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 3 A **LOCALITY:** Choroaoheib **WW** 39843 **DATE:** 03 to 08 June 2000

| TIME | DEPTH mbgl | MARSH FUNNEL TEST 1000 ml (sec) | MARSH FUNNEL TEST 500 ml (sec) | E. C. mS/cm | DENSITY | pH | TEMPERATURE ° C | COMMENT |
|---|---|---|---|---|---|---|---|---|
| 14:00<br>(4/6) | 159 | 33<br>*29* | 22 | 12.27<br>*11.65* | ≤ 1.16 | 8.5<br>*8* | 21.3<br>*19.3* | Before start of geophysics<br>*Water from tanker used for mixing.* |
| 07:45<br>(07/06) | 253 | 34<br>*29* | 23 | 12.4<br>*11.5* | | 8.5<br>*8* | 17.3<br>*14.5* | During geophysics<br>*Water from tanker used for mixing* |

**GENERAL REMARKS:**

1. This borehole was logged at depths of 159 m (ϕ 9 7/8") and again at 253 m (ϕ 7 7/8").
2. Parameters recorded from samples filtered through a very fine sieve.
3. To determine the electrical resistivity of the samples as Ω-m., the E.C., expressed as S/m should be inversed (1/x).

# 4. Geophysical Log and Casing Design

# Poseidon Geophysics

(Reg. No. 98550)

CO. Poseidon Geophysics
WELL J3A WW 39843
PROJ.
LCN. Choroaoheib
STE. J3 J3A
FILING No.

**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** J3A WW39843

**LOCATION** CHOROAOHEIB

**COUNTRY** REPUBLIC OF NAMIBIA

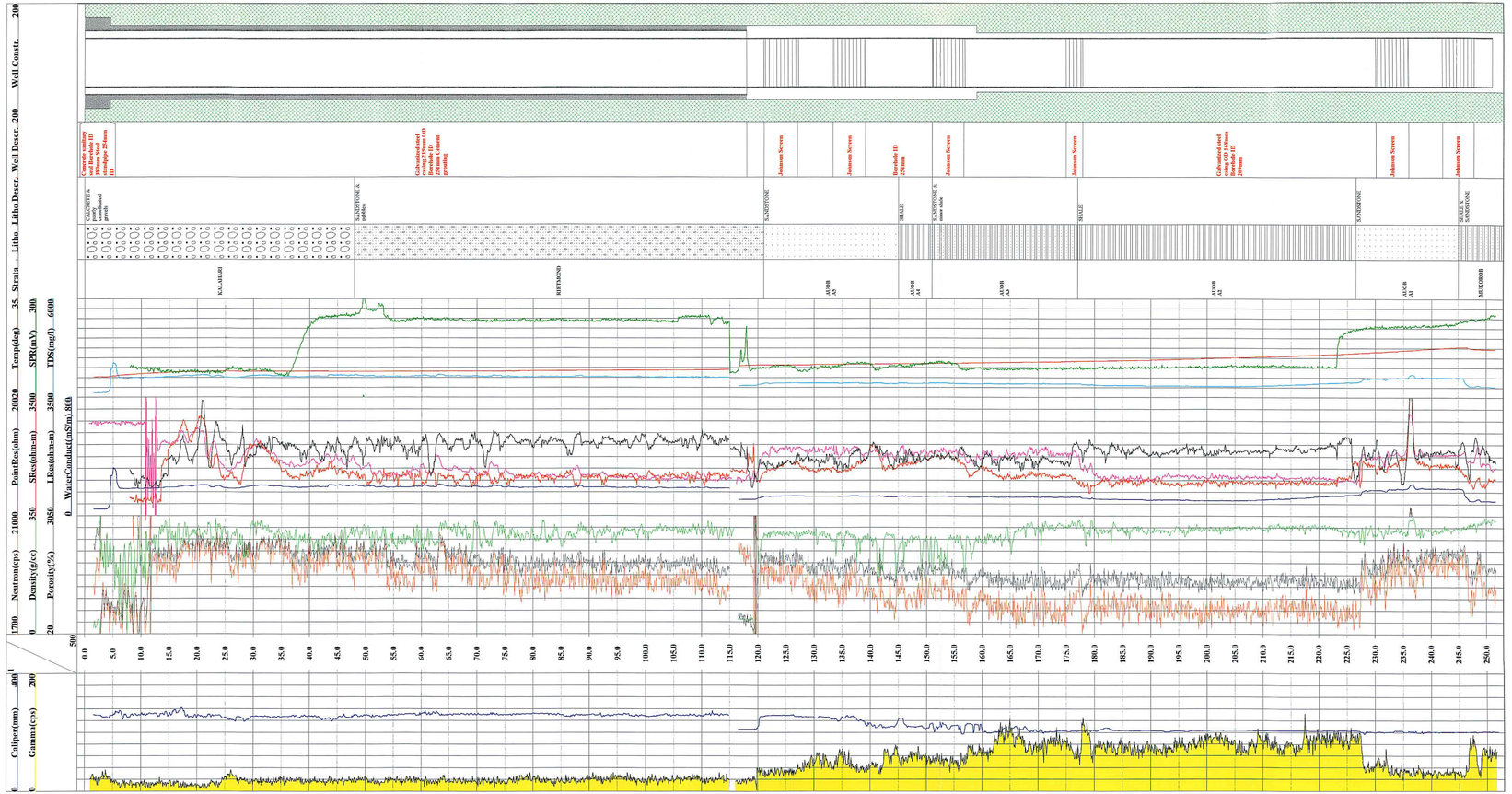
BH COORDINATES S 24.04792
E 18.79312

COLLAR ELEVATION 1205m
LOG MEAS. FROM Groundlevel

DRILLING MEAS. FROM Groundlevel

| | |
|---|---|
| DATE | 21 May 2000 |
| TYPE LOG | Physical Properties |
| DEPTH-DRILLER | 253m |
| DEPTH-LOGGER | 252.10m |
| BTM LOGGED INTERVAL | 252.10m |
| TOP LOGGED INTERVAL | 0.60m |
| PERMANENT DATUM | Groundlevel |
| RECORDED BY | Clemence Kambewu |
| 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 3 A FARM: Choroaoheib R 300 WW 39843 DATE: 11/06/00 (starting)**

| TIME (actual) | P.I.D. (mbsu) | ½ 90° V-Notch (mm) | Yield ($m^3/h$) | Water level (mbsu) | Remarks |
|---|---|---|---|---|---|
| 07:40 | 121 | 40 to 120 | 4,68 | 12.25 | Start airlift on14/06/00 |
| 08:07 | | 40 to 120 | | 19.20 | Water surging results in fluctuations in V-Notch readings |
| 08:30 | | 40 to 120 | | 20.54 | |
| 08:45 | | 35 to 120 | | 20.58 | |
| 09:30 | | 35 to 120 | | 20.56 | |
| 10:00 | | 35 to 120 | | 20.40 | |
| 10:15 | | 35 to120 | | 20.40 | |
| 10:30 | | 35 to 120 | | 20.40 | |
| 10:45 | | 37 to 118 | | 20.40 | |
| 11:00 | | 37 to 118 | | 20.40 | |
| 11:15 | | ~77 | 4 | 20.40 | |
| 11:30 | | | | 20.40 | |
| 11:45 | | | | 20.40 | |
| 12:00 | | | | 20.40 | |
| 12:15 | | | | 20.40 | |
| 12:30 | | | | 20.40 | |
| 12:45 | | | | 20.40 | |
| 13:00 | | | | 20.40 | |
| 13:15 | | | | 20.40 | |

| TIME (actual) | P.I.D. (mbsu) | ½ 90° V-Notch (mm) | Yield ($m^3/h$) | Water level (mbsu) | Remarks |
|---|---|---|---|---|---|
| 13:30 | 121 | | | 20.40 | Water surging resulting in approximated V-Notch readings |
| 13:45 | 121 | ~77 | 4 | 20.40 | |
| 14:00 | | | | 21.47 | |
| 14:15 | | | | 20.40 | |
| 14:30 | | | | 20.40 | |
| 14:45 | | | | 20.40 | |
| 15:00 | | | | 20.43 | |
| 15:15 | | | | 20.40 | |
| 15:30 | | | | 20.40 | |
| 15:45 | 121 | | | 20.40 | |
| 16:00 | | | | 20.48 | |
| 16:15 | | | | 20.49 | |
| 16:30 | | | | 20.45 | |
| 16:45 | | | | 19.80 | |
| 17:00 | | | | 20.16 | |
| 17:15 | | | | 20.16 | |
| 17:30 | | | | 22.89 | |
| 17:45 | | | | 30.37 | |
| 18:00 | | | | 31.65 | Develop through the night at depth 121 m. |
| 06:50 | 121 | ~78 | 4 | 30.66 | 15/06 collect 5 * 1liter samples for A5 - - water clear @ 07:45 |
| 08:30 | 124 | 110 | 10.08 | 33.88 | |
| 09:30 | | | | 33.88 | |
| 10:30 | | | | 33.87 | |
| 11:30 | | | | 33.87 | |
| 12:30 | 124 | 110 | 10.08 | 34.68 | |

