CHAPTER 5 GROUNDWATER POTENTIAL EVALUATION

5.1 Introduction

The groundwater potential of three aquifers, namely the Kalahari, Auob and Nossob Aquifer is evaluated in this chapter using hydrogeological indices.

5.2 Storage of Groundwater

The storage of groundwater in each aquifer can be estimated from their volumes and effective porosity as shown in Table 5.2-1. An effective porosity is necessary to estimate the amount of groundwater, which means available void space of each aquifer for water use. This value was assumed on the basis of the results of neutron logging at the JICA test boreholes.

Table 5.2-1 Groundwater Storage of Each Aquifer

Aquifer	Thickness (m)	Area (m^2)	Volume (m^3)	Effective Porosity (%)	Groundwater Storage (m^3)
Kalahari (Saturated)	0-250	52.6E+9	2.36E+12	5	**120E+9**
Auob Aquifer	0-150	50.7E+9	3.60E+12	5	**180E+9**
Nossob Aquifer	0-60	9.98E+9	1.24E+12	5	**57E+9**

The table indicates that the Auob Aquifer contains more groundwater than the Kalahari and the Nossob Aquifer. The amount of groundwater within the Auob Aquifer is more than three times of that of the Nossob Aquifer. It is concluded that the Auob Aquifer is a better aquifer than the other aquifers in the study area in terms of groundwater storage. These groundwater storages are huge volumes, however, it should be considered that a very little of groundwater within the aquifers is virtually available for the extraction because of technical and economical reasons. Consequently, it is necessary to consider other indices instead of aquifer storage to evaluate the groundwater potential of the aquifers.

5.3 Groundwater Potential Evaluation

Four indices, water depth, water quality, depth of aquifer and specific yield were selected for this purpose as shown in Table 5.3-1.

The evaluation point is given to the maximum as 100 points and minimum as 0 point in each index and it distributes equally between them. For example, water depth of the Nossob Aquifer varies G.L-172.3m to G.L. +23.9m (artesian). The former is given 0 point as the minimum evaluation and the latter is given 100 points as the maximum evaluation. Total evaluation point (TP) is summed them up. Therefore the maximum total evaluation is given 400 points. The point in each index is calculated with a simple linear function as follows.

Table 5.3-1 Index for Evaluation of Aquifers

Index \ Items		Maximum Evaluation		Minimum Evaluation		Related Factors
		Maximum Value (100 Point)	Aquifer	Minimum value (0 Point)	Aquifer	
I	Water Depth (B.G.L m)	-23.9	Nossob	172.37	Kalahari	Withdrawal cost, Operation cost
II	Water Quality (TDS mg/l)	354.6	Auob	39,428	Nossob	Human health, Productivity or quality of crops and
III	Depth of Aquifer (B.G.L. m)	0	Kalahari	440	Nossob	Initial cost (Drilling cost)
IV	Specific Yield (m^3/hr/m)	15.92	Auob	0.0008	Nossob	Capacity of aquifer

I, II, III: $y = \frac{(x - Mm)\times 100}{Mx - Mm}$

IV: $y = \frac{100}{Mx - Mm}\times(x - Mm)$

$$TP = \sum_{n=I}^{VI} y_n$$

Mx : Maximum Value
Mm : Minimum Value
y : Evaluation Value
x : Data Value
TP : Total Evaluation Point
n : Index No.

Since the statistical weight among indices is changeable for any purposes, they were treated evenhandedly in this study.

5.3.1 Groundwater Depth

The required capacity of the pump for withdrawal depends on the depth of the groundwater table from the ground surface in case of the same withdrawal volume. The depth of groundwater is also closely related to withdrawal cost, namely, operation cost of production wells. The groundwater depth of each aquifer is illustrated in Fig. 5.3-1 to 5.3-3.

