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

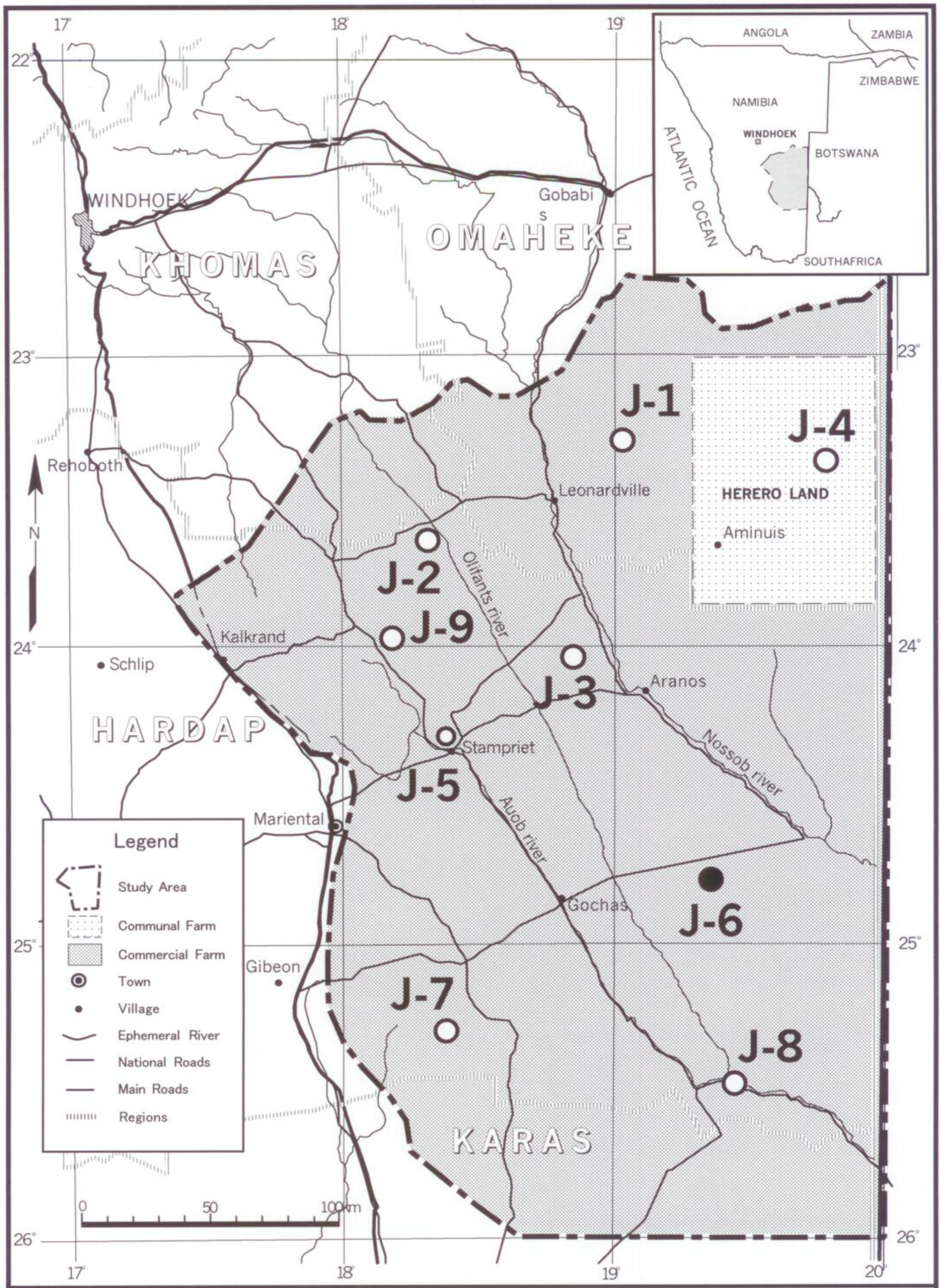
J6-N (WW 39851)

Cobra R 349

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

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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 Cobra **WW 39851**
Jica Reference: J 6 N **S 24. 79963°**
Date completed: 26 June 2000 **E 19. 33457°**
(final casing installed) **Collar elev.: 1104 mamsl**

Depth below surface (m)	Section (m)	Lithology	Stratigraphy
0 - 4	4	Very coarse-grained subsurface **sand**. Unsorted.	
4 - 26	22	Calcareous **sandstone** with pebbles and granules, light pinkish to white.	
26 - 104	78	Calcareous **sandstone**, moderate brown, drill-cuttings severely ground. Between 48 and 52 m a gravelly horizon was intersected.	
104 - 111	7	Light brown medium to coarse grained **sandstone**, calcite cemented.	
111 - 121	10	Calcareous **sandstone**, moderate brown, drill-cuttings severely ground.	**KALAHARI**
121 - 141	20	Calcareous **sandstone**, medium grained quartz grains. Dispersed quartz granules ∅ 2 mm, sub angular, sandstone purple to dark grey.	
141 - 153	12	As above, with colour change to moderate orange brown.	
153 - 158	5	As above, with intercalated bands of moderate red brown **sandstone**, medium to coarse grained, with quartz granules ϕ 2 – 3 mm displaying FeO staining between 156 and 158 m.	
158 - 168	10	Prominent **sandstone** to 164 m, fining to a shale at 168 m, colour dark yellowish brown.	
168 - 177	9	Moderate brown clayey **shale**. At 177 m moderate brown very fine sandstone/siltstone	**RIETMOND**
177 - 186	9	Very pale orange medium to coarse grained **sandstone**, moderately sorted and sub-rounded quartz grains. Sandstone friable, porous and slightly calcareous. A few chips of moderate brown siltstone in sample. Intercalated thin dark yellowish orange shale. Aquifer.	**AUOB A 5**
186 - 199	13	Greyish pink to moderate pink medium to coarse-grained micaceous feldspathic **sandstone**. Muscovite and biotite recorded. The sandstone is friable and porous. From 197 m sandstone becomes well foliated with an increase of biotite.	
199 - 209	10	Medium to coarse-grained feldspathic **sandstone**, friable and porous and slightly micaceous (mainly muscovite.) Dark yellowish orange. Clayey possibly due to intercalated shales.	

