

### **3. GEOPHYSICAL SURVEY**

#### **3.1 Procedure for Determining Geophysical Survey Sites**

The following figure and tables that were used for determining the geophysical survey sites in November 1990 are provided herein.

Fig. B-3.1 Flow Chart Showing A Procedure to Determine The Location of Geophysical Prospecting

Table B-3.1 IKKs Where Deep Well Data are Available

Table B-3.2 IKKs in Which Geophysical Prospecting Can be Omitted

Table B-3.3 IKKs in Which Geophysical Prospecting Should be Conducted

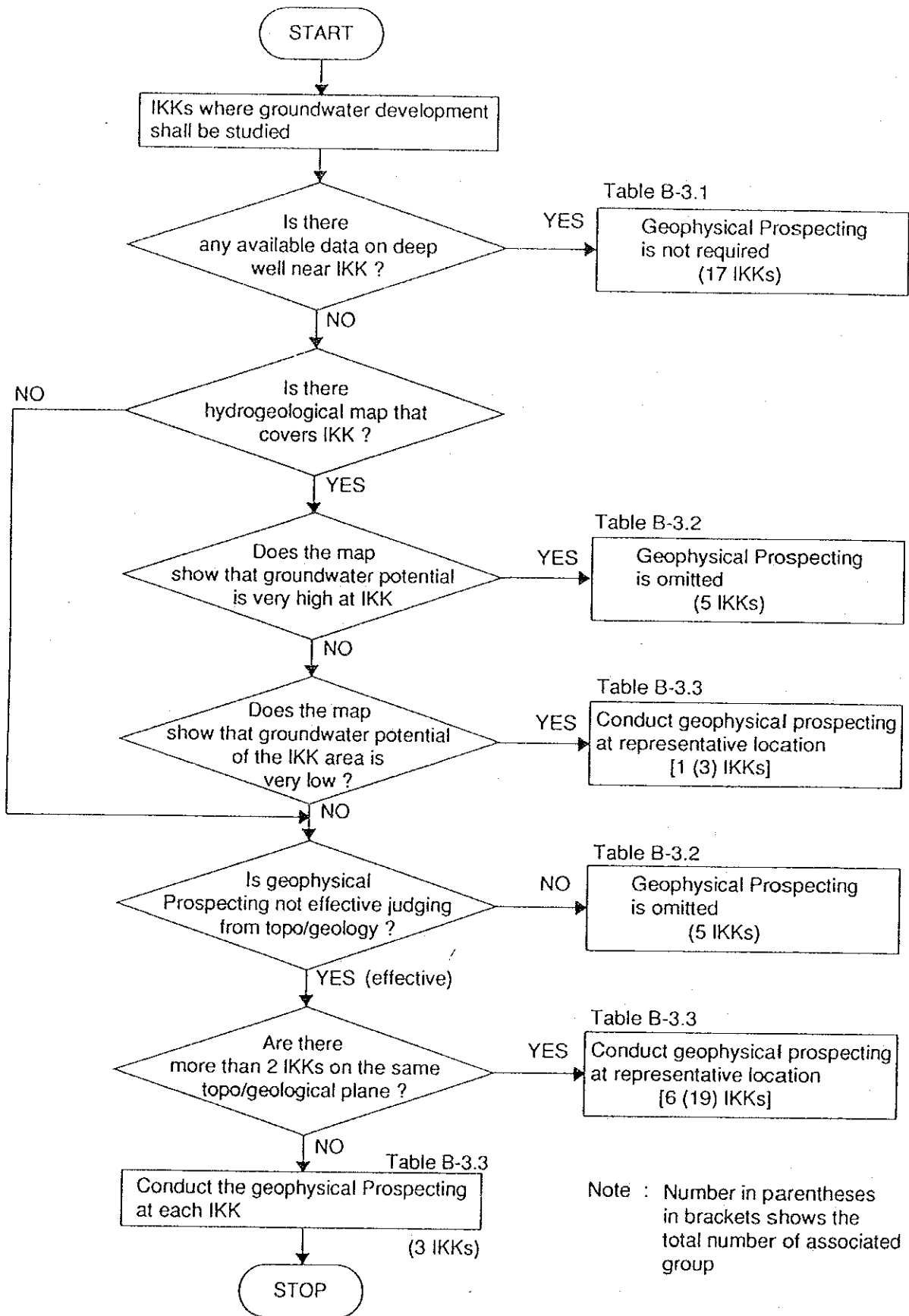


Fig. B-3.1 Flow Chart Showing A Procedure to Determine The Location of Geophysical Prospecting