| TIME (actual) | P.I.D. (mbsu) | ½ 90° V-Notch (mm) | Yield ($m^3/h$) | Water level (mbsu) | Remarks |
|---|---|---|---|---|---|
| 13:30 | 127 | 115 | 11.25 | 34.73 | |
| 14:30 | | | | 33.68 | |
| 15:30 | | | | 33.68 | |
| 16:30 | | | | 33.68 | |
| 17:00 | 127 | 115 | 11.25 | 25.68 | |
| 17:30 | 133 | 100 | 7.92 | 25.69 | |
| 18:00 | | | | 24.68 | Develop through the night @ 133 m. |
| 07:00 | 133 | 100 | 7.9 | 24.67 | Date 16/06/00 |
| 08:20 | 136 | 110 | 10.08 | 23.87 | |
| 09:20 | 136 | 110 | | 23.83 | |
| 09:45 | 139 | 115 | 11.25 | 20.47 | |
| 10:45 | 151 | 115 | | 20.16 | |
| 11:45 | 151 | | | 17.94 | |
| 12:45 | 151 | | | 20.10 | |
| 13:45 | 151 | | | 20.24 | |
| 14:15 | 154 | | | 20.24 | |
| 15:45 | 157 | | | 16.70 | |
| 16:30 | 157 | | | 19.90 | |
| 17:00 | 175 | | | 16.98 | |
| 18:00 | 175 | 108 | | 19.60 | |
| 19:00 | 175 | 105 | | 19.60 | |
| 20:00 | 175 | 105 | | 19.90 | |
| 21:00 | 175 | 110 | 10.08 | 19.90 | |
| 22:00 | 175 | 110 | | 19.90 | |
| 23:00 | 175 | 110 | | 19.90 | |
| 07:00 | 178 | 110 | 10.08 | 16.73 | 17/06/00 |
| 10:30 | 230 | 110 | | 16.69 | |

| TIME (actual) | P.I.D. (mbsu) | ½ 90° V-Notch (mm) | Yield ($m^3/h$) | Water level (mbsu) | Remarks |
|---|---|---|---|---|---|
| 11:00 | 230 | 108 | 10 | 17.68 | |
| 11:30 | | 105 | 9 | 18.68 | |
| 12:00 | | 105 | | 19.72 | |
| 13:00 | 230 | 105 | | 19.61 | |
| 14:00 | 245 | 115 | 11.25 | 19.61 | Clean borehole sump |
| 15:00 | | 115 | | 19.62 | |
| 16:00 | | 115 | | 19.60 | |
| 17:00 | | 115 | | 19.63 | |
| 18:00 | 245 | 115 | 11.25 | 16.70 | Continue until 06:00. (Date 18/05/00) |
| 06:00 | 245 | | | | Stop airlift. Add chlorine to disinfect borehole. |

**Remarks:**

1. In total 81.5 hours of airlift developing took place.
2. In addition, development was also done by means of submersible pump. Pumping was done at various rates, de-watering a considerable section of the borehole, thus flushing residual remnants of the drill cuttings and drill chemicals. This was done on 2/7/2000.

| TIME (actual) | Pump time (min) | Water Level (mbsu) | Yield ($m^3/h$) | E.C. (mS/m) | Remarks |
|---|---|---|---|---|---|
| 13:20 | 0 | 11.45 | | | Rest water level |
| 13:21 | 1 | 17.16 | | | |
| | 2 | 16.62 | | | |
| | 3 | 16.31 | | | |
| | 4 | 16.09 | | | |
| | 5 | 15.82 | | | |

| TIME (actual) | Pump time (min) | Water Level (mbsu) | Yield ($m^3/h$) | E.C. (mS/m) | Remarks |
|---|---|---|---|---|---|
| | 6 | 16.08 | | | |
| | 7 | 16.05 | | | |
| | 8 | 15.90 | | | |
| | 9 | 15.66 | | | |
| | 10 | 15.55 | | | |
| | 14 | 16.56 | 1.846 | | |
| | 20 | 15.67 | | | |
| | 26 | 15.46 | | | |
| | 30 | 15.41 | | | |
| | 35 | 15.38 | | | |
| | 40 | 15.33 | | | |
| | 50 | 15.29 | | | |
| | 60 | 15.20 | | | |
| 14:30 | 70 | 15.13 | | | |
| | 72 | 16.34 | 5.1 | | |
| | 74 | 17.17 | | | |
| | 76 | 17.36 | | | |
| | 80 | 17.33 | | | |
| 14:50 | 90 | 17.31 | | | |
| | 95 | 18.54 | 9.93 | | |
| | 100 | 18.55 | 9.83 | | |
| | 105 | 19.47 | 14.94 | | |
| | 110 | 20.65 | 13.87 | | |
| | 112 | 20.62 | 20.75 | | |
| | 115 | 20.61 | | | |
| | 116 | 20.60 | | | |
| | 120 | 22.09 | 29.27 | | |

| TIME (actual) | Pump time (min) | Water Level (mbsu) | Yield ($m^3/h$) | E.C. (mS/m) | Remarks |
|---|---|---|---|---|---|
| | 136 | 22.04 | | | |
| | 150 | 22.05 | 30.7 | 120.4 | |
| 16:30 | 180 | 22.06 | 30.25 | | Maximum capacity of pump. |

# 6. Evaluation of Pumping Test

# 1. PUMPING TEST ANALYSIS

***J3-A (WW39843)* - Pumping well**

J3-K (WW39842) - *Observation well*

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

The Well Efficiency was analysed by making use of the Rorabaugh method for step draw down data. Aquifer parameters used for the calculation of well efficiency were obtained from the evaluation results of the constant discharge test, which is discussed in **Section 1.2** below. Initial data, especially at the beginning of the test is poor, but could be ignored for the purpose of this evaluation.

The well efficiencies at the range of pumping rates used during the step drawdown test are summarised in **Table 1** below. The correlation between the pumping rates and draw down is however poor during simulation of the actual data and the correctness thereof is questioned.

Table 1: J3-A: Borehole efficiency at various pumping rates

| Borehole number | Step | Abstraction Rate [$m^3/h$] | Draw Down* [m] | Borehole Efficiency [%] |
|---|---|---|---|---|
| J3-A | 1 | 10.4 | 2.82 | 77.9 |
| | 2 | 15.1 | 3.78 | 77.1 |
| | 3 | 20.1 | 4.63 | 76.4 |
| | 4 | 25.1 | 6.12 | 75.8 |
| | 5 | 30.0 | 7.47 | 75.2 |

* at cut-of time $\Delta t$, after which well bore storage has no affect on the well performance

Data on the linear and non-linear well losses and skin factors as well as the efficient well radius are presented in **Annex 1.**

## 1.2. Constant Discharge Test Analysis (Annex 2 - 5)

The constant discharge draw down curve of abstraction borehole **J3-A** indicates some leaky conditions induced after about **300 minutes** of pumping. For leaky aquifers, the Walton / Hantush I analysis method with draw down and recovery data was used to calculate the hydraulic conductivity of the aquifer and the aquitard **(Annex 2 & 3**). Using the normal Theis or Cooper-Jacob analysis results in the over estimation of the hydraulic conductivity of the leaky aquifer and an under estimation of the hydraulic conductivity of the aquitard. (Kruseman, De Ridder, 1992).

For unknown reasons the recovery of the water level in the pumping borehole **J3-A** was beyond the indicated rest water level prior to the test.

Aquifer storativity was estimated due to the fact that observation borehole **J3-K** is located in the Kalahari aquifer and not in the pumped Auob sandstone aquifer. During the duration of the constant discharge test no direct influence from pumping can be observed in the water level of observation borehole **J3-K**, which indicates that the Kalahari aquifer was not influenced by abstraction over the period of testing (See **Annex 5**).

