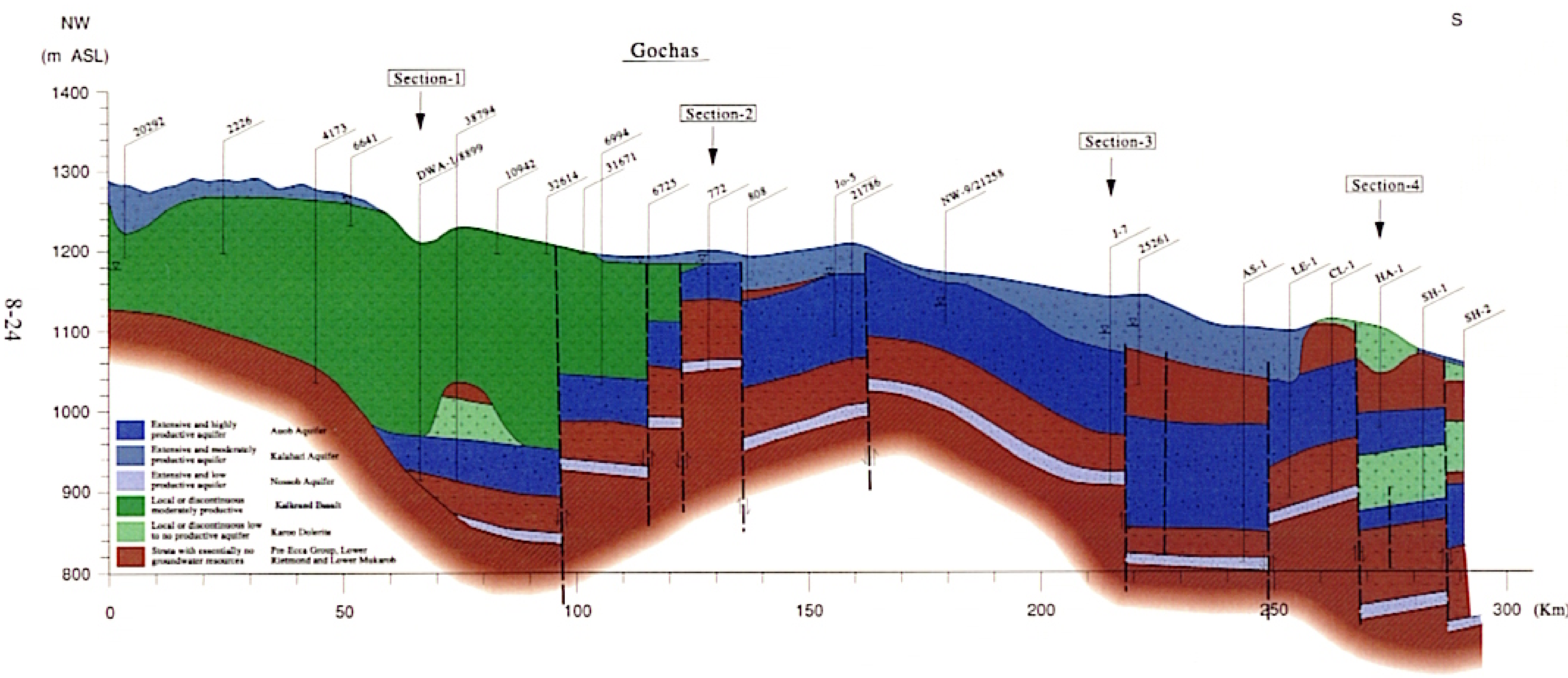

Fig. 8.3-17 Hydrogeological Cross Section-7

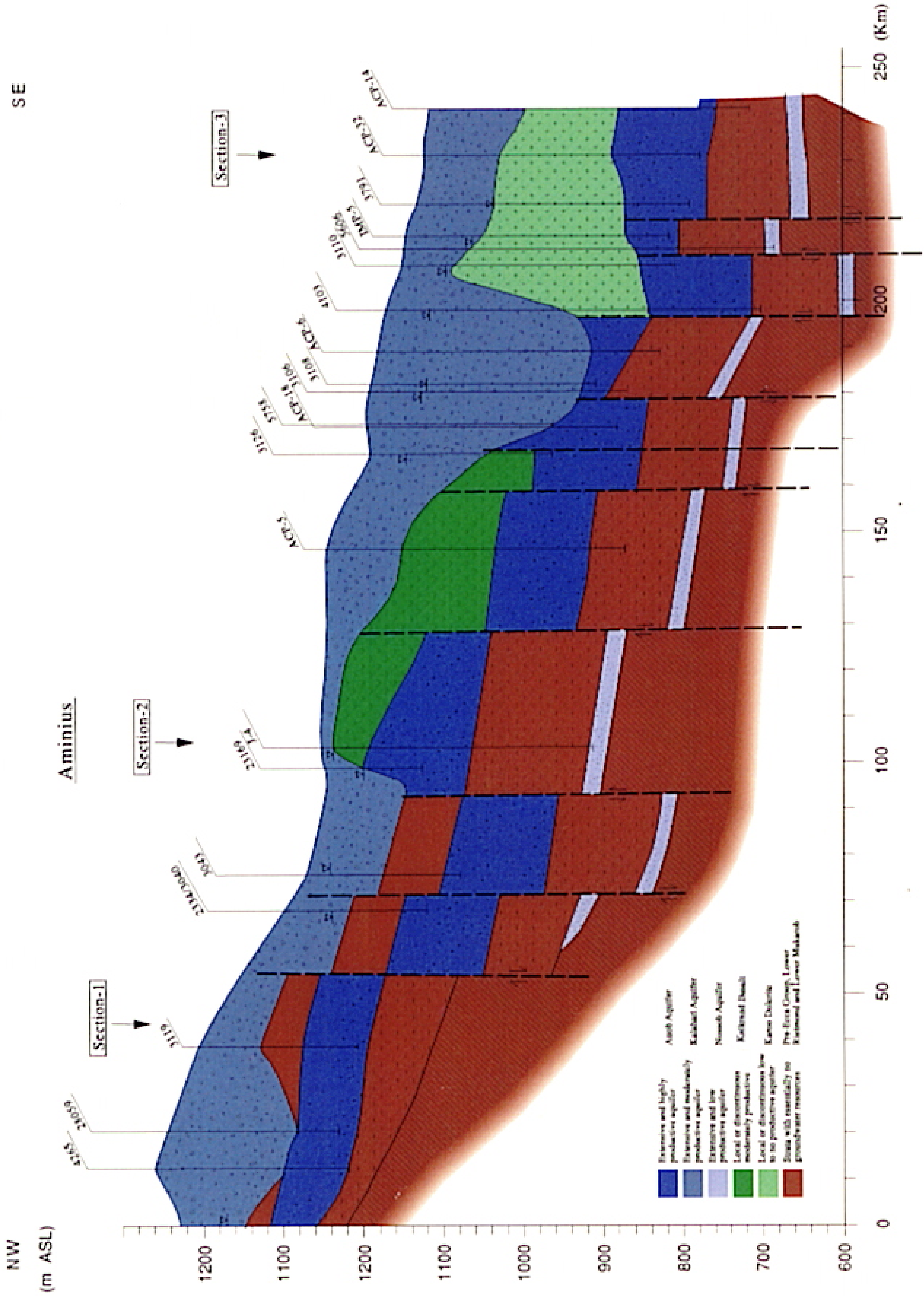

Fig. 8.3-18 Hydrogeological Cross Section-8

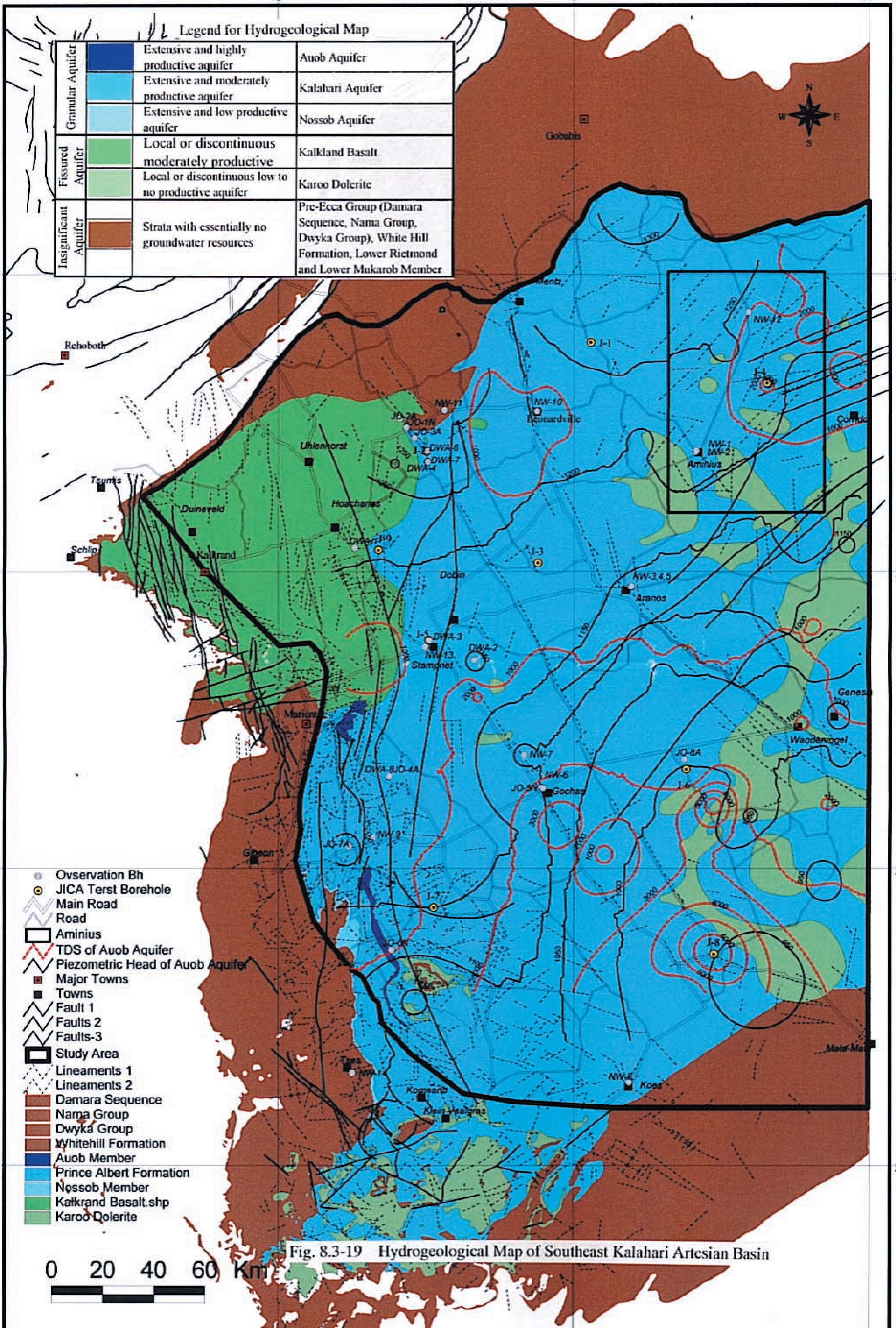

Fig. 8.3-19 Hydrogeological Map of Southeast Kalahari Artesian Basin

8.4 Groundwater Level

8.4.1 Elevation Survey

Measurement of ground elevation was conducted by DGPS in order to get precise data of piezometric head and to analyze groundwater flow mechanism, groundwater recharge and so forth. Target boreholes for measurement; more than 300 boreholes, were JICA test boreholes, DWA observation boreholes and existing boreholes which were suitable for water level measurement as shown in Fig.8.4-1

8.4.2 Distribution of Piezometric Head

In general, piezometric head is always fluctuating for example dairy change, seasonal change or yearly change and so forth. Therefore it is ideal circumstance to deal with the data that are measured simultaneously at all water points. However, it is almost impossible particularly in such a huge area as this study area and besides, three different types of aquifers must be dealt with.

Although JICA Test Boreholes are the most reliable for this purpose at present because of their sufficient stratigraphic checking and aquifer management as the observation boreholes, supplementary data covering the whole area are necessary to study groundwater flows. Then piezometric heads were measured at selected existing boreholes, which had hydrogeological information in DWA's database.

