CHAPTER 8 HYDROGEOLOGY

8.1 Existing Database and Hydrocensus

Not only geological information but also existing boreholes information is indispensable for hydrogeological analysis. The Department of Water Affairs established the first database as the Groundwater Database in 1980'. Hydrocensus was conducted in this study in order to revise and compliment it.

8.1.1 Groundwater Database of DWA

Groundwater Database of DWA contains basic borehole data; equipment; summarised geology; and the four parameters of water quality. Borehole positions and coordinates were estimated from 1: 50 000 topographical maps plotting positions and coordinates are of varying accuracy.

DWA's database listed a total of 7,855 boreholes and 1,506 farmers in the study area. Forty eight percent of total, 3,816 boreholes have WW Nos. given by DWA. DWA keeps raw data of those boreholes submitted upon completion of borehole construction, however, the number of boreholes that have available hydrogeological information is about 10% of total.

The Study Team reviewed raw borehole data of DWA from the geological and hydrogeological points of views. They were classified into three (3) categories from the hydrogeological point of view as below.

<u>A Class</u>: boreholes, which have detailed geological description (817 boreholes in total)

<u>B Class</u>: boreholes, which have incomplete hydrogeological description (878 boreholes in total)

<u>C Class</u>: boreholes, which have no hydrogeological description, or boreholes of which raw data are not available.

8.1.2 Hydrocensus

Hydrocensus consisted of two major survey items, water point survey (boreholes, wells, springs) and farm survey. Their survey formats are attached in the end of 8.1 and a summary of the number of questionnaire items answered is given in Appendix J.

A total of 6,279 boreholes, wells and springs have been surveyed. For two sites the status was questionable, for 17 boreholes the status was not given, 390 boreholes were recorded as destroyed, 955 as not used and the remaining 4,915 sites were used. The borehole positions were determined by GPS, other hydrogeological variables measured and information gathered from the farmers. The main achievement is that for the first time the borehole positions were accurately recorded and the measured holes marked with aluminium plates indicating the geographical coordinates. Following the positions of the visited boreholes - and considering that a few farms are without boreholes - the coverage of the HydroCensus is at least above 96%.

Eleven hundred and sixty six properties are listed in the HydroCensus Farm spreadsheet, many farms consisting of more than one registered property. Following own record keeping at least 1269 properties have been covered. Fifty-one farms of the farm spreadsheet belong to the Government of Namibia. According to the farm database supplied by the DWA there are, however, 91 Government farms within the Study Area out of a given total of 1321 properties larger than 10 ha. However, many of the communal farms, like Aminuis and the Corridor farms - together 23 - are not listed under the Government of Namibia. On the other hand, no farm questionnaires could be prepared for a considerable number of Government farms.