1) Kalahari Aquifer

Groundwater depth becomes deeper to the east side of the study area. In particular, the southeastern area around J-6 which is located in the Pre-Kalahari Valley is the deepest place and its depth reaches to 100m more. (Fig. 5.3-1)

2) Auob Aquifer

A distribution of water depth is generally similar to that of the Kalahari Aquifer. The area whose water depth is more than 100m extends around J-6 and J-8 in the southeastern area of the basin. On the other hand, it becomes shallower in the western area of the basin around Stampriet and the artesian wells are located in the area. Though many artesian wells or springs are found along the Auob and Nossob River, they are not presented in Fig. 5.3-2 except for the center of Stampriet because no data of piezometric head is available. Therefore, Stampriet is presented as a small red colored area in the figure.

3) Nossob Aquifer

Sufficient data is not available on this aquifer because of its characteristics. Therefore, it restricts the accuracy of the analysis. The Nossob Aquifer has a high piezometric head in the other words, high pressure. Four areas in red around J-3, J-5, J-6 and Gochas respectively are noticed in Fig.5.3-3. If the data on this aquifer is increased, they will put together and show a large area in the center of the basin.

5.3.2 Groundwater Quality

The total dissolved solid (TDS) as a representative of water quality is an important factor for water quality standard, treatment cost for drinking water and productivity of live stocks and agricultural crops. A discussion of water quality is omitted in this section because it has been done in Chapter 3.8.