1) Kalahari Aquifer (Fig.8.4-2)

Groundwater of the Kalahari Aquifer is flowing from the northwest to the southeast harmonizing with geological conditions of it. A gradient of groundwater table becomes steeper in Aranos or Gochas area but it is inclined gently toward the Salt Block.

2) Auob Aquifer (Fig.8.4-3)

Groundwater flow of the Auob Aquifer as a whole is similar to the Kalahari Aquifer. A concentric circle at J-8 seems to be attributed to its peculiar circumstance that the observation borehole for Auob Aquifer at J-8 targeted merely the A1 bed situated in the lowest of the Auob Member so that this borehole doesn't represent the whole Auob Aquifer.

3) Nossob Aquifer (Fig.8.4-4)

General direction of groundwater flow is also from the northwest to the southeast. The gradient of groundwater piezometric head becomes steep locally near the west of Aranos. The average of piezometric head in the Nossob Aquifer is gentle as 1/1000. This value does not largely change among three aquifers. Although the Nossob Aquifer is located at the lowest altitude, its piezometric head is the highest in the south-eastern part of the basin.

4) Kalkrand Basalt (Fig.8.4-5)

Groundwater flow of the Kalkrand Basalt has two directions. One is toward the southwest: Uhlenhorst to Kalkrand and the other is toward the southeast: Uhlenhorst to Dobbin.

8.4.3 Fluctuation of Piezometric Head

There are two kinds of data in order to investigate a fluctuation of piezometric head. One is DWA’s observation record of 22 boreholes at 5 areas: Gonchanas, Tsugela, Boomplaas, Spes Bona and Olifantswater. The other is 19 JICA test boreholes and eight existing boreholes that all of them were equipped with piezometric gauges during this study.

1) DWA’s Observation Boreholes

(1) Kalahari Aquifer (Fig.8.4-8)

Observation boreholes for this aquifer are located in Olifantswater and Tugela. It is possible to browse the fluctuation of piezometric head for approximately 15 years. General tendency of head is 5cm/year decline in average. However, an upturn of head is found at all boreholes from the early 2000. It implies the possibility of recharge by the heavy rain on Feb. and Mar. 2000.

(2) Auob Aquifer (Fig.8.4-9)

Artificial or other effects to their head are recognised at the observation boreholes for the Auob aquifer at Boonplaas and SpesBona. Drawdown speed is 5-6cm/year in average. Upturn of head after Feb. 2000 is remarkable at Tugela as well as Kalahari Aquifer. However, the extreme similarity of upturn between the Kalahari and the Auob Aquifer at Tugela made us to have a suspicion about leakage between them.

(3) Nossob Aquifer (Fig.8.4-10)

According to DWA-8N and DWA-10N, the degree of head decline is almost same as the Auob Aquifer and they may indicate upturn by that heavy rain.

2) JICA Test Boreholes and Existing Boreholes

(1) JICA Test Boreholes

Fluctuations of piezometric head at JICA test boreholes and existing boreholes are drawn in Fig.8.4-11 (1) to Fg.8.4-11 (9)

<u>J-1A</u>: It is remarkable movement of piezometric heads of J-1A, which was rapidly increasing from June 2000 to August 2000. This rise may be attributed to the recharge caused by the heavy rain on February 2000. However, the piezometric head has been almost stable after August 2000.

<u>J-2</u>: Both piezometric heads of the Auob and the Nossob Aquifer are slightly increasing and especially they indicate some recharge in April 2001.

<u>J-3</u>: The rapid rise of the Auob Aquifer's head started form the beginning of observation: the middle of August 2000 to September 2000. Three months difference between J-1A and this seems to be time lag of recharge caused by distance from recharge area, which is assumed to be located around northern margin of the basin.

<u>J-4</u>: J-4A maybe present the last phase of recharge just after starting of monitoring. J-4K shows that a water level of the Kalahari Aquifer simply drawdowns. The piezometric head of the Nossob Aquifer is gradually drawdowning.

<u>J-5</u>: Data is in short and then monitoring should be continued.

<u>J-6</u>: The fluctuation of J-6N is incomprehensible, its pressure prove should be checked or repaired.

<u>J-7</u>: Water level of the Kalahari Aquifer simply is drawdowning likewise J-4K. Data of the Nossob Aquifer in short and then monitoring should be continued. .

<u>J-8</u>: Both heads of Kalahari and Nossob is almost constantly rising.