209 - 222	13	Greyish red to very dusky red **shale**. Intercalated medium to coarse grained feldspathic sandstone. Muscovite and biotite present. Colour of sandstone brownish grey to grayish red. Shale increases with depth, sandstone decreases with depth. From 219 to 222 m the colour of the shale changes to blackish red.	**AUOB A 4**
222 - 232	10	Light grey to medium dark grey fine to medium grained slightly calcareous micaceous **sandstone** with intercalated wel- laminated dark grey shale and siltstone. Flakes of strong brown clay present. With depth sandstone changes to medium to coarse grained.	**AUOB A 3**
232 - 236	4	Predominantly well-laminated **shale** with subordinate intercalated micaceous sandstone layers. Flakes of strong brown clay present.	**AUOB A 2**
236 - 264	28	Medium gray medium to coarse grained calcareous **sandstone** . Very porous with pure white calcite nodules ∅ 2 – 3 mm.	**AUOB A 1**
264 – 285	21	As above with intercalated **shale/siltstone** layers. Formation more micaceous (biotite). Colour darker grey. Sandstone slightly calcareous.	**UPPER MUKOROB**
285 - 352	67	Grey to dark grey **shale**. Carbonaceous dark grey below 330 m.	**MUKOROB**
352 - 380	28	Light grey to grey **sandstone**, very fine at 380 m, and coarsening upwards to a fine sandstone at 374 m. From 374 m a second cycle starts with a thin **shale**, grey, coarsening upwards over very fine to a fine to medium grained sandstone at 353 m.	**NOSSOB**
380 – 385 EOH	5	Grey **shale**/mudstone	**DWYKA**

General remarks:

1. Drilling method mud rotary results in severe grinding of samples during up-hole transport. Samples thus often collected as a "clayey" mass and carefull washing is necessary to interpret geology.
2. This borehole was logged by A. Wierenga and F. Bockmuhl.

2. Penetration Record

	Penetration Record Borehole J 6 N WW 39851			
Depth (m)	Pen. Rate (min/m)	Time	Date	Remarks
1				start of drilling at diameter 311 mm
5				
10				
	3.8			
	4.65			
	4.2			
	4.9			
	4.65			
	4.7			
	4.7			
	4.85			
20	5.1			
	6.3			
	6.1			
	5.6			
	5.2			
	6.1			
	6.2			
	6.2			
	6.95			
	6.9			
30	6.8			
	6.2			
	6.35			
	6			
	6			
	5.8			
	6.9			
	5.1			
	2.3			
	4.1			
40	7.4			
	10.2			
	7.05			
	10.85			
	9.2			
	15.45			
	18.45			
	17.5			
	10.6			
	6.8			
50	13.95			
	15.7			
	13.4			
	14.9			
	12.65			

	11.55			
	13.2			
	18.45			
	16.4			
	13.85			
60	10.75			
	12.5			
	14.4			
	11.4			
	10			
	2.65			
	7.3			
	7.2			
	7.55			
	6.95			
70	6.7			
	6.6			
	7.5			
	7.4			
	6.3			
	6.85			
	7.6			
	7.1			
	6.9			
	7.2			
80	6.7			
	5.2			
	6.35			
	6.75			
	6.9			
	7.25			
	7.4			
	7.4			
	7.45			
	10.15			
90	9.45			
	9.65			
	7.8			
	7.85			
	6.9			
	6.6			
	6.4			
	6.5			
	7.7			
	5.6			
100	7.5			
	5.2			
	5.2			
	4.2			
	4.8			
	5.05			
	4.6			
	6.45			
	7			
	3.35			
110	3			