**Table B-3.1 IKKs Where Deep Well Data are Available**  
(Geophysical Prospecting is not Required)

| No. | Province     | Kabupaten   | IKK        | Available Well                            |
|-----|--------------|-------------|------------|---|
| 1   | Central Java | Blora       | Jepon      | 2 test wells by P2AT at Desa Soko         |
| 2   | Central Java | Blora       | Mendenrejo | 2 production wells by P2AT at Desa Sumber |
| 3   | Central Java | Pati        | Tayu       | 150 m deep well by PPSAB                  |
| 4   | Central Java | Brebes      | Bulakamba  | 2 test wells                              |
| 5   | Central Java | Brebes      | Losari     | 2 test wells                              |
| 6   | Central Java | Klaten      | Bayat      | 7 artesian wells in Desa Banyaripan       |
| 7   | Central Java | Sargen      | Plupuh     | A deep well by P2AT                       |
| 8   | Central Java | Sargen      | Sambirejo  | 3 deep wells in Kecamatan Kadawung        |
| 9   | East Java    | Probolinggo | Banyuanyar | A deep well, 6 Km West                    |
| 10  | East Java    | Mojokerto   | Kutorejo   | 120 m deep well by P2AT                   |
| 11  | East Java    | Jombang     | Mojowarno  | 2 deep wells by P2AT                      |
| 12  | East Java    | Jombang     | Ngoro      | Some production wells for factory use     |
| 13  | East Java    | Tuban       | Bangilan   | A test well by P2AT                       |
| 14  | East Java    | Tuban       | Bulu       | A production well by P2AT                 |
| 15  | East Java    | Tuban       | Jenu       | 3 test wells by P2AT                      |
| 16  | East Java    | Bojonegoro  | Sumberrejo | A test well by ENCONA                     |
| 17  | East Java    | Bojonegoro  | Baureno    | A test well by ENCONA                     |

Note : There are two test wells that have resulted in failure because of little ground water.  
They are ;

- 1) 100 m deep test well in Kec. Kembangbahu, Kab. Lamongan, East Java.
- 2) 75 m deep test well in Kec. Ngimbang, Kab. Lamongan, East Java.

Table B-3.2 IKKs in Which Geophysical Prospecting Can be Omitted

| Reason for Omitting  | IKK                    | Kabupaten | Prov. | No. |
|--|------------------------|-----------|-------|-----|
| Judging from topo/geological conditions or hydrogeological maps, it is obvious that the groundwater potential is very high | Karangnongko           | Klaten    | C.J.  | 1   |
|  | Diwek, Gudo            | Jombang   | E.J.  | 2   |
|  | Jiwan                  | Madiun    | E.J.  | 1   |
|  | Gedeg                  | Mojokerto | E.J.  | 1   |
| Judging from topo/geological Conditions, it is obvious that the geophysical prospecting is not effective/applicable        | Banjarrejo             | Biora     | C.J.  | 1   |
|  | Jatiroto, Nguntoronadi | Wonogiri  | C.J.  | 2   |
|  | Karangsambung          | Kebumen   | C.J.  | 1   |
|  | Tista                  | Buleleng  | Bali  | 1   |

Total 10

Table B-3.3 Ikks in Which Geophysical Prospecting Should be Conducted

| Classification   | Conducting IKK | Associated IKK                           | Kabupaten   | PROV. |
|--|----------------|--|-------------|-------|
| I. Area of Low Groundwater Potential<br>Conduct the prospecting at a representative location to make sure the underground conditions | Karanggeneng   | Kembangbahu, Brondong                    | Lamongan    | E.J.  |
| II. Area of the same topo/ Geological Conditions<br>Conduct the prospecting at a representative location                             |                |  |             |       |
| (1) Coastal lowland (South)  | Klegenwonosari | Mirit, Setrojenar, Petanahan, Ambalresmi | Kebumen     | C.J.  |
| (2) Alluvial plain   | Purwodadi      | Ngombol, Grabag                          | Purworejo   | C.J.  |
| (3) High Alluvial plain  | Butuh          | Prembun                                  | Kebumen     | C.J.  |
|  |                | Kemiri                                   | Purworejo   |       |
| (4) Solo river plain (Middle to upstream basin)  | Jenar          | Tangen, Gondang, Miri                    | Sragen      | C.J.  |
| (5) Solo river plain (Downstream basin)  | Kapas          | Balen                                    | Bojonegoro  | E.J.  |
| (6) Brantas river plain  | Kudu           | Megaluh                                  | Jombang     | E.J.  |
| III. Others Independent Locatton   | Gemuh          | ---                                      | Kendal      | C.J.  |
|  | Besuk          | ---                                      | Probolinggo | E.J.  |
|  | Kunir          | ---                                      | Lumajang    | E.J.  |
| Total  | 10             | 15                                       |             |       |