Table 8.1-1 Number of Returns in Each Survey Item

Water Points Survey

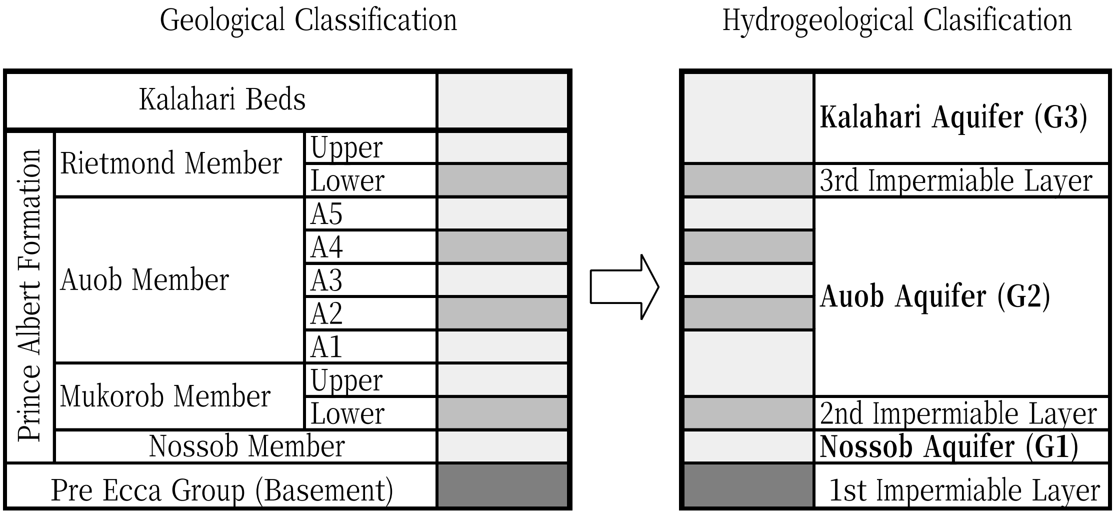
QUESTIONNAIRE ITEM	No of Returns	QUESTIONNAIRE ITEM	No of Returns
Survey Date:	6,279	Water use Unknown (x)	301
Farm Number:	6,279	Permit Number	294
Type (BH; WELL; SPR; Other):	6,277	Depth of seal	287
Sketch number:	6,274	2nd Water struck Aquifer	273
Team Area / Person:	6,271	Remarks 2	227
Latitude (°S)	6,265	1st Water struck Aquifer	211
Longitude (°E)	6,265	Type of seal (CEM; BEN; Define)	211
Status (U; NU; DES)	6,264	1st Water struck water level (m)	185
Ground elevation (mamsl)	6,204	Second casing depth to top (m)	125
Topo	6,005	2nd Water struck Yield (m3/h)	120
Outer casing above ground (m)	5,873	2nd Water struck from (m)	102
Installation Type (WP; M; C; Sub; PH)	5,148	Second casing inside diameter (mm)	101
Well number	4,768	3rd Water struck water level (m)	101
Flow meter	4,368	1st Water struck to (m)	100
Entered by:	4,288	Second casing depth to bottom (m)	92
Reservoir Height (m)	4,233	2nd Water struck water level (m)	91
Reservoir Material	4,204	2nd Water struck Quality	82
Reservoir Diameter (m)	4,113	Reading	70
Drilling report available (Y/N)	4,107	Screen inside diameter (mm)	66
Make, Model, Capacity	3,879	3rd Water struck to (m)	61
Reservoir Covered (Y/N)	3,442	Second casing Wall thickness	59
Installation depth PID (m)	3,319	Second casing material	59
Outer casing inside diameter (mm)	3,192	Screen depth to bottom (m)	45
Site Name:	2,966	Screen casing material	37
Water use Stock (m3/d)	2,888	Screen depth to top (m)	36
Distance to kraal (m)	2,587	Screen Wall thickness	36
Direction to kraal (°)	2,504	3rd Water struck Aquifer	34
EC (mS/m)	2,447	Screen opening width (mm)	28
Final Borehole depth (m)	2,446	3rd Water struck from (m)	27
WW number	2,385	2nd Water struck to (m)	23
Completion Date	2,377	Screen opening length (mm)	19
Leakage indicated (Y/N); see Remarks	2,365	Screen opening Horizontal spacing (mm)	17
Water level measured (m)	2,324	Screen opening Vertical spacing (mm)	17
Temperature (°C)	2,219	3rd Water struck Yield (m3/h)	14
Remarks	2,200	Third casing inside diameter (mm)	12
Reservoir Leaking/ Overflowing (x)	2,034	Remarks (3)	12
Water sampled (Y/N) = Bottle number	1,992	3rd Water struck Quality	11
Description of Strata (1)	1,831	Third casing material	9
Water use Domestic (m3/d)	1,821	Third casing depth to top (m)	8
Outer casing material	1,690	Third casing depth to bottom (m)	8
Water use Irrigation (m3/d)	1,509	Description of Strata (2)	8
Water level type (RWL; AFF; PMP)	1,483	Third casing Wall thickness	6
Outer casing Wall thickness	1,465	Description of Strata (3)	6
Pumping operation (h/d)	1,338	4th Water struck Aquifer	4
Water use Present (m3/y)	900	Description of Strata (4)	4
1st Water struck Yield (m3/h)	889	4th Water struck from (m)	3
1st Water struck Quality	659	4th Water struck to (m)	3
Outer casing depth to bottom (m)	641	4th Water struck water level (m)	3
Water level after completion (m)	545	4th Water struck Yield (m3/h)	3
1st Water struck from (m)	399	4th Water struck Quality	3

Farm Survey

QUESTIONNAIRE ITEM	No of Returns
Date of Survey	1,166
Farm No	1,166
Info entered by	1,165
Farm name	1,160
Owner Name	1,158
BHs In Use	1,112
BHs Drilled	1,104
Farm area	1,095
Address	1,084
Latitude	1,082
Stock No. Small	1,081
Orig. Farm No	1,064
Power	1,057
Telephone	1,048
Stock No. Large	1,047
Rain	1,041
Feed source Wet	1,033
Feed source Dry	1,012
WL	1,010
Respondent	1,009
Employees	1,001
Breeding method	1,001
Land use Grazing	981
GW Points	977
Years	976
Farmer	962
ha / SSU	961
Longitude	921
Water use Stock	886
Intended changes	867
Water use Domestic	860
Other	858
ha / LSU	833
Water use Irrigation	692
Selling weight	649
Water use Surface water	607
Fattening Period	602
Lodges	585
Land use Irrigated	554
Land use Unusable	502
Springs Dried up	323
Crop 1 type	309
Crop 1 ha	301
Irr. Method	293
Intended Irr. Increase	291
Fertilise type	282
Crop 2 type	247
Crop 2 ha	246
Fertilser rate	245
Crop 3 type	228
Crop 3 ha	227
Fax	122
e-mail	41
Comment	5