<u>J-9</u>: J-9A was drawdowning from Sep. 2000 to Mar. 2001 but it was rising up after the rainfall in Apr.2001.

(2) Existing Boreholes Monitoring duration for existing boreholes is short and then it should be continued.

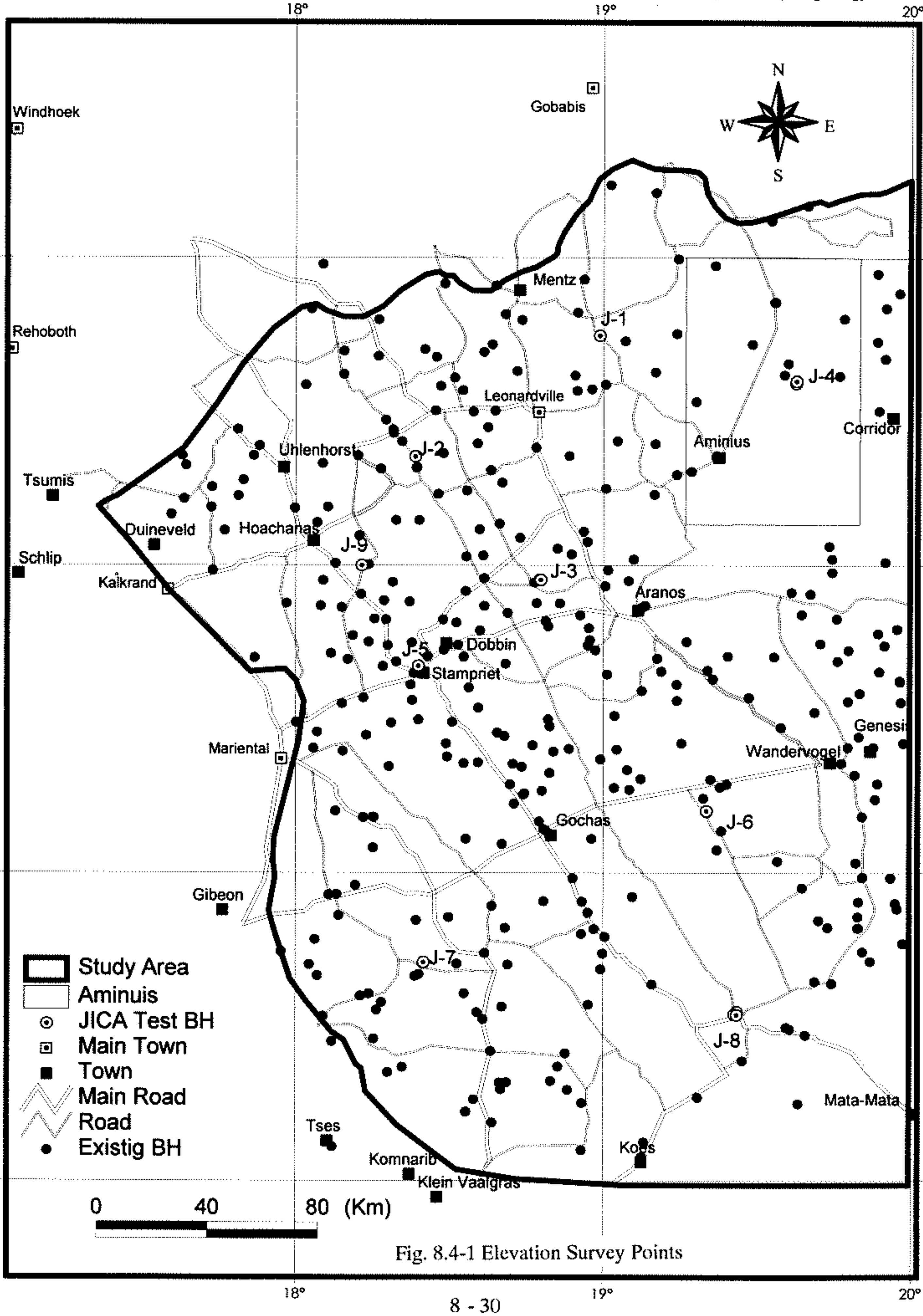

Fig. 8.4-1 Elevation Survey Points