### 3.2 The Method of Geophysical Survey

#### (1) Number of Measuring Points

The number of measuring points was assigned, depending on the depth of proposed wells, as shown below.

| <u>Proposed Well Depth</u> | <u>No. of Resistivity Survey</u> | <u>No. of EM Survey</u> |
|----------------------------|----------------------------------|-------------------------|
| 50 m , or shallow well     | 2                                | 20                      |
| 150 m , or deep well       | 5                                | 10                      |

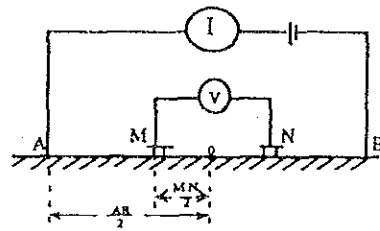
A 50 m deep well had been proposed for 3 IKKs of Klegenwonosari, Butuh and Purwodadi in the group of 10 IKKs, when the geophysical survey was about to start.

#### (2) The Resistivity Survey

The apparent resistivity of subsurface materials and its variation were measured at each designated point by the Schlumberger method. The distances of electrodes used in this survey are as shown below.

|                 |          |          |          |          |          |          |          |          |          |           |           |
|-----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|
| <u>Step No.</u> | <u>1</u> | <u>2</u> | <u>3</u> | <u>4</u> | <u>5</u> | <u>6</u> | <u>7</u> | <u>8</u> | <u>9</u> | <u>10</u> | <u>11</u> |
| <u>AB/2(m)</u>  | 1.5      | 3        | 4.5      | 6        | 9        | 12       | 15       | 21       | 30       | 45        | 52.5      |
| <u>MN/2(m)</u>  | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1&5      | 5         | 5         |

|                 |           |           |           |           |           |           |
|-----------------|-----------|-----------|-----------|-----------|-----------|-----------|
| <u>Step No.</u> | <u>12</u> | <u>13</u> | <u>14</u> | <u>15</u> | <u>16</u> | <u>17</u> |
| <u>AB/2(m)</u>  | 60        | 75        | 90        | 105       | 120       | 150       |
| <u>MN/2(m)</u>  | 5         | 5         | 5         | 5&25      | 25        | 25        |



The resistivity measurement equipment was Yokogawa Model 3244. All the data obtained in the field measurement were analyzed by means of a computer using a software called "RESIST".

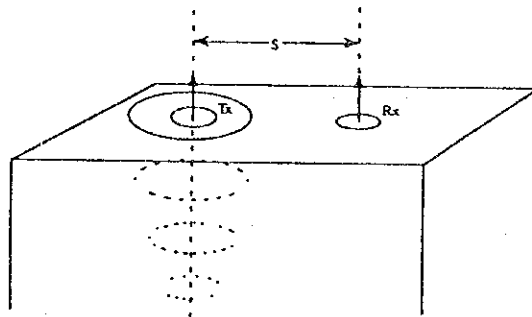
#### (3) The Electromagnetic Survey

The electromagnetic survey was also carried out at each designated point by a method so called "the loop-loop method", using a specific equipment called "EM34-3DL" and associated transmitter coil and receiver coil, all made by GEONICS in Canada.

The said method measures a conductivity of terrain that is proportional to electrical resistivity. The principle of measurement is as follows:

As shown in a sketch on the following page, a transmitter coil Tx that produces audio frequencies at different levels is placed on the earth (assumed uniform) and a receiver coil Rx is located at a short distance away.

The time-varying magnetic field arising from the alternating current in the transmitter coil induces very small currents in the earth. These currents generate a secondary magnetic field which is sensed, together with the primary field, by the receiver coil. The ratio of the secondary to primary magnetic fields is now linearly proportional to the terrain conductivity, which makes it possible to construct a direct-reading of terrain conductivity by measuring this ratio.