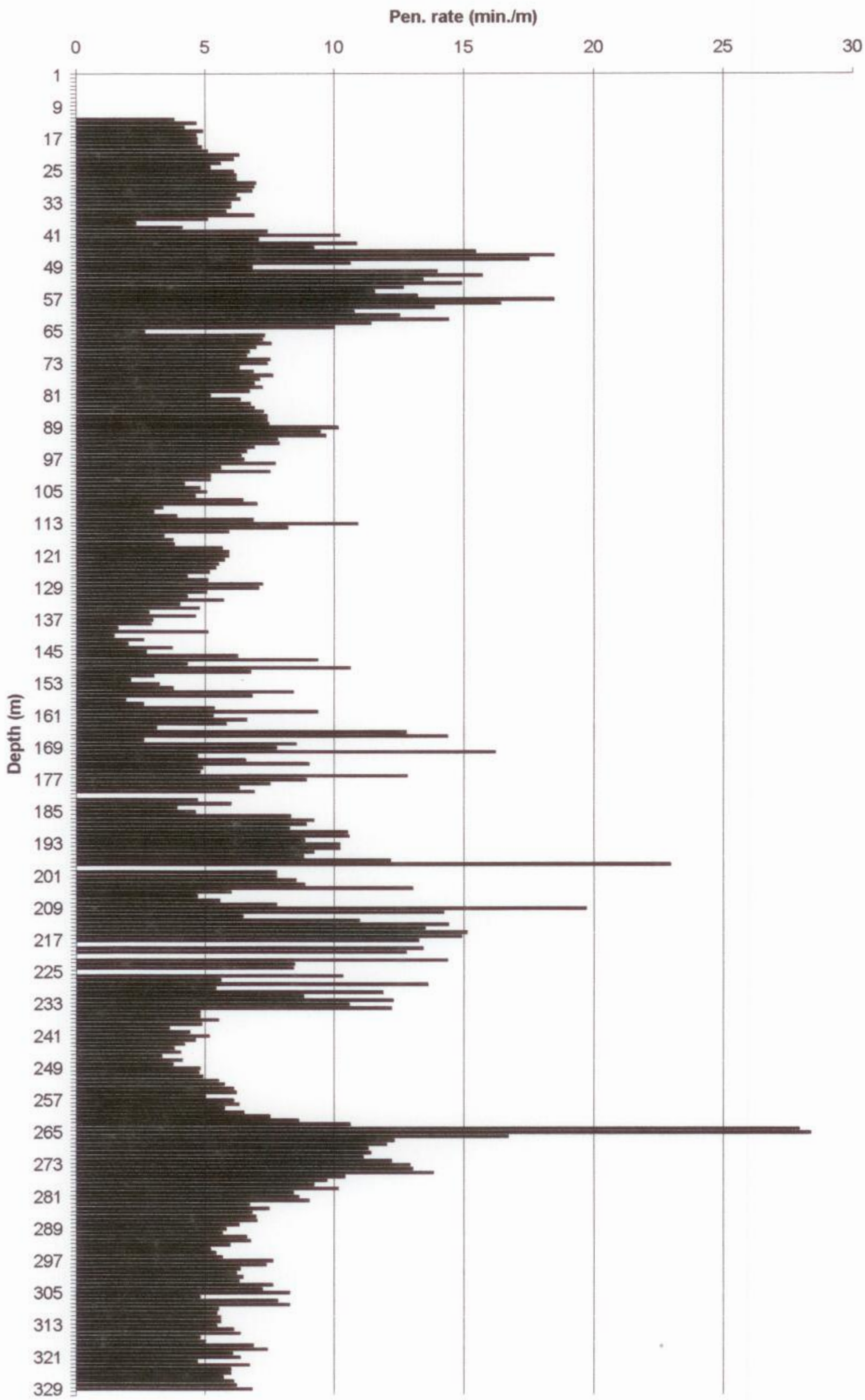
	3.9			
	6.85			
	10.9			
	8.2			
	5.9			
	3.4			
	3.75			
	3.8			
	5.65			
120	5.9			
	5.9			
	5.75			
	5.5			
	5.4			
	5.15			
	4.3			
	5.1			
	7.2			
	7.05			
130	5.05			
	4.3			
	5.7			
	4			
	4.75			
	2.8			
	4.6			
	2.95			
	2.9			
	1.6			
140	5.1			
	1.45			
	2.6			
	2			
	3.7			
	2.7			
	6.25			
	9.35			
	4.3			
	10.6			
150	6.75			
	3			
	2.1			
	3.2			
	3.75			
	8.4			
	6.8			
	1.9			
	2.6			
	5.35			
160	9.35			
	5.3			
	6.6			
	5.8			
	3.1			
	12.75			
	14.35			

	2.6			
	8.5			
	7.75			
170	16.2			
	4.7			
	6.55			
	9			
	4.9			
	4.8			
	12.8			
	8.9			
	7.5			
	6.3			
180	6.9			
	4.7			
	6			
	3.9			
	4.6			
	8.3			
	9.2			
	8.9			
	8.25			
190	10.5			
	10.55			
	8.85			
	10.2			
	10.2			
	9.2			
	8.8			
	12.15			
	22.95			
200	7.75			
	7.75			
	8.5			
	8.85			
	13			
	6			
	4.7			
	5.55			
	7.75			
	19.7			
210	14.2			
	6.45			
	10.95			
	14.4			
	13.5			
	15.1			
	14.9			
	13.25			
	13.4			
220	12.75			
Depth (m)	Pen. Rate (min./m)			
	14.35			

	8.45			
	8.4			
	10.3			
	5.6			
	13.6			
	5.4			
	11.85			
230	8.8			
	12.25			
	10.55			
	12.2			
	4.8			
	4.8			
	5.5			
	4.85			
	3.6			
	4.4			
240	5.15			
	4.6			
	4.2			
	3.8			
	4.05			
	3.3			
	4.1			
	3.75			
	4.8			
	4.75			
250	4.9			
	5.5			
	5.75			
	6.1			
	6.2			
	5			
	6.1			
	6.3			
	5.75			
	6.5			
260	7.5			
	8.6			
	10.6			
	27.9			
	28.35			
	16.7			
	12.3			
	12			
	11.3			
	11.4			
270	11.1			
	12.2			
	12.9			
	13			
	13.8			
	10.4			
	9.7			
	9.2			