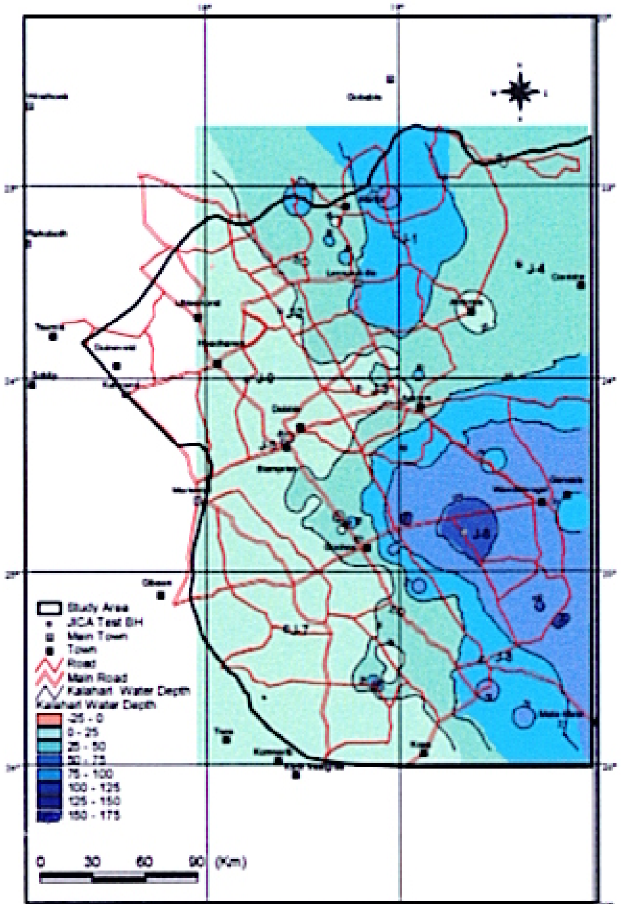

Fig. 5.3-1 Water Depth of Kalahari Aquifer

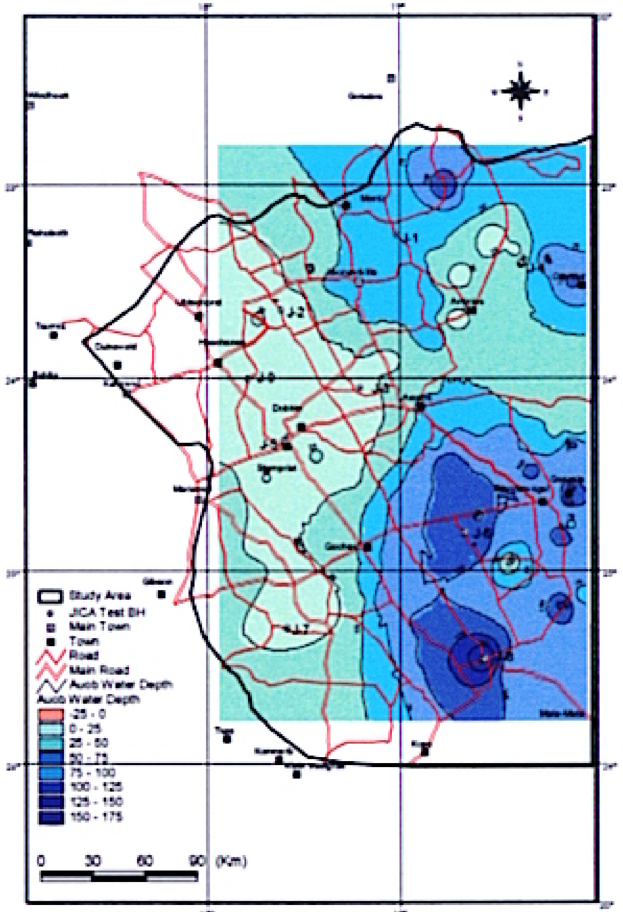

Fig. 5.3-2 Water Depth of Auob Aquifer

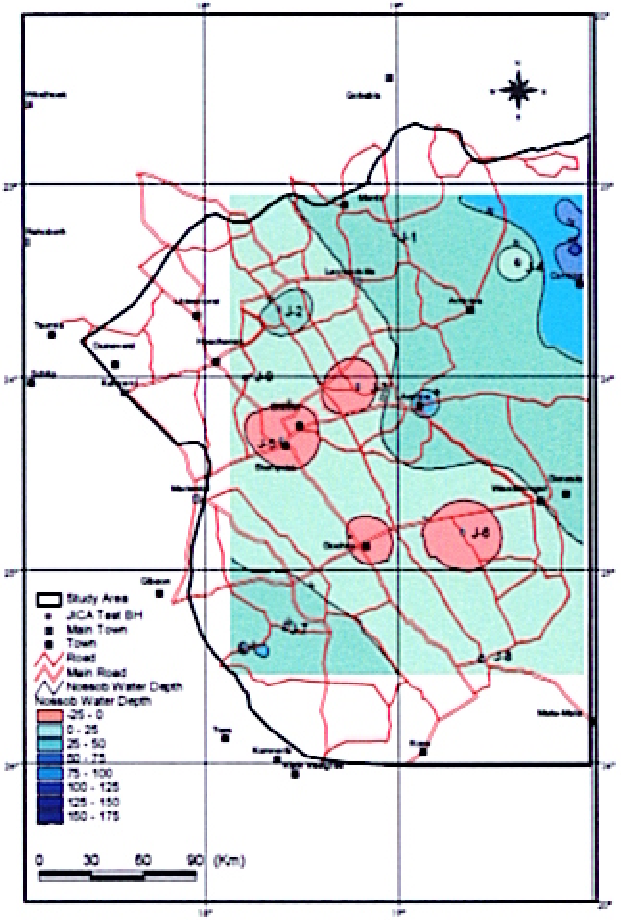

Fig. 5.3-3 Water Depth of Nossob Aquifer

5.3.3 Depth of Aquifer

A depth of an aquifer itself is a main factor of drilling cost as an initial cost for a production well. Therefore the depth of each aquifer from the ground surface was selected as one of the indices for the evaluation of aquifers. Fig. 5.3-4 and 5 show the distribution of the depth of the Auob and Nossob Aquifer. The Kalahari Aquifer is regarded as 0m although the aquifer is covered by thin surface soil or sand dune.

The depth of both aquifers becomes deeper to the eastern part of the basin. The bluish colored area showing the depth of more than 300m is spreading widely in the case of the Nossob Aquifer. (Fig.5.3-5)

5.3.4 Specific Yield

The specific yield (or capacity) of the aquifer evaluated from pumping tests was chosen as an index of aquifer productivity. As shown in Fig. 5.3-6 to 8, the range of specific yield of each aquifer is considerably broad. Although appropriate data from pumping tests is limited to the results of JICA test boreholes, it is possible to grasp the general tendency from them.