The coils were allocated at 3 spacings of 10 m, 20 m and 40 m, and the reading was made for horizontal mode and vertical mode at every allocation of coils.

All the data thus measured were analyzed by means of a computer using a software called "EMIX 34".

### 3.3 Geophysical Survey Report

The following is provided herein.

Fig. B-3.2 Geophysical Survey Point Plan, which consists of 10 different plans

Fig. B-3.3 Cross-sectional Resistivity Profile, which consists of 10 different drawings

Photographs: Field Work Scenes of Geophysical Survey

#### Notes on Code Number on Fig. B-3.2:

The first two figures stand for IKK as follows:

|                       |                     |
|-----------------------|---------------------|
| 01 --- Klegenwonosari | 06 --- Kapas        |
| 02 --- Butuh          | 07 --- Kudu         |
| 03 --- Purwodadi      | 08 --- Karanggeneng |
| 04 --- Gemuh          | 09 --- Besuk        |
| 05 --- Jenar          | 10 --- Kunir        |

The two figures in the middle stand for the prospecting method.

|  |
|--|
| 01 --- Resistivity survey (Schlumberger method)  |
| 02 --- Electromagnetic survey (Loop-Loop method) |

The final two figures stand for survey points in IKK.



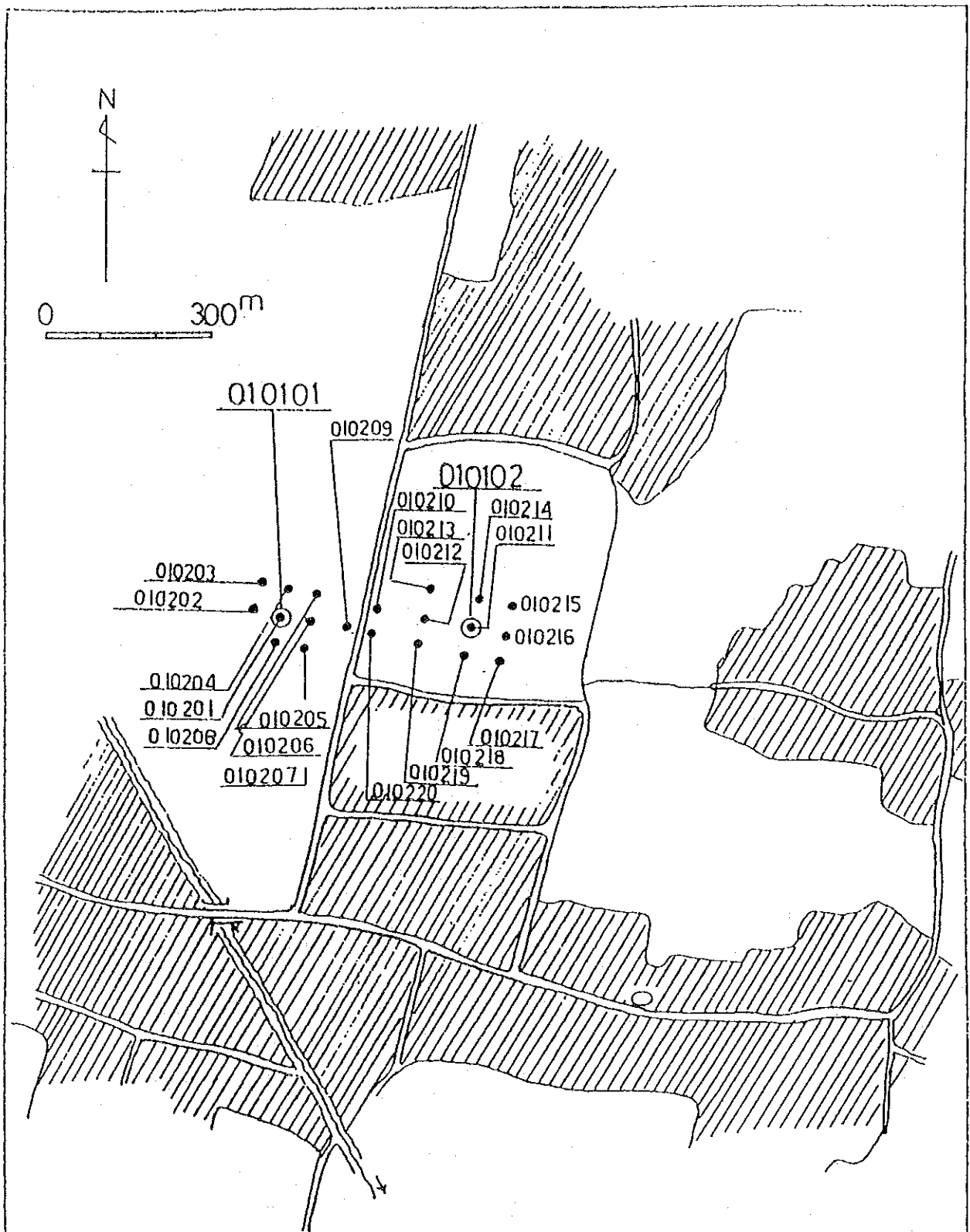
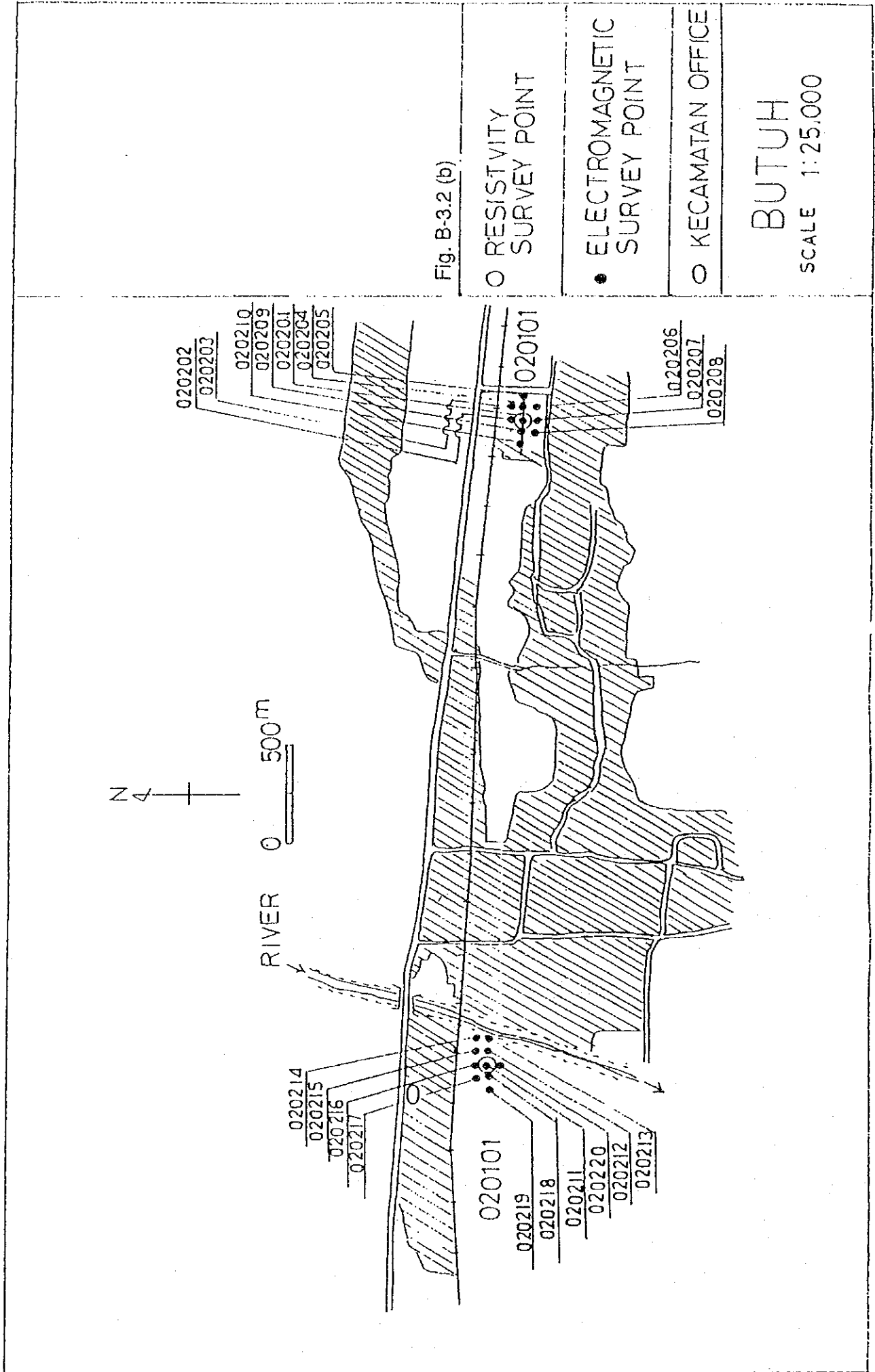