The occurrence of leakage could be due to water derived from storage within the aquitard. The sandstone within the Rietmond formation is confined and under higher hydraulic pressure and will also contribute to leakage occurring into the Auob Sandstone Aquifer. The results of the constant discharge analysis are summarised in **Table 2** below.

Table 2: Aquifer Parameters calculated for J3-A; Auob

| Borehole number | Analysis Method | T | s | k | S | Simulation model | Comments |
|---|---|---|---|---|---|---|---|
| | | [$m^2$/day] | [m] | [cm/sec] | [-] | | |
| J3-A | Walton / Hantush I-draw down | 194 | 34 | $6.6 \times 10^{-3}$ | *$1 \times 10^{-5}$ | Walton / Hantush I | *Storativity estimated - Observation borehole not located in the tested aquifer |
| | Walton / Hantush I-recovery | 194 | 34 | $6.6 \times 10^{-3}$ | *$1 \times 10^{-5}$ | | |

A much higher hydraulic conductivity value was calculated for this part of the aquifer in the Auob sandstone if compared with other pumping test evaluations in the Auob sandstones.

The Hantush model for leaky condition from aquitard storage was used to simulate and verify the actual data and analysis approach of the constant discharge test. Simulation parameters summarised in **Table 2** were used in simulation of the actual pumping test data (See **Annex 1.4** for simulation results).

**Annex 1.5** compares the draw down results of the pumping borehole **J3-A** and observation borehole **J3-K** and it is clear that pumping from the Auob sandstone aquifer did not have any influence on the Kalahari aquifer.

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

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

$R = 3000 \times 4.5 \times 8.1 \times 10^{-3} = \underline{109\ m}$

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. In case of a confined aquifer the radius of influence most probably larger and the 109 m are considered to be the minimum value.

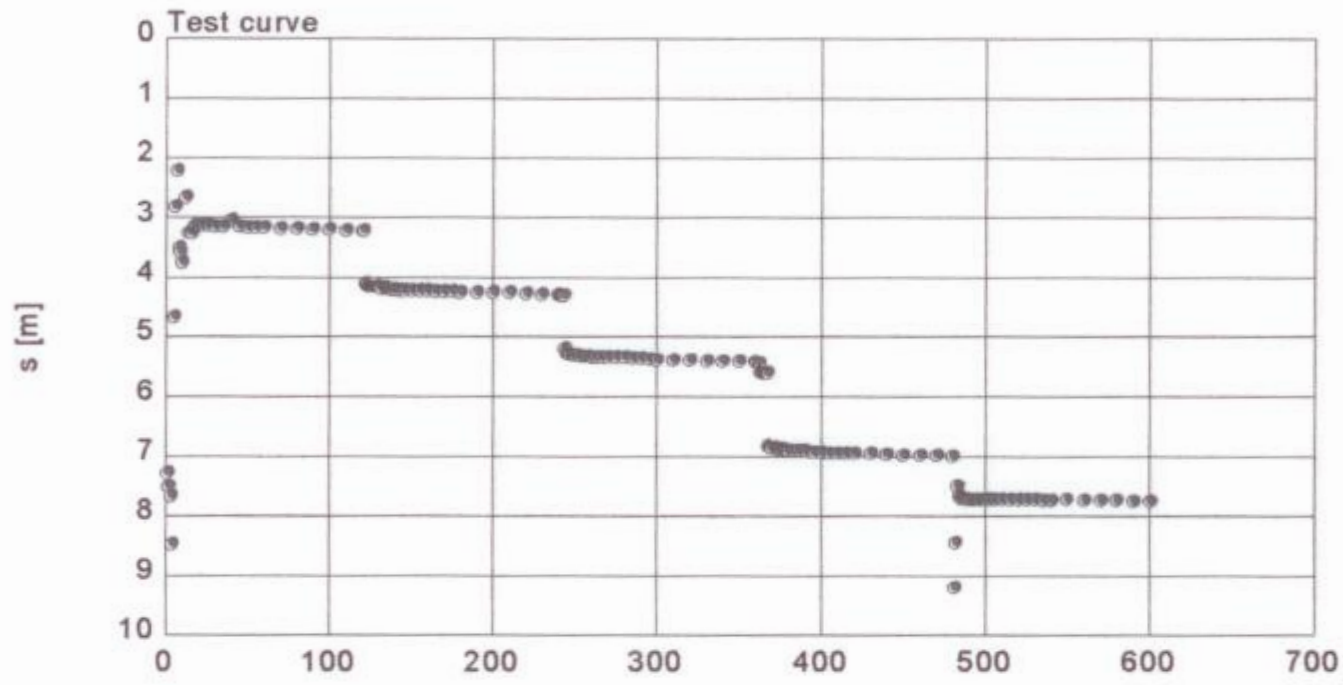
A proper evaluation of R (and storativity S) will only be possible once reliable data from observation wells, penetrating the same aquifer as the pumped well, are available.