8.2 Definition of Aquifer

The major aquifers in the Stampriet Artesian Basin used to be defined as the Kalahari, Auob and Nossob Aquifer respectively harmonizing with geological nomenclature. However, the necessity of new definition from hydrogeological point of view was raised in order to construct a conceptual model for groundwater simulation and to make a groundwater management plan. The new definition was proposed in this study as follows from the results of the geological and hydrogeological study.



According to the analysis of the data from JICA Test Boreholes, the review of existing borehole data and the preliminary hydrogeological analysis, aquifer type of considerable number of existing boreholes defined before must be changed to shallower or younger aquifer type. For example, WW21784, DWA observation borehole in Olifantswater that used to be considered as Nossob borehole must be Auob borehole.

8.3 Structure of Aquifers

Hydrogeological structure of each aquifer was studied by analysing data from A Class boreholes principally in DWA Database, coal investigation boreholes, JICA test boreholes, geological maps and so on. The results were presented in Fig.8.3-1 to Fig.8.3-18.

8.3.1 Distribution of Aquifer

1) Kalahari Aquifer

The Rietmond Member is intercalated between the Auob Member and the Kalahari

Member. It consists of the upper and the lower part, and the latter plays as an impermeable layer. Then, the Kalahari Aquifer should be defined as the combination of the upper part of the Rietmond Member and the Kalahari Beds itself.

A bottom surface of the Kalahari aquifer is shown in Fig.8.3-2. This map indicates an erosion surface before sedimentation of the Kalahari Beds in the other words, “African Surface”. It also shows that the Pre-Kalahari Valley was deeply eroded from 60 Km southeast of Aminius to J-6 and Aranos to J-6 too and the cross sections also present that its erosion reached to the Auob aquifer. This valley is bended at J-6 to the southeast, run through Mata-Mata to the South Africa along present Auob river and joined the Orange river area.

Fig. 8.3-3 presents the thickness of the lower Rietmond Member. It shows the considerably extensive area of its non-distribution in the centre and south of the basin. Since this means that the Kalahari aquifer covers the Auob Aquifer directly without impermeable layer, there is a possibility that groundwater of the Auob Aquifer is leaking upward into the Rietmond Member. However, no matter what this circumstance is recognized locally, both aquifers should be treated as an independent aquifer each other because of the poor connectivity in the upper Rietmond Member.

On the other hands, the distribution of thickness of the Kalahari Beds in Fig.8.3-1 well coincides with the Pre-Kalahari Valley. Its maximum thickness is 250 meters more.

2) Auob Aquifer

The Auob Member is locally cropped out at the east of Mariental and along the scarp that is extending to the south of Mariental. This member can be classified into five units; A1 to A5 from geological viewpoint. However, they are dealt with one hydrogeological unit in this study because of their horizontally changeable lithofacies.

The Mukorob Member underlain the Auob Member consists of the upper part, which is regarded as a permeable layer and the lower part, which is an impermeable layer. Therefore the Auob Aquifer was defined as the combination of the upper Mukorob Member and the whole of the Auob Member.

A top surface of the Auob Aquifer is shown in Fig. 8.3-4. As a whole, the surface declines from northwest to southeast. Its elevations at the north-western margin of the basin and the south-eastern corner of it are 1350m ASL and 800m ASL respectively.

Isopach map of the Auob Aquifer is illustrated in Fig.8.3-5. The thickness of the aquifer ranges from 100 meters to 150 meters and 150 meters more in places. On the other hands, it becomes thinner immediately near the marginal area of the basin. It is remarkable that the area ranges from 0 to 50 meters thick extends N-S direction in the centre of the basin.

3) Nossob Aquifer

The Nossob Aquifer is intercalated between the Mukorob Member and the Pre-Ecca Group, which include the Dwyka Group, the Nama Group and the Damara Sequence as the basement rocks of the Stanpriet Artesian basin. The outcrops of this aquifer are locally recognised along the scarp extended in the west of N-S faults, which lie to the west of the basin.

The isopach map of the lower Mukorob Member, which plays as an impermeable layer is shown in Fig.8.3-6. Increase of thickness takes place from the west to the east of the basin and the maximum value comes up to 125 metres.

According to the top surface of the Nossob Aquifer shown in Fig.8.3-7, it is inclined from the northwest to the southeast as well as the Auob Aquifer. Its elevation is approximately 1000m ASL at the north-eastern margin of the basin and 650m ASL at the south-eastern corner of it.