	10.15			
	8.4			
280	8.6			
	9			
	6.7			
	7.45			
	6.8			
	6.95			
	7			
	6.3			
	5.8			
	5.65			
290	6.6			
	6.75			
	5.95			
	5.2			
	5.4			
	5.65			
	7.6			
	7.35			
	6.35			
	6.2			
300	6.45			
	6.3			
	7.6			
	7.2			
	8.25			
	4.8			
	7.8			
	8.25			
	5.5			
	5.45			
310	5.6			
	5.6			
	5.45			
	6.1			
	6.35			
	4.8			
	5			
	6.85			
	7.4			
	6.05			
320	6.35			
	4.7			
	6.7			
	6			
	6			
	5.7			
	6.1			
	6.2			
	6.8			
330				

Penetration Record J 6 N



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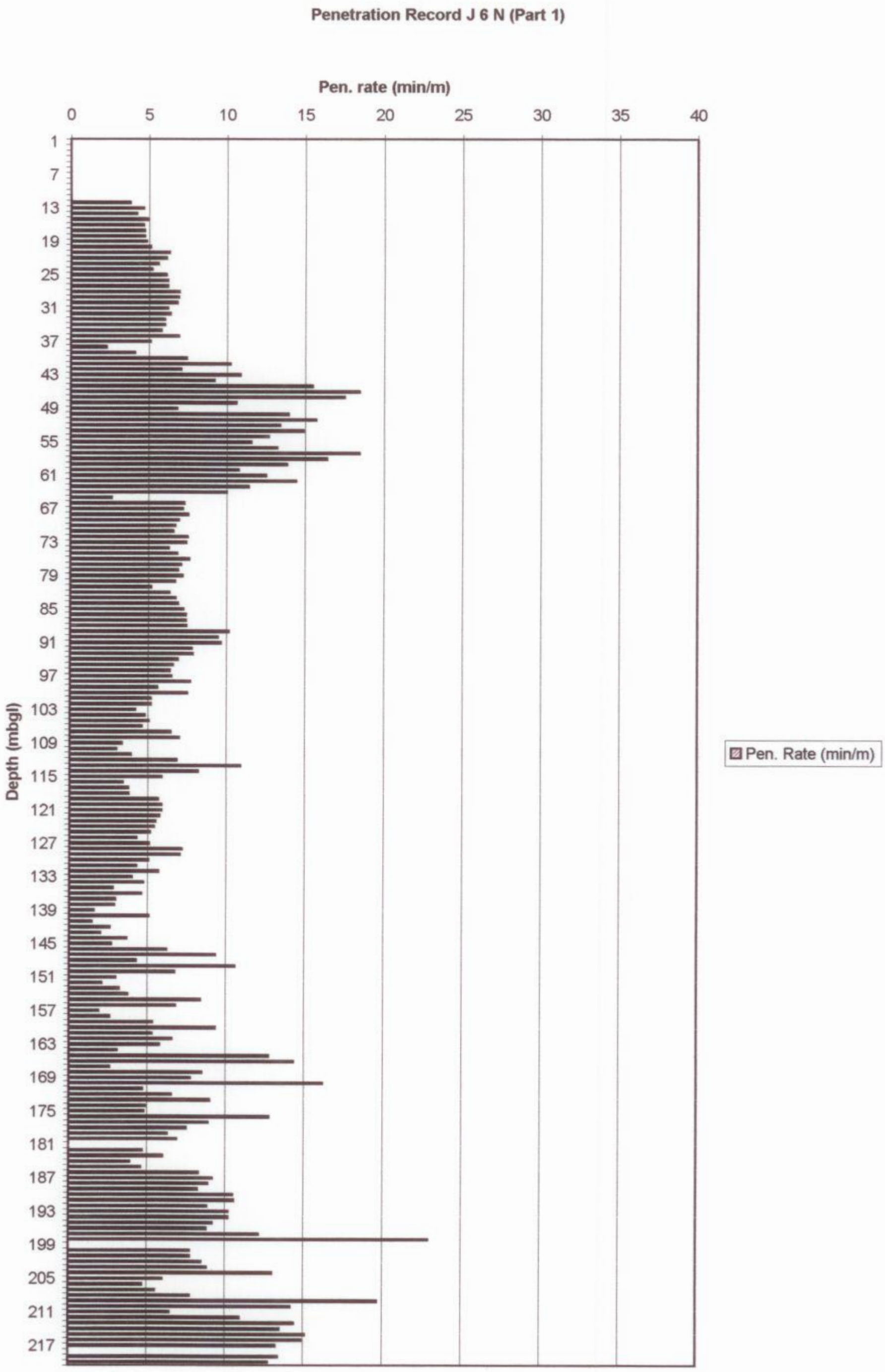