# Groundwater Study in the Stampriet Artesian Basin

## Evaluation of Test Pumping Data

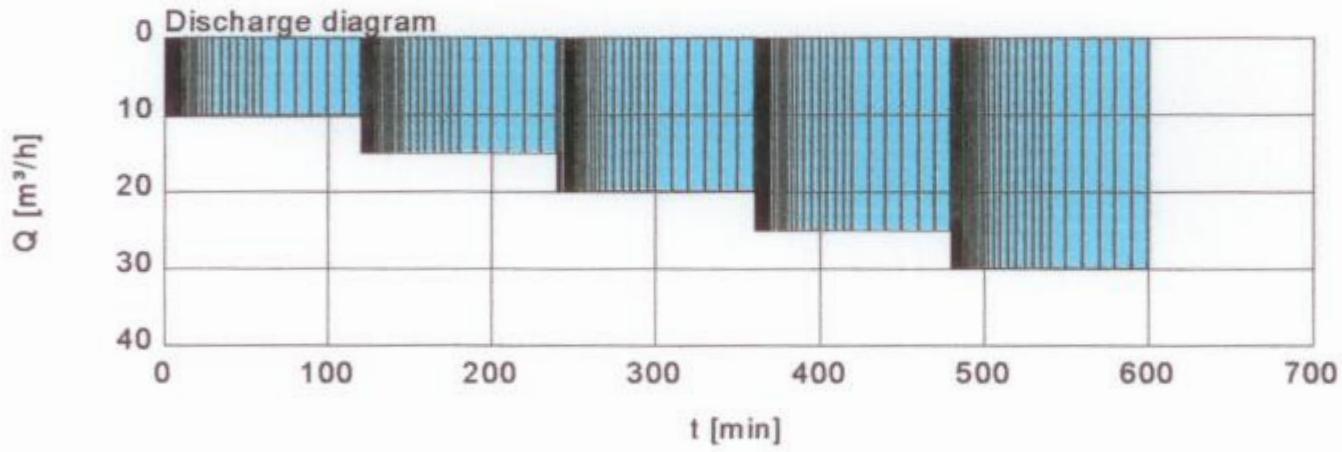
### Step test analysis

Pumped well J3_A



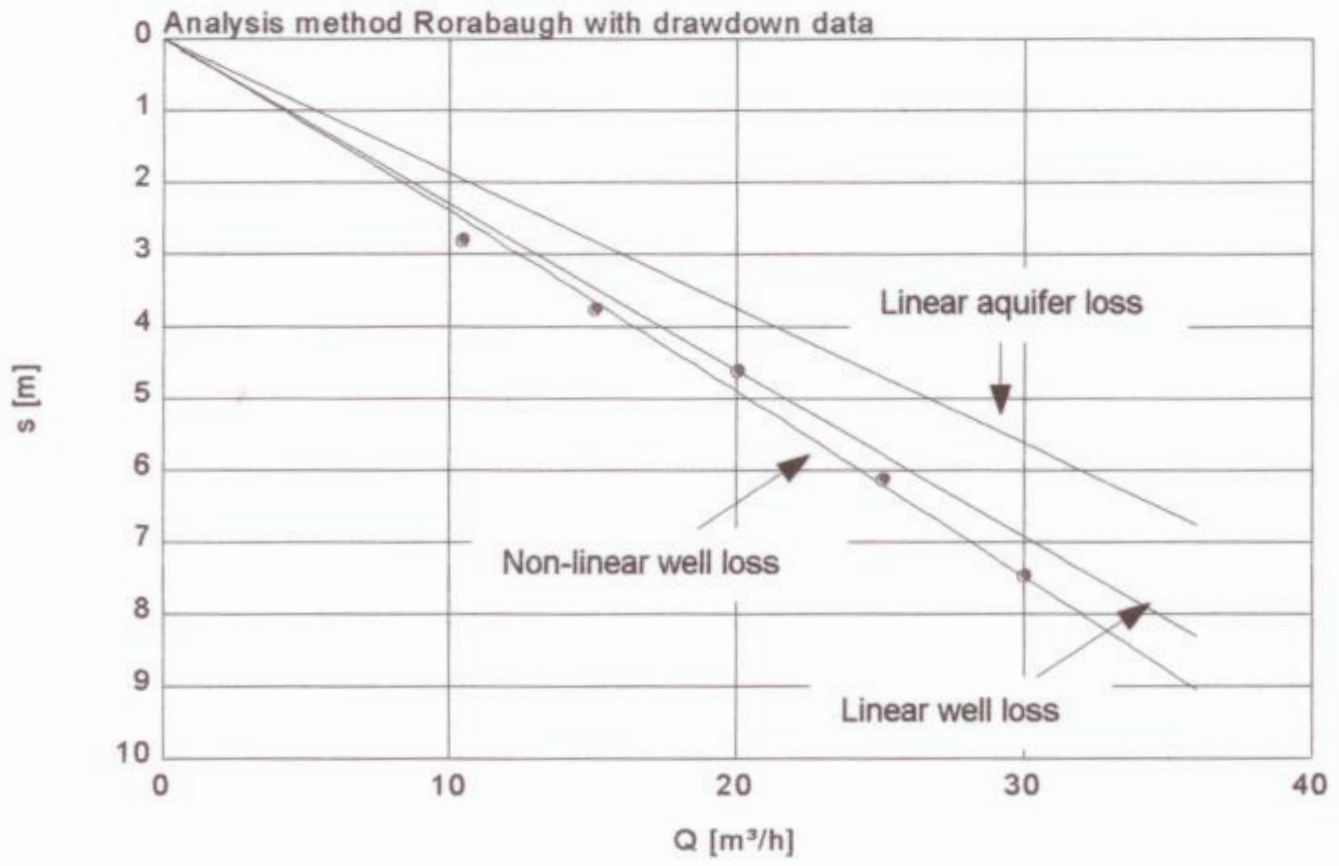

**Borehole, well & aquifer**

| | |
|---|---|
| Drilled: | |
| Latitude: | 24.04792 |
| Longitude: | 18.79312 |
| Elevation: | 1205 [m] |
| Depth: | 253 [m] |
| Stick up: | 0.80 [m] |
| Bh. radius: | 0.1255 [m] |
| Casing radius: | 0.084 [m] |
| RWL: | 15.42 [m] |
| max.drawdown: | 9.20 [m] |
| Aq.type: | confined |
| Aq.thickness: | 34.00 [m] |
| Stratigraphy: | Auob Sandstone |
| Lithology: | sandstone + shale |




**Test running**

| | |
|---|---|
| Start: | 04/07/2000 08:10:00 |
| Dis.dur.: | 600 [min] |
| Av.dis.: | 20.1 [m³/h] |
| Max.dis.: | 30 [m³/h] |
| Min.dis.: | 10.4 [m³/h] |
| Total dis.: | 201 [m³] |
| Crew: | Metzger_PM |
| Supervisor: | PCI |




**Results**

Well performance:

s: $(B1+B2)*Q+C*Q^P$

| | |
|---|---|
| Linear aquifer loss B1: | 0.24 |
| Linear well loss B2: | -8.7E-03 |
| Non-linear well loss C: | 2.3E-3 |
| Exponent P: | 1.61 |

| | Q [m³/h] | s [m] | Eff [%] |
|---|---|---|---|
| Step 1: | 10.4 | 2.82 | 77.9 |
| Step 2: | 15.1 | 3.78 | 77.1 |
| Step 3: | 20.1 | 4.63 | 76.4 |
| Step 4: | 25.1 | 6.12 | 75.8 |
| Step 5: | 30.0 | 7.47 | 75.2 |

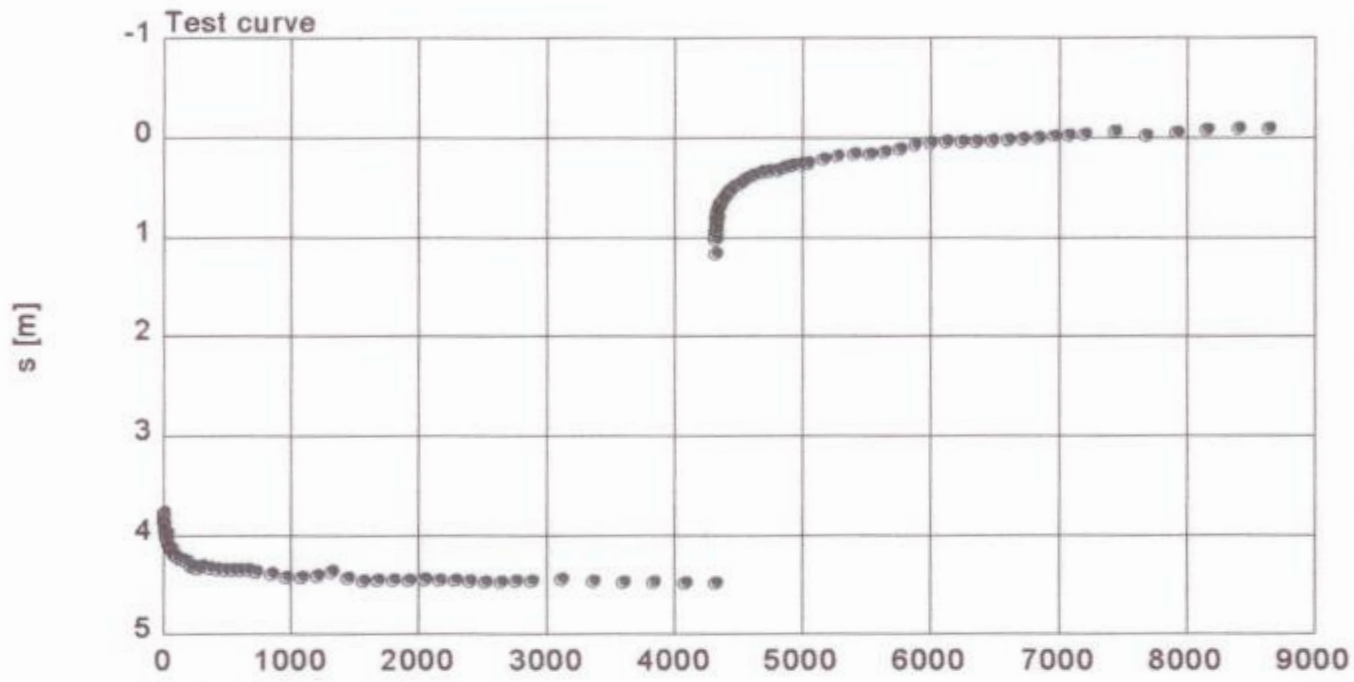
| | |
|---|---|
| Linear skin factor: | -0.45 [-] |
| Non-linear skin factor: | 2.92 [d/m³] |
| Effective well radius: | 5.1E-3 [m] |