It is clear that the most superior aquifer in terms of the specific yield is the Auob Aquifer and the most inferior aquifer is the Nossob Aquifer.

As for the Auob Aquifer, the specific yield in the western part of the basin around Stampriet is higher than the eastern part. Unexpectedly the specific yield of the Kalahari Aquifer is lower.

The distribution pattern of specific yield for the Nossob Aquifer is much different from them. The specific yield in the southwestern area of the basin or Stampriet area is low but it is getting better towards the Aminius area.

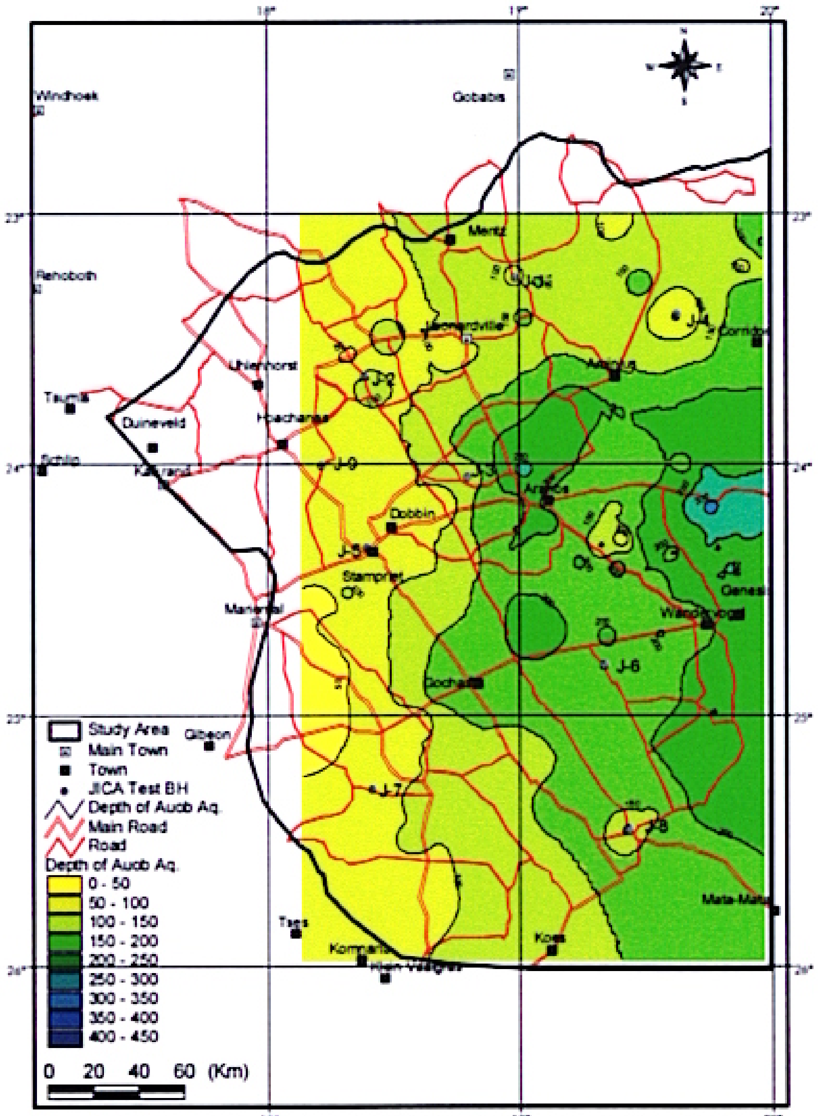

Fig. 5. 3-4 Depth of Auob Aquifer