Chart2

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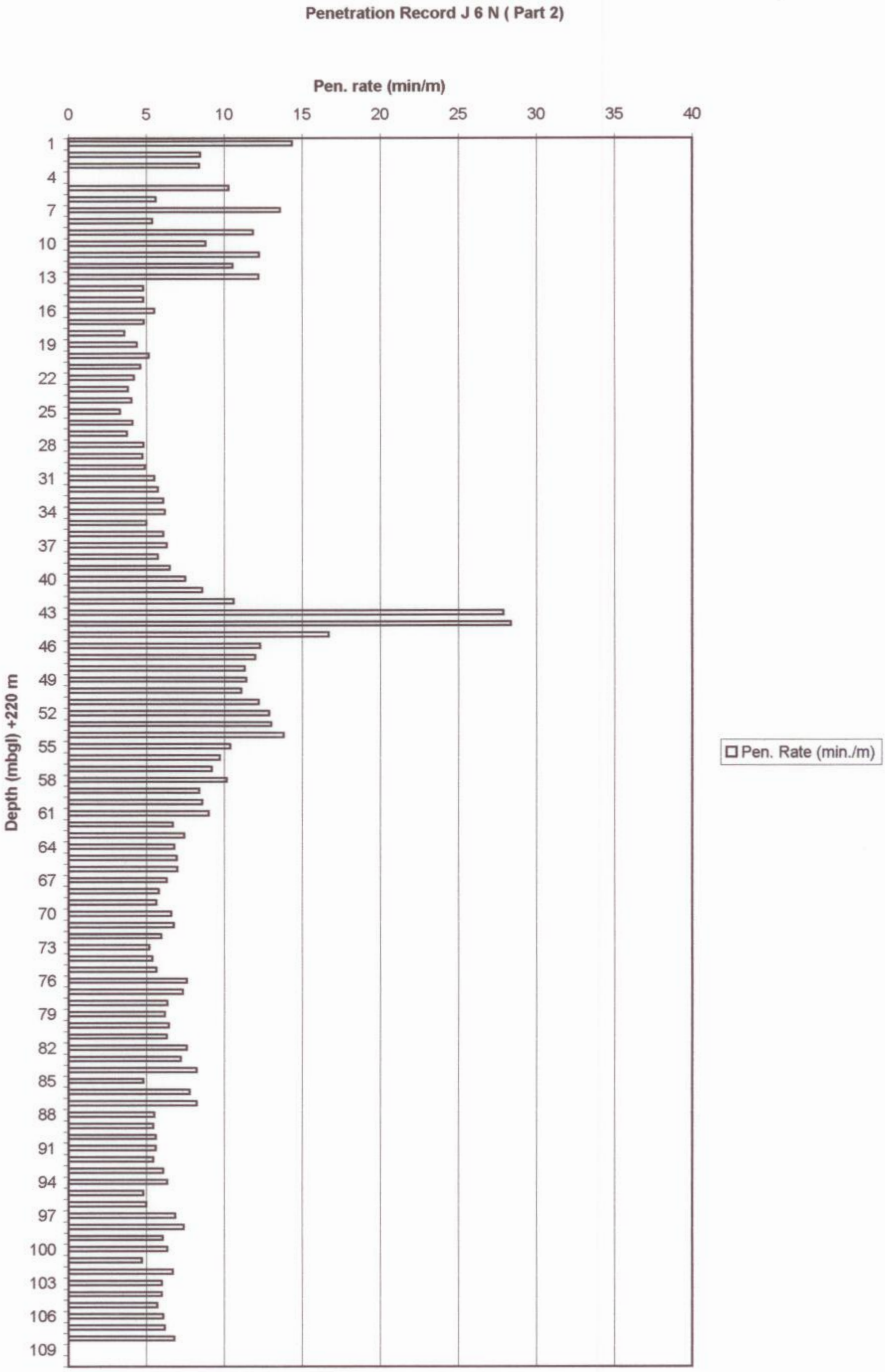


Chart3

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 6 N LOCALITY: Cobra R 349 WW 39851 DATE: 10/06 to 24/06/00

TIME	DEPTH mbgl	MARSH FUNNEL TEST 1000 ml (sec)	MARSH FUNNEL TEST 500 ml (sec)	E. C. mS/cm	DENSITY	pH	TEMPERATURE ° C	COMMENT
16:45 10/06				0.816		8.5		Water used for mixing
08:00 13/06	223	44	28	1.98		8	15.5	At start of logging
		29	18	0.96		9	15.5	Water used for mixing
08:00 18/06	328	39	25	1.55		8.5	13.3	At start of logging
		29	20	0.88		8.5	12	Water used for mixing
23/06	336	42	28	2.56		12	24.8	
		29	19	0.97		9	14.6	Water used for mixing
	356	35	24	2.25		12	25.7	
09:10 24/06	379	34	22	2.4	- 1.16	12	25.3	
15:30 24/06	385	34	21	2.43		12	23.9	
		29	19	1.02		9	16.5	Water used for mixing

4. Geophysical Log and Casing Design

Poseidon Geophysics

(Reg. No. 93553)