# Groundwater Study in the Stampriet Artesian Basin

## Evaluation of Test Pumping Data

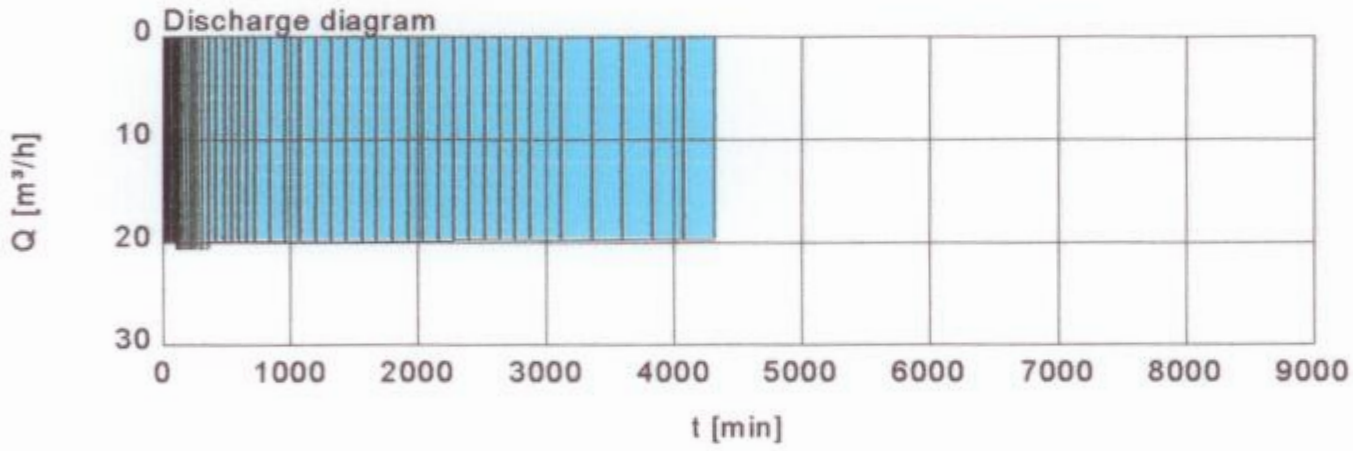
### Test pumping analysis

### Pumped well J3_A



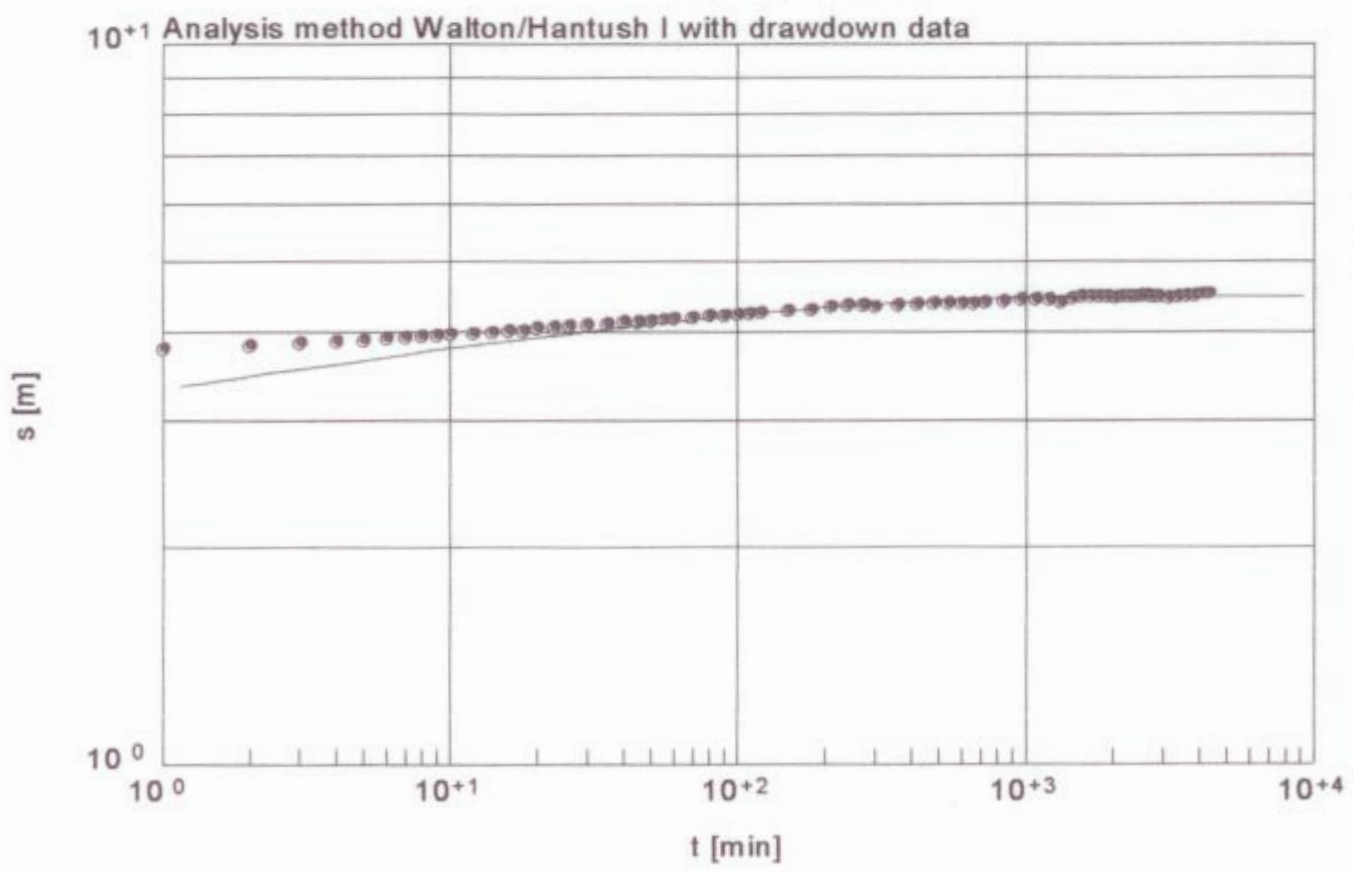

**Borehole, well & aquifer**

| | |
|---|---|
| Drilled: | |
| Latitude: | 24.04792 |
| Longitude: | 18.79312 |
| Elevation: | 1205 [m] |
| Depth: | 253 [m] |
| Stick up: | 0.80 [m] |
| Bh. radius: | 0.1255 [m] |
| Casing radius: | 0.084 [m] |
| RWL: | 16.57 [m] |
| max.drawdown: | 4.49 [m] |
| Aq.type: | confined |
| Aq.thickness: | 34.00 [m] |
| Stratigraphy: | Auob Sandstone |
| Lithology: | sandstone + shale |




**Test running**

| | |
|---|---|
| Start:05/07/2000 09:00:00 | |
| Dis.dur.: | 4320 [min] |
| Av.dis.: | 19.9 [m³/h] |
| Max.dis.: | 20.6 [m³/h] |
| Min.dis.: | 19.8 [m³/h] |
| Total dis.: | 1.44E3 [m³] |
| Crew: | Metzger_PM |
| Supervisor: | PCI |




**Results**

| | |
|---|---|
| Match parameter: | |
| Q: | 19.9 [m³/h] |
| t: | 4.71 [min] |
| s: | 3.61 [m] |
| 1/u: | 2.05E8 [-] |
| W(u,r/B): | 18.4 [-] |
| Aquifer parameter: | |
| T: | 194 [m²/d] |
| k: | 5.71 [m/d] |
| Boundary parameter: | |
| B: | 1E4 [m] |
| m': | 60 [m] |
| k': | 0.000116 [m/d] |

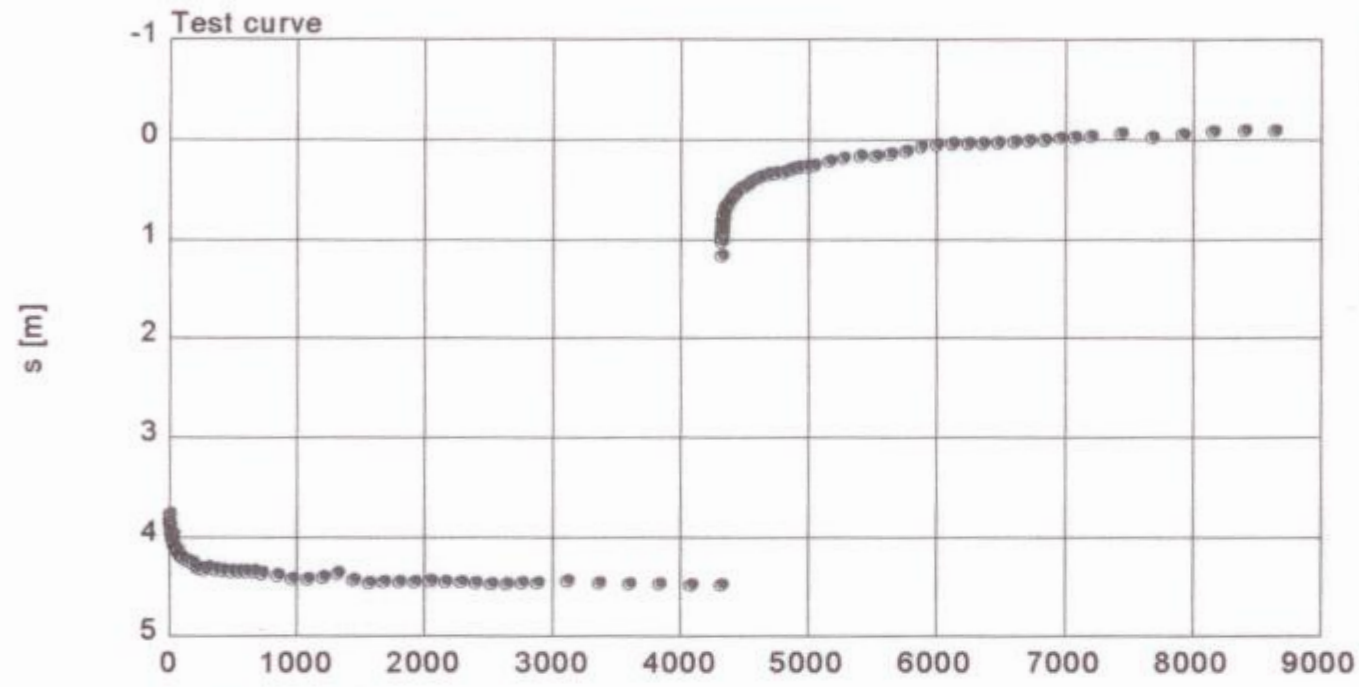
Date 17/08/00 | prepared by BIWAC | Annex 2