Fig. B-3.2 (a) Geophysical Survey Point Plan

- RESISTIVITY SURVEY POINT
- ELECTROMAGNETIC SURVEY POINT
- KECAMATAN OFFICE

KLEGENWO-  
-NOSARI  
SCALE 1:10,000



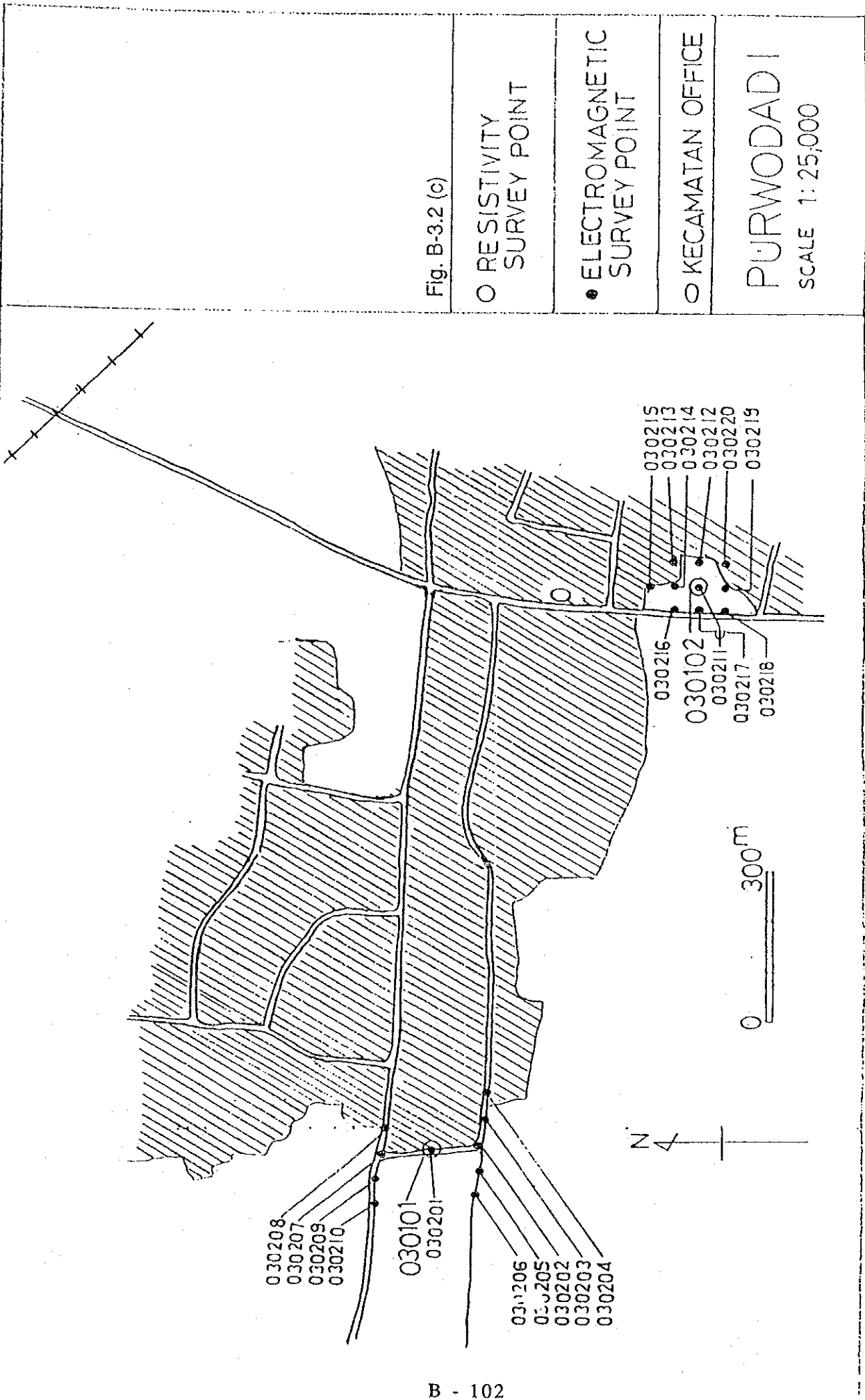


Fig. B-3.2 (c)