CO. Poseidon Geophysics
WELL_&N WW 39851
PROJ.
LCN. Cobra
STE. J 6
FILES No. &N

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 J6N WW39851

LOCATION COBRA

COUNTRY REPUBLIC OF NAMIBIA

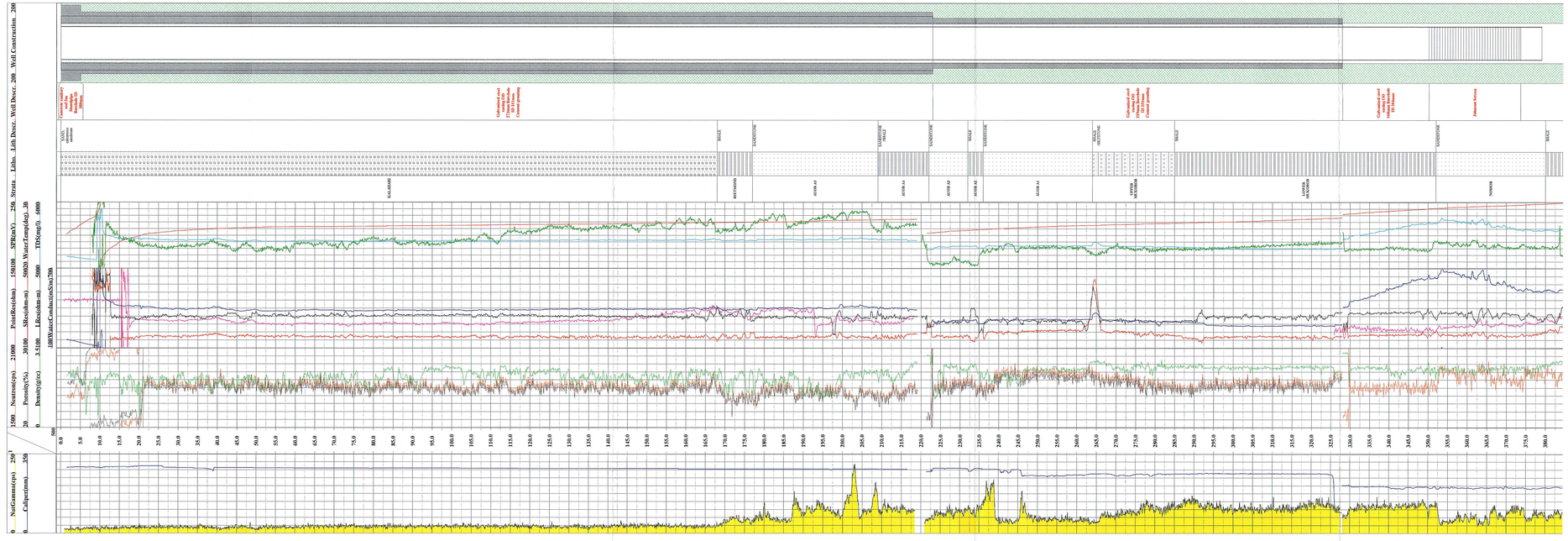
BH COORDINATES

COLLAR ELEVATION
LOG MEAS. FROM Groundlevel

DRILLING MEAS. FROM Groundlevel

DATE	24 June 2000
TYPE LOG	Physical Properties
DEPTH-DRILLER	385m
DEPTH-LOGGER	385.10m
BTM LOGGED INTERVAL	385.10m
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 6 N LOCALITY: Cobra R349 WW 39851 DATE: 28/06/2000 (starting)

TIME (actual)	P.I.D. (mbsu)	½ 90° V-Notch (mm)	Yield (m^3/h)	E.C. (mS/m)	Water Level (mbsu)	Remarks
11:00	348				0 (artesian)	Date 28/06/00. Introduce 25 kg Sodium Tri Poly Phosphates and chlorine. Re-circulate airlifted water in borehole by introducing it back on the outside of the 6" casing.
09:30	348					Date 29/06/00. Re-circulation was done through the night. Stop after total of 22.5 hours airlift development.
12:25						Date 29/06/00. Begin to airlift.
16:30	348				> 108	No water to be airlifted. Air pipe is only 112 m. Stop. Measure rate of recovery.
16:45					106	
8:20					91.85	Date 30/06/00.
17:00					97.18	After airlift pipes were removed from borehole.
8:50					85.5	Date 1/7/00. Decide to develop by cable tool.
12:00					85.5	
11:00						Date 1/7/00. **Cable Tool data.**
13:00					84.41	Bailing 2 hours
17:00					84.40	Plunging 4 hours
20:00						Bailing 3 hours

TIME (actual)	P.I.D. (mbsu)	½ 90° V-Notch (mm)	Yield (m^3/h)	E.C. (mS/m)	Water Level (mbsu)	Remarks
08:30						Date 2/7/00.
10:00			1.3		94.33	Bailing 1.5 hours: 78 bailers removed, with each bailer containing 25 l. Total removed 1.95 m^3.
16:30					87.00	Plunging 6.5 hours. pH 9.81. Water still full of drill fluid.
08:00					85.70	Date 3/07/00.
11:00			0.675			Bailing 3 hours: 81 bailers @ 25 l removed for atotal amount of 2.025 m^3.
17:30						Plunging 6.5 hours.
09:00			.600			Date 4/7/00. Bailing 24 bailers @ 25 l. Water still dark grey, but without drilling mud.
10:00			.300		133	Date 5/7/00. Install airlift pipes. Airlift for 2 hours.
8:40					121	Date 06/07/00. Air pipe at 180 m.
09:00		35 - 70				Surging. Fill up borehole with water from tanker.
07:30						Date 7/7/00. Start with borehole artificially filled.
08:30						Borehole empty. Decide to low blower tube to 220 m.
12:00						No water reaches surface.
10:00		20 - 40	Surging			Date 8/7/00: Start blowing with the addition of drill foam. Regular add water from the tanker to borehole. Effective airlifting for the day 6 hours.
						Date 9/6/00: Repeat of previous days activities. Total for the day 3 hours effective airlifting.
09:00					126	No airlifting.
09:00				919	31.62	Date 12/07/00. Start bailing with **Cable Tool.** pH 10.47
17:00				661		Water from tanker. 98 bailers @35 l (??). Could not