# Groundwater Study in the Stampriet Artesian Basin

## Evaluation of Test Pumping Data

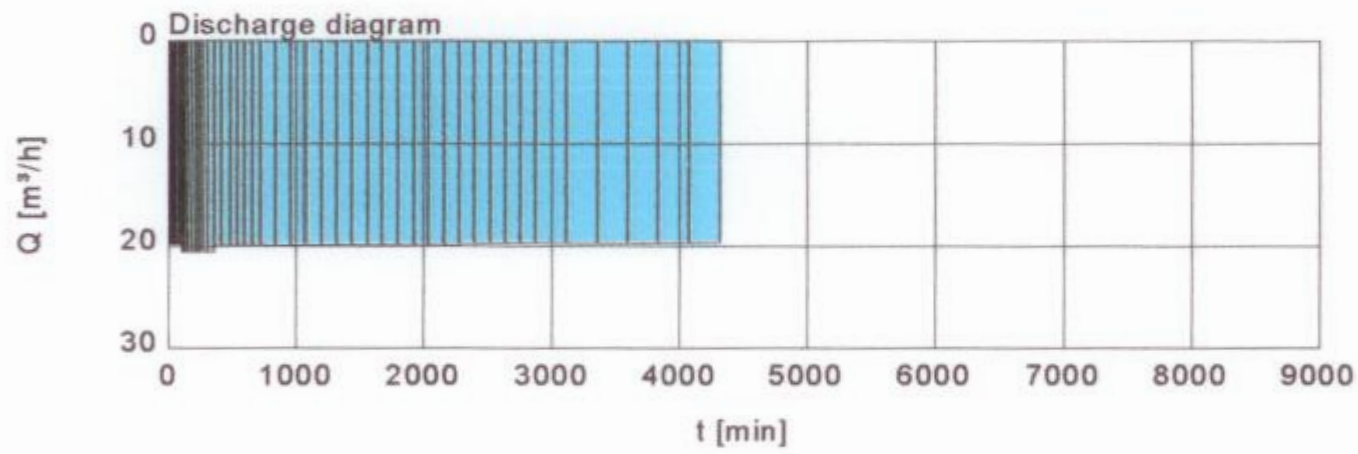
### Test pumping analysis

Pumped well J3_A



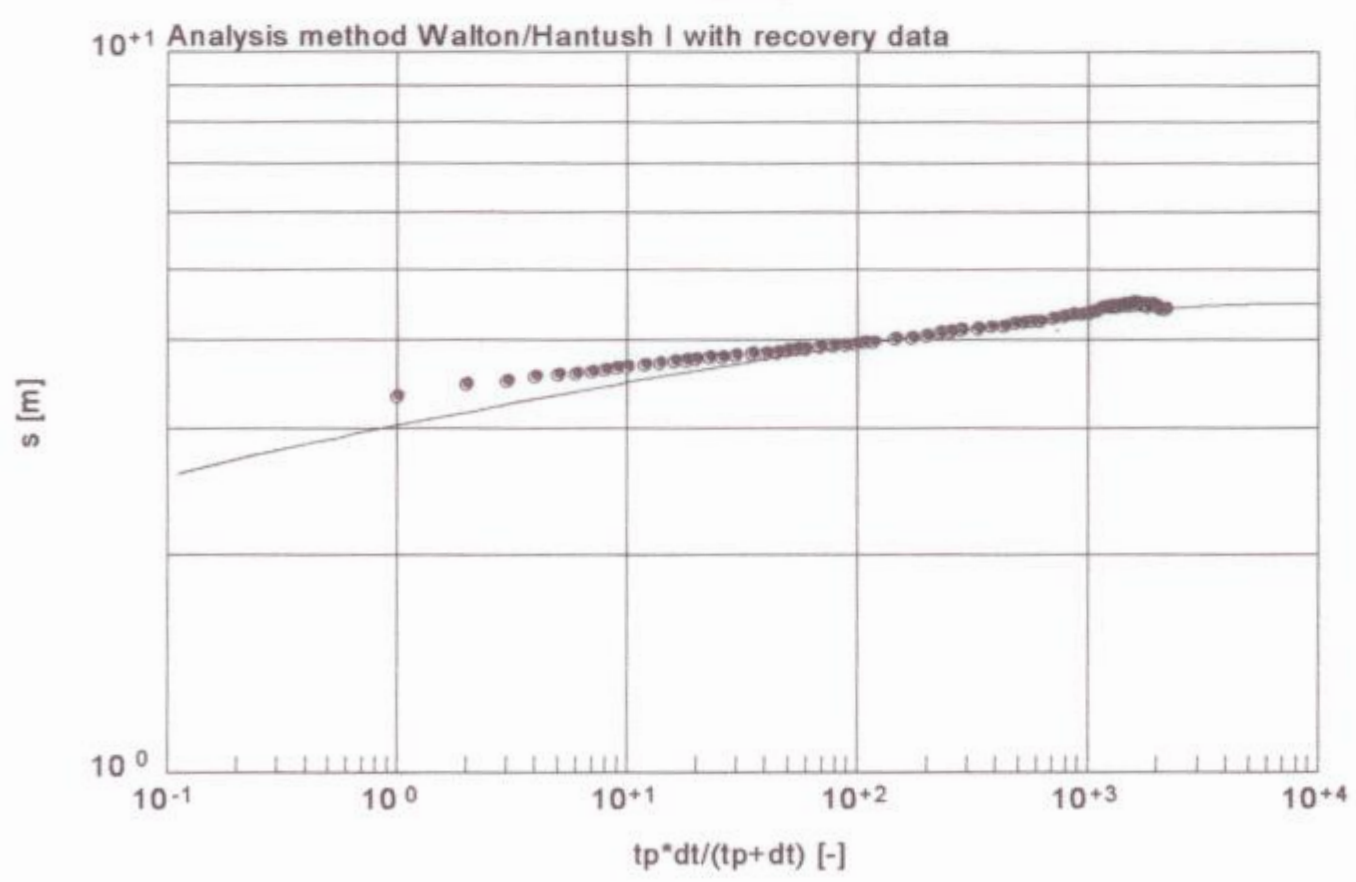

**Borehole, well & aquifer**

| | |
|---|---|
| Drilled: | |
| Latitude: | 24.04792 |
| Longitude: | 18.79312 |
| Elevation: | 1205 [m] |
| Depth: | 253 [m] |
| Stick up: | 0.80 [m] |
| Bh. radius: | 0.1255 [m] |
| Casing radius: | 0.084 [m] |
| RWL: | 16.57 [m] |
| max.drawdown: | 4.49 [m] |
| Aq.type: | confined |
| Aq.thickness: | 34.00 [m] |
| Stratigraphy: | Auob Sandstone |
| Lithology: | sandstone + shale |




**Test running**

| | |
|---|---|
| Start: | 05/07/2000 09:00:00 |
| Dis.dur.: | 4320 [min] |
| Av.dis.: | 19.9 [m³/h] |
| Max.dis.: | 20.6 [m³/h] |
| Min.dis.: | 19.8 [m³/h] |
| Total dis.: | 1.44E3 [m³] |
| Crew: | Metzger_PM |
| Supervisor: | PCI |