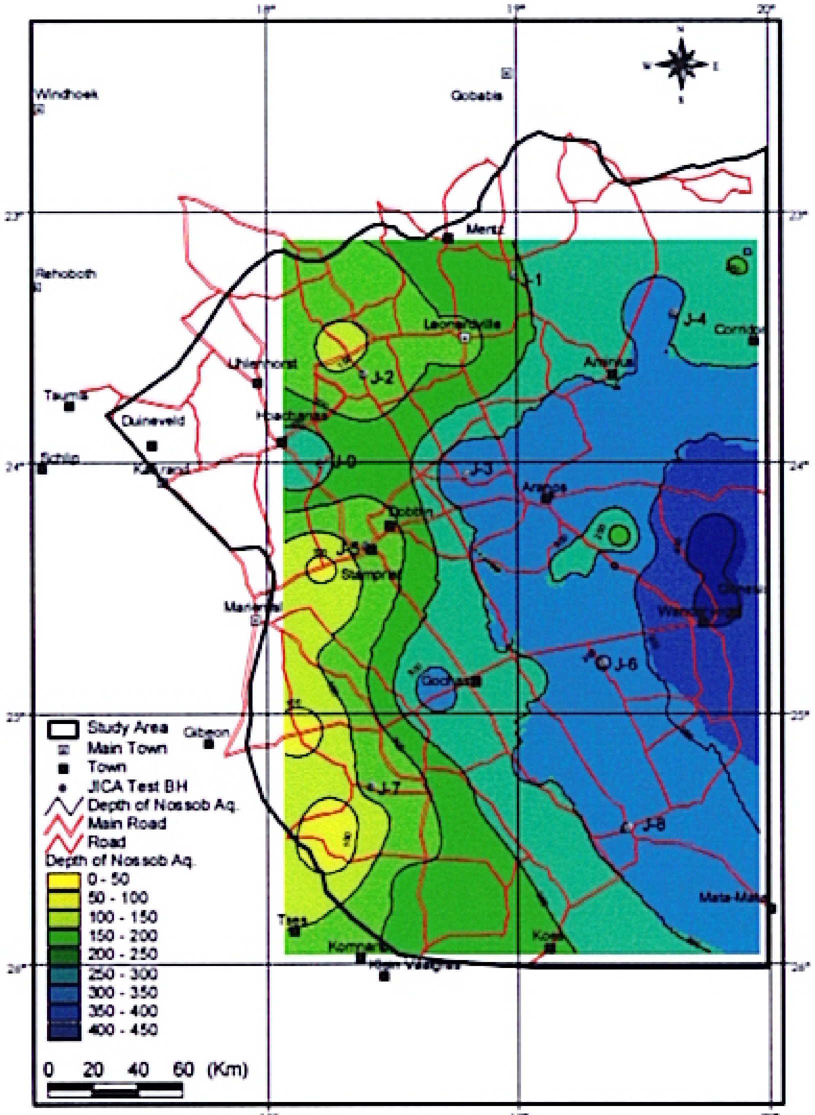

Fig. 5. 3-5 Depth of Nossob Aquifer

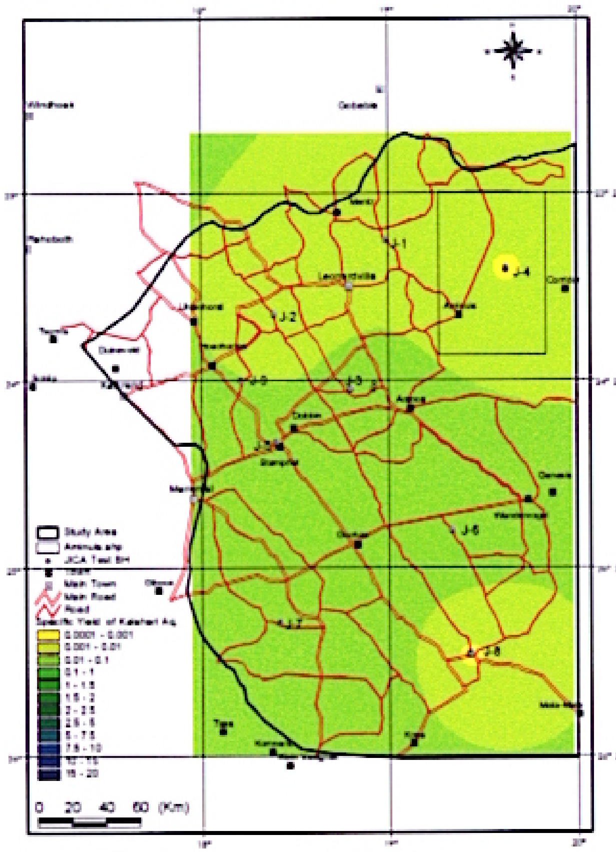

Fig. 5.3-6 Specific Yield of Kalahari Aquifer

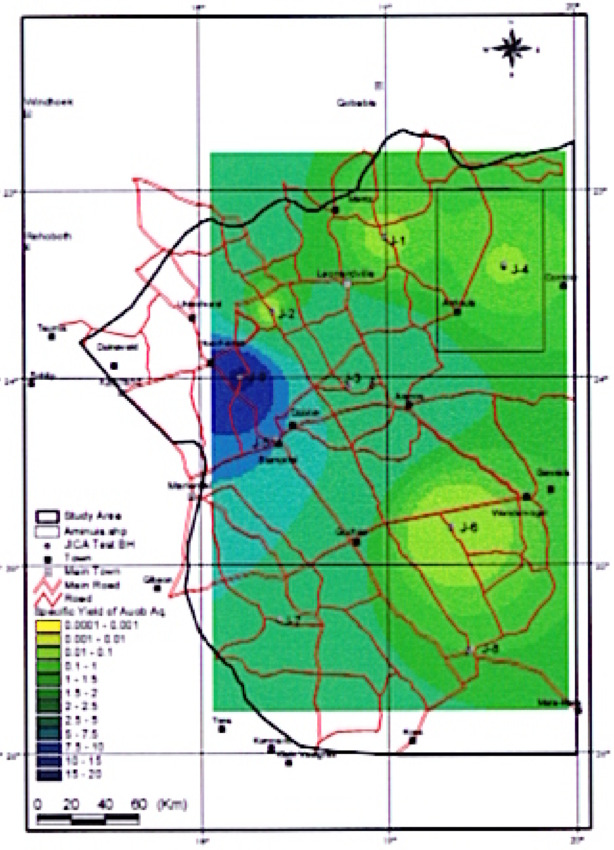

Fig. 5.3-7 Specific Yield of Auob Aquifer

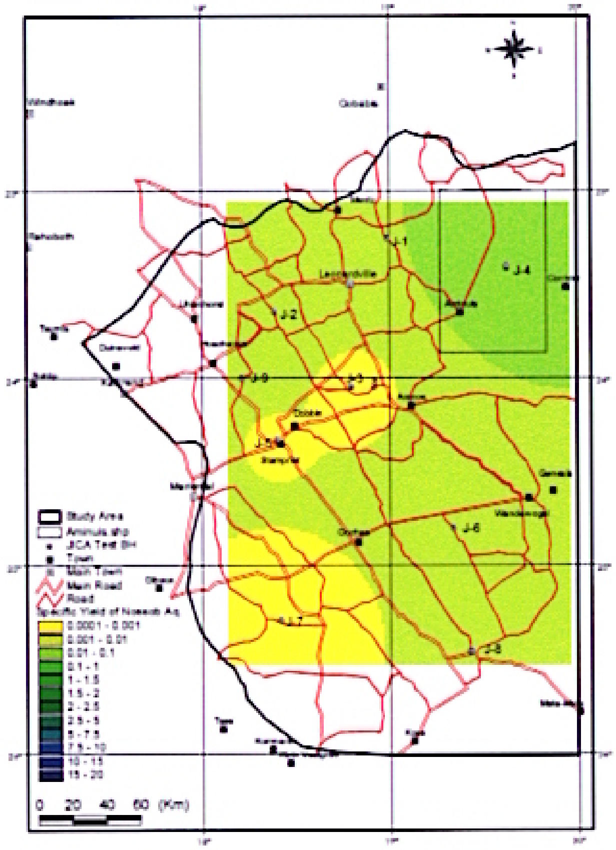

Fig. 5.3-8 Specific Yield of Nossob Aquifer