○ RESISTIVITY SURVEY POINT

● ELECTROMAGNETIC SURVEY POINT

○ KECAMATAN OFFICE

PURWODADI  
SCALE 1:25,000

030208  
030207  
030209  
030210

030101  
030201

030206  
030205  
030202  
030203  
030204

030215  
030213  
030214  
030212  
030220  
030219  
030216  
030102  
030211  
030217  
030218

0 300m

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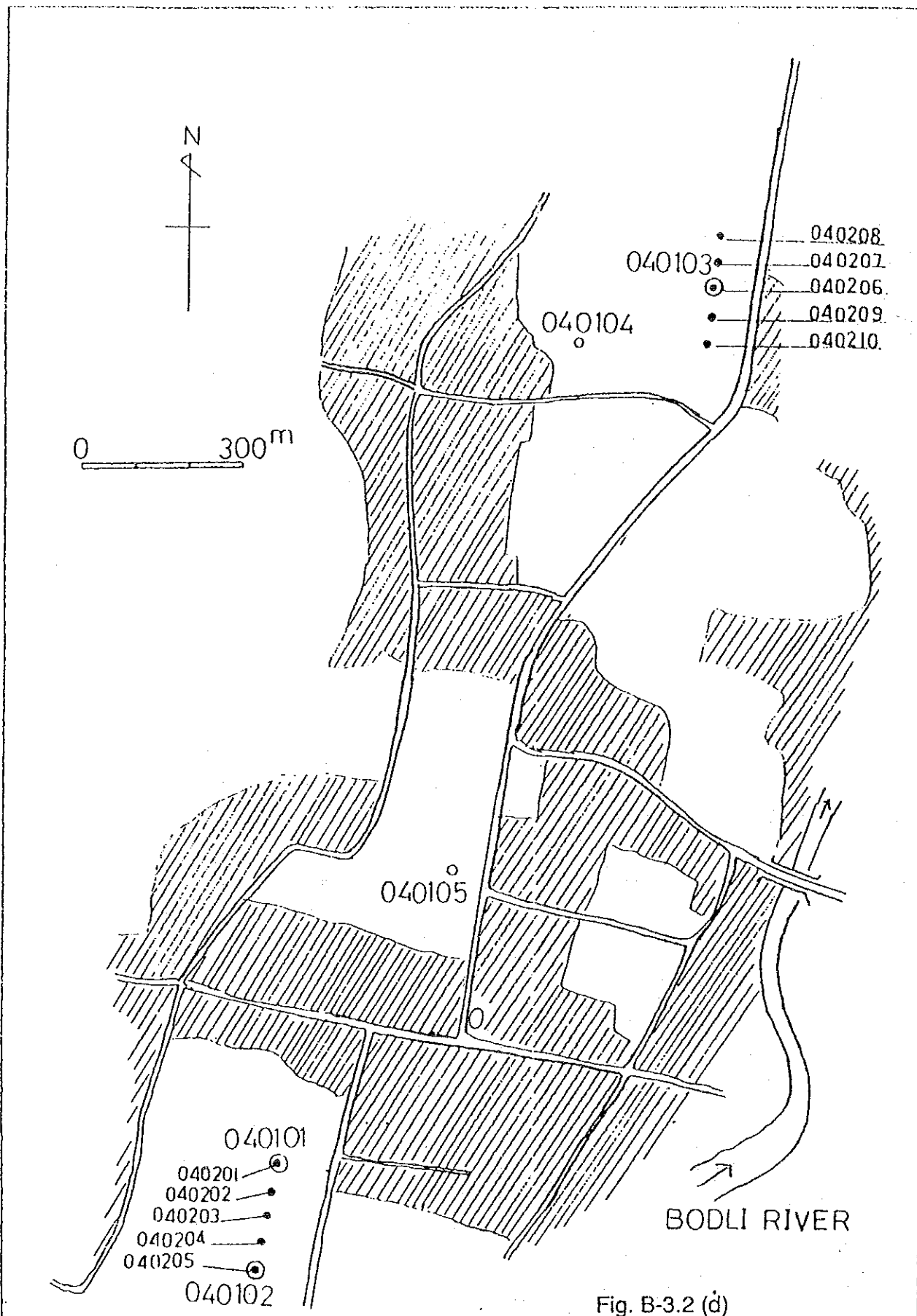