The distribution of the Nossob Aquifer's thickness is presented in the isopach map in Fig.8.3-8. Even if the precision of the isopach could not be satisfied because the number of boreholes that reach to the Nossob Aquifer and pass through is not so many, the general tendency must be useful in this study.

The figure indicates that the thickness of aquifer intends to increase toward the centre of the basin, although there is no distribution on the margin of the basin. An average thickness of the aquifer is estimated approximately 25 meters. However, there are thick parts of the aquifer in places. The maximum thickness of it is reported 94 meters in the petroleum core holes, drilled in the farm Vreda during 1963 and 1994.

The summary of JICA test boreholes is shown in Fig. 8.3-9 for reference.

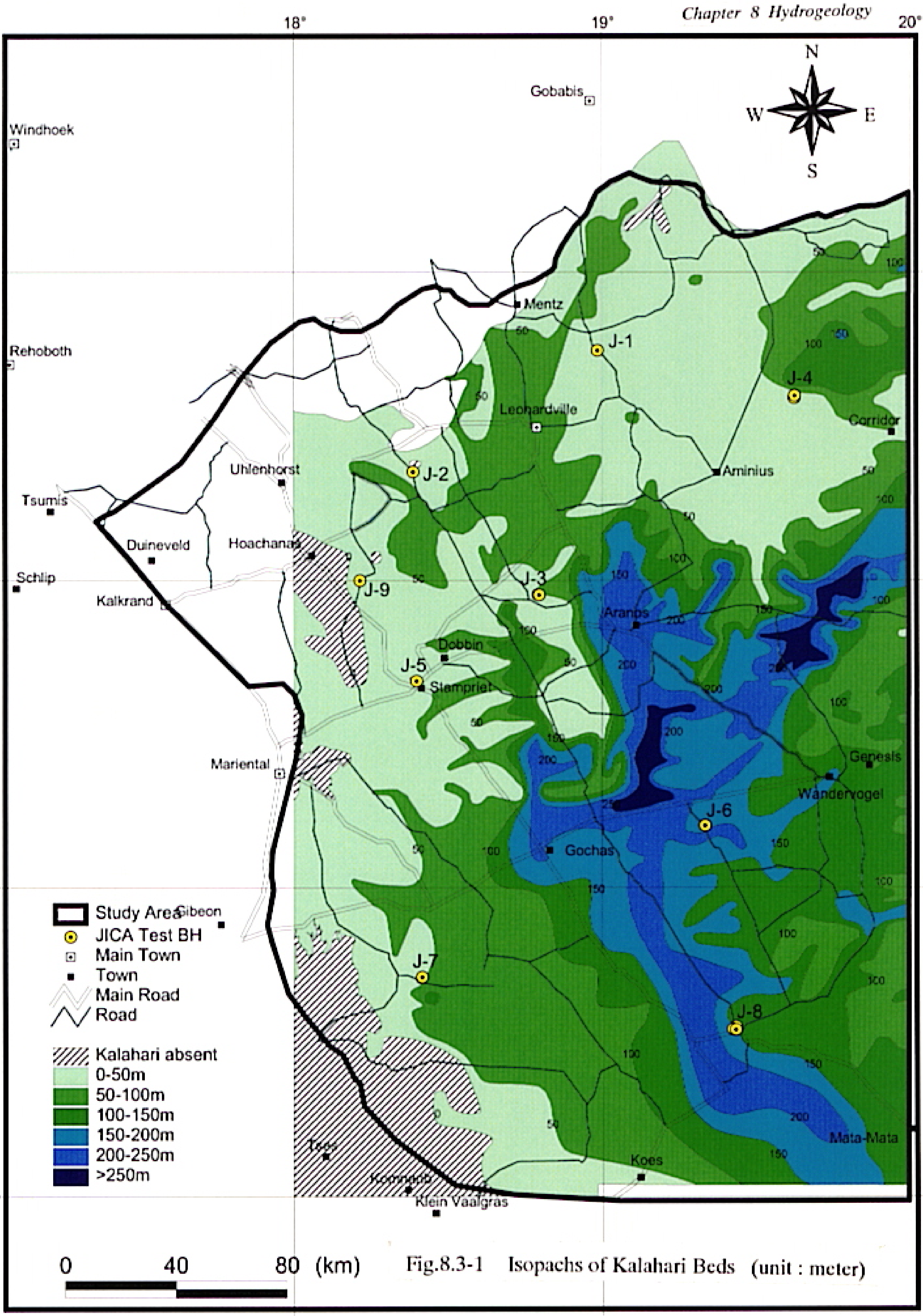


Fig.8.3-1 Isopachs of Kalahari Beds (unit : meter)