TIME (actual)	P.I.D. (mbsu)	½ 90° V-Notch (mm)	Yield (m^3/h)	E.C. (mS/m)	Water Level (mbsu)	Remarks
						empty borehole. pH 10.78
08:00				816	107.56	Date 13/07/00: repeat bailing. pH 11.62
17:00						72 bailers removed. Borehole not empty.
08:00					170.15	Date 14/07/00: Carry on with bailing.
17:00						Remove 69 bailers
08:00					195.1	Date 15/07/00: carry on with bailing.
11:00						Stop bailing. 21 bailers removed.
11:30					145.86	Date 17/7/00. Water level measurement only.

Remarks:

1. This artesian borehole is very low yielding. Recovery is extremely slow.
2. A total of 93.5 hours was spent on developing by both airlift and cable tool.
3. Because of low yield and slow recovery it was decided not to develop by submersible pump, or to conduct a pumping test.
4. Testing to be done by pressure release only, and specifically by "slug test".

6. Evaluation of Pumping Test

1. EVALUATION OF SLUG TEST

The piezometric level of artesian borehole **J6-N** was measured at more than 20 m above surface. Borehole **J6-N** was tested by abstracting 1.2 litre of groundwater (free flow via a valve) during a period of 4 seconds. Before the test a pressure probe was lowered and the piezometric level was calibrated at theoretical 4.18 m depth below collar.

The original drawdown was measured at Y_0 = 15.06 m and modelled at Y_0 = 20.15m (**See Figure 2**). The borehole recovered to the original level after approximately 16 hours.

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 sandstone aquifer (**See Table 1 and Figures 1 and 2**).

Table 1: Solutions for slug (abstraction) test J6-N

Test	Solution	T [m^2/day]	K [cm/sec]	Y_0 [m]	S* [--]
Free flow: abstraction of 1.2 litre during 4 seconds	Cooper-Bredehoeft-Papadopulos	1.487			$\leq 1 \times 10^{-5}$
	Bouwer-Rice		6.1×10^{-5}	20.15	