**Results**

| | |
|---|---|
| Match parameter: | |
| Q: | 19.9 [m³/h] |
| t: | 246 [min] |
| s: | 4.14 [m] |
| 1/u: | 2.24E9 [-] |
| W(u,r/B): | 21.1 [-] |
| Aquifer parameter: | |
| T: | 194 [m²/d] |
| k: | 5.71 [m/d] |
| S+sf: | 3.8E-6 [-] |
| Boundary parameter: | |
| B: | 1E4 [m] |
| m´: | 60 [m] |
| k´: | 0.000116 [m/d] |

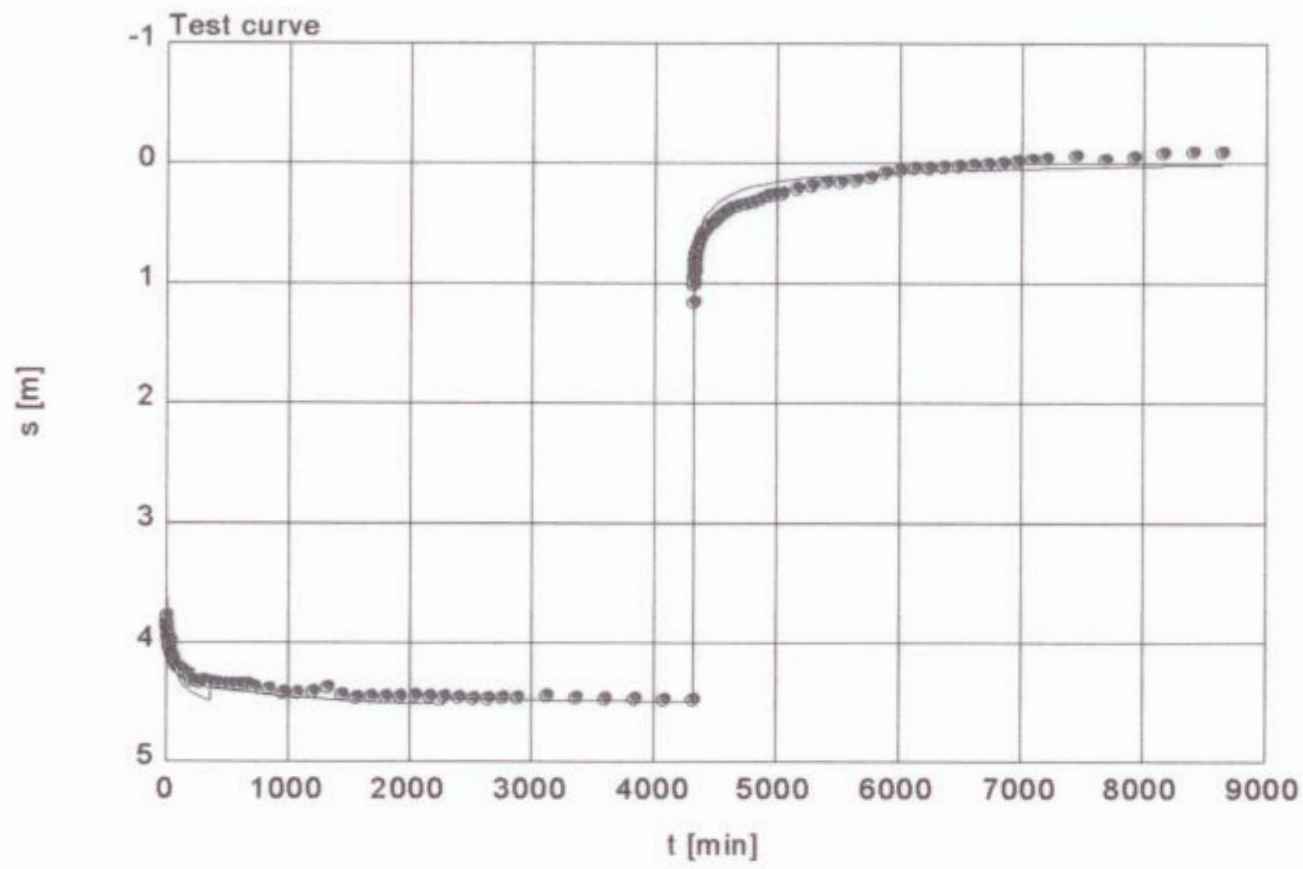
Date 17/08/00 | prepared by BIWAC | Annex 3

# Groundwater Study in the Stampriet Artesian Basin

## Evaluation of Test Pumping Data

### Test pumping diagnosis

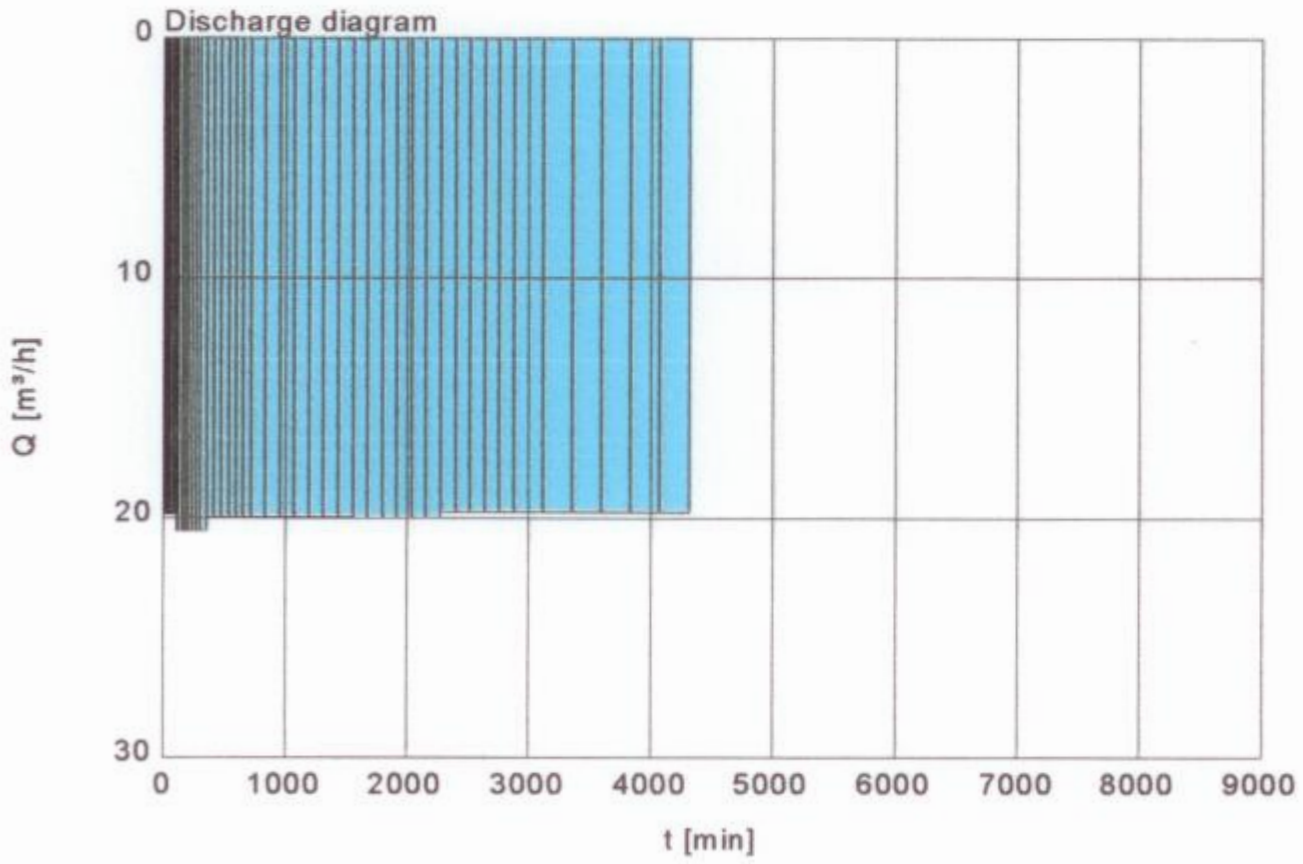
Pumped well J3_A




Remarks

The Walton / Hantush I method for leaky aquifers was used to simulate the actual pumping test data.

Simulation parameters were derived from the pumping test evaluations.