* estimated

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

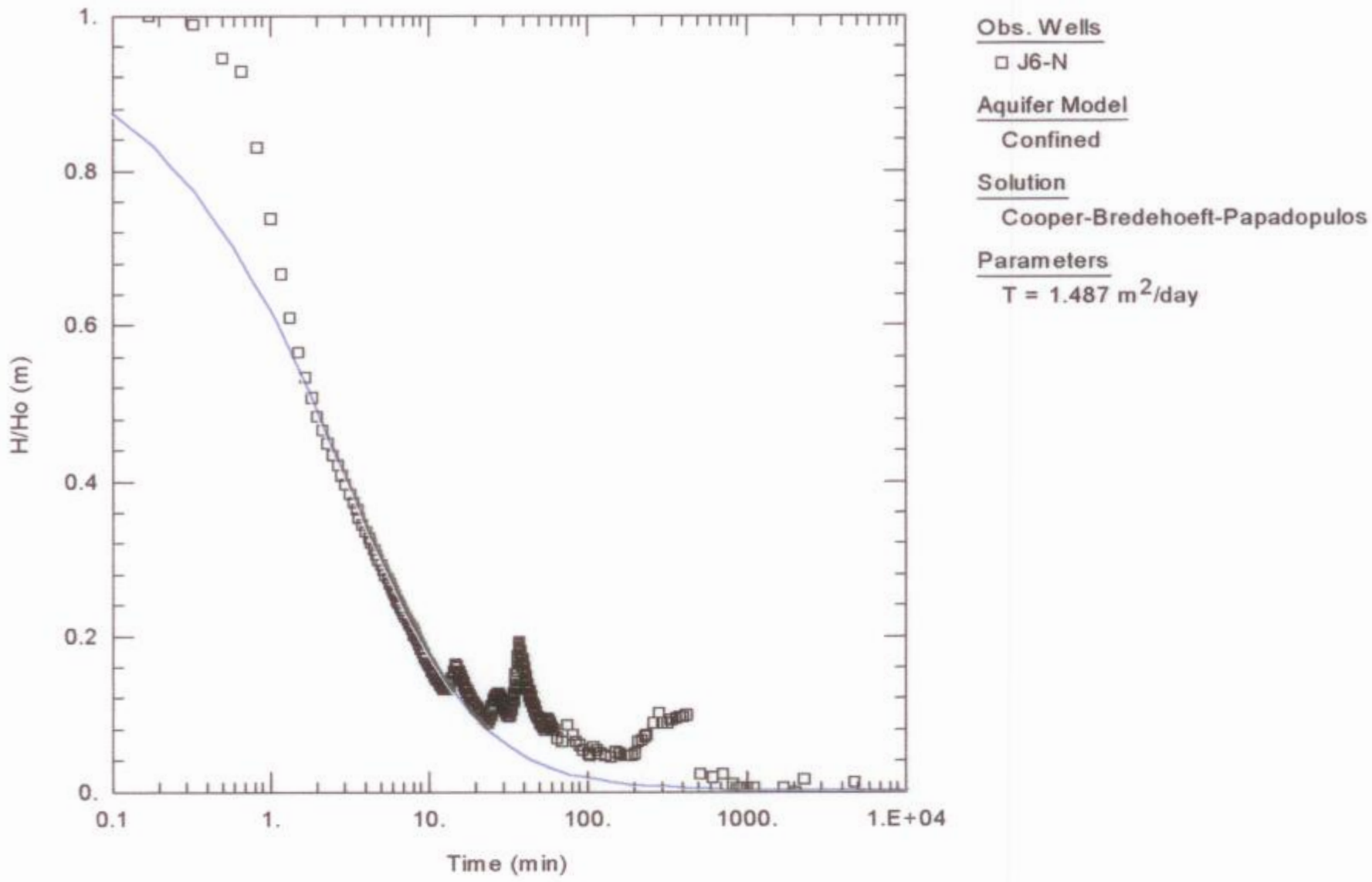


Figure 1: Free flow recovery; Cooper-Bredehoeft-Papadopulos Solution

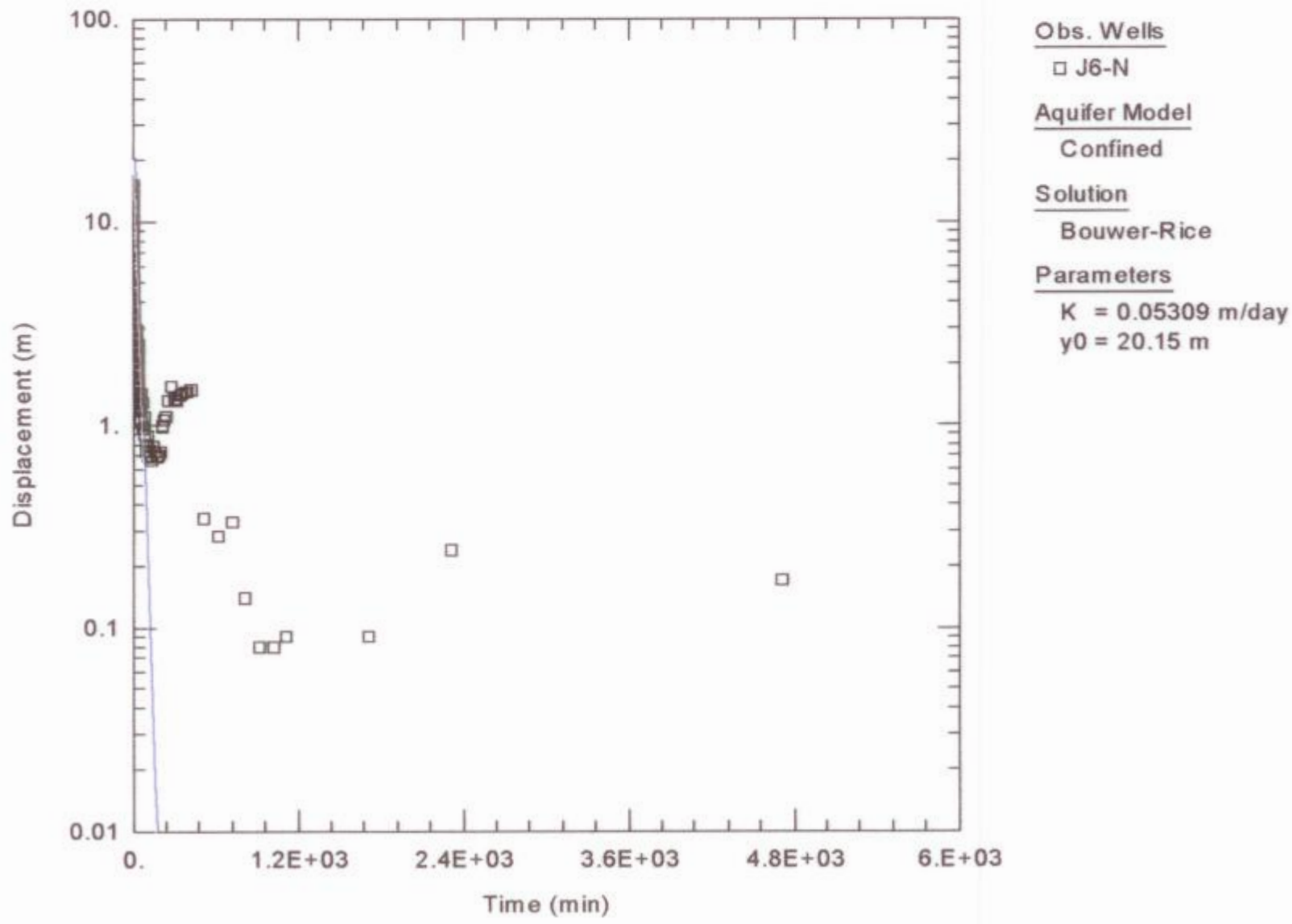


Figure 2: Free flow recovery; Bouwer-Rice Solution

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 6 N **LOCALITY: Cobra R 349**

WW 39851

1. **Serial Number of floater**: F20230
2. **Date installed**:
3. **Rest Water Level when installed**: artesian
4. **Distance from stick-up to logger**: n/a
5. **Distance from logger to water level**: n/a
6. **Cut off**: n/a