Discharge info

Dis.dur.:4320 [min]
tcorr: 4317 [min]
---
Av.dis.: 3.97 [m³/h]
max.dis.:4.11 [m³/h]
min.dis.:3.95 [m³/h]
Qn: 3.96 [m³/h]
---
Dis.sum: 285 [m³]

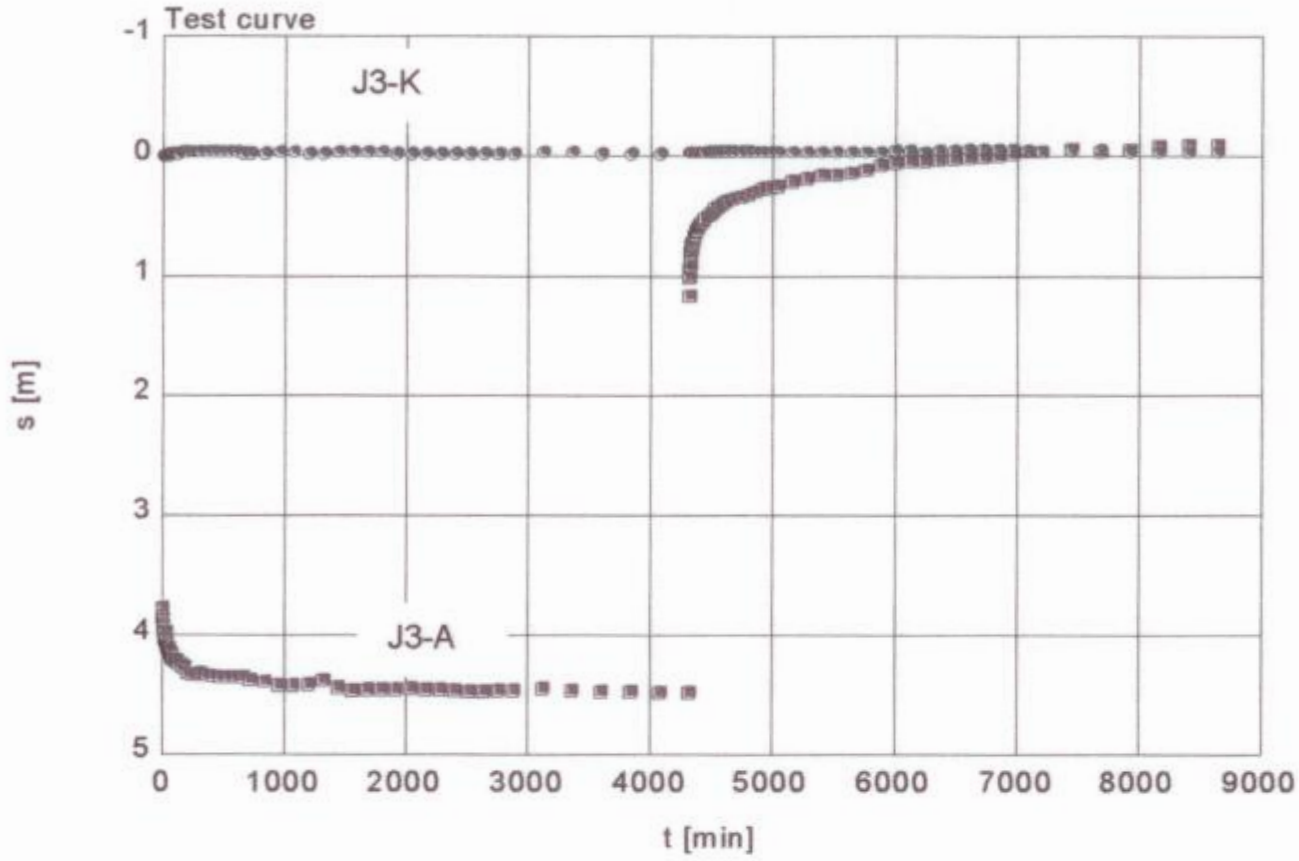
Date 17/08/00 | prepared by BIWAC | Annex 4

# Groundwater Study in the Stampriet Artesian Basin

## Evaluation of Test Pumping Data

### Test pumping diagnosis

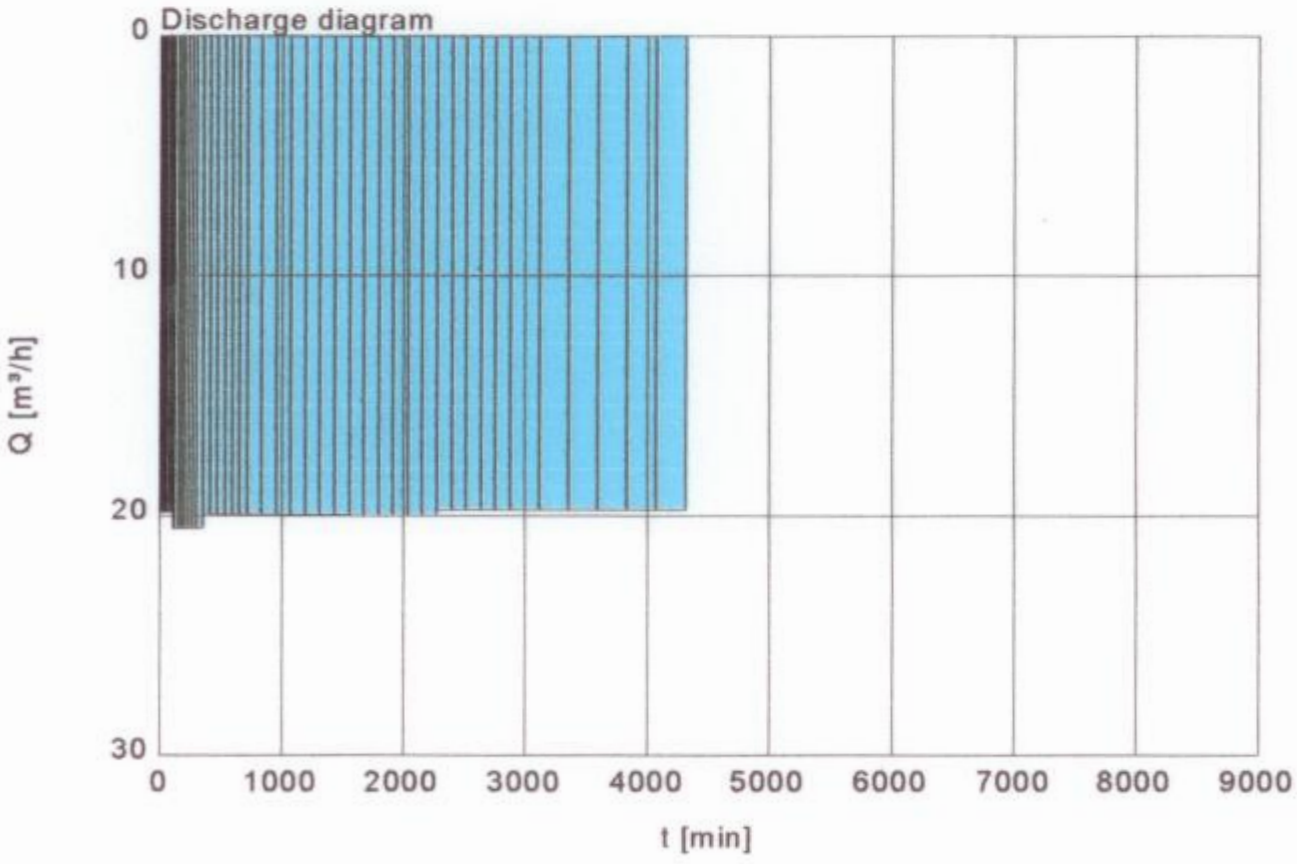
Pumped well J3_A




Remarks

Merged data from observation borehole J3-K and pumping borehole J3-A.

Pumping from the Auob sandstone aquifer (J3-A) did not have any influence on the water level in the Kalahari aquifer borehole (J3-K).




Discharge info

Dis.dur.:4320 [min]
tcorr: 4317 [min]
---
Av.dis.: 3.97 [m³/h]
max.dis.:4.11 [m³/h]
min.dis.:3.95 [m³/h]
Qn: 3.96 [m³/h]
---
Dis.sum: 285 [m³]

Distance to observation borehole J3-K = 215.9 m

| Date 17/08/00 | prepared by BIWAC | Annex 5 |
|---|---|---|

# 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 3 A LOCALITY: Choroaoheib R 300**

**WW 39843**

1. **Serial Number of floater**: 4491
2. **Date installed**: 6/9/00
3. **Rest Water Level when installed**: 14.98 mbsu
4. **Distance from stick-up to logger**: 10.0
5. **Distance from logger to water level**: 4.98
6. **Cut off**: 10.0 m (0.91 + 9.11)