Fig. B-3.2 (d)

- RESISTIVITY SURVEY POINT
- ELECTORMAGNETIC SURVEY POINT
- KECAMATAN OFFICE

GEMUH

SCALE 1:10,000

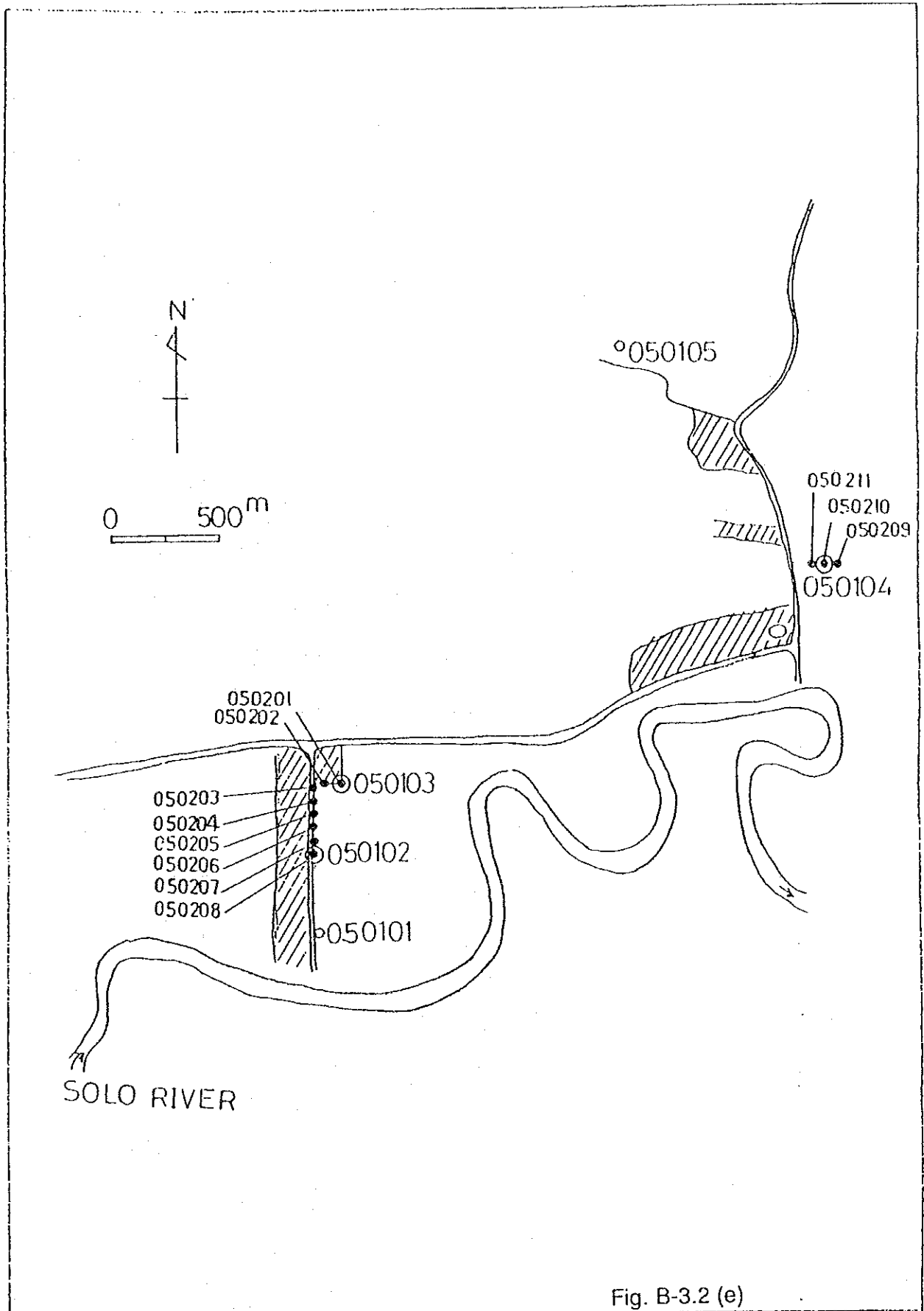


Fig. B-3.2 (e)

- RESISTIVITY SURVEY POINT
- ELECTORMAGNETIC SURVEY POINT
- ◻ KECAMATAN OFFICE

JENAR  
SCALE 1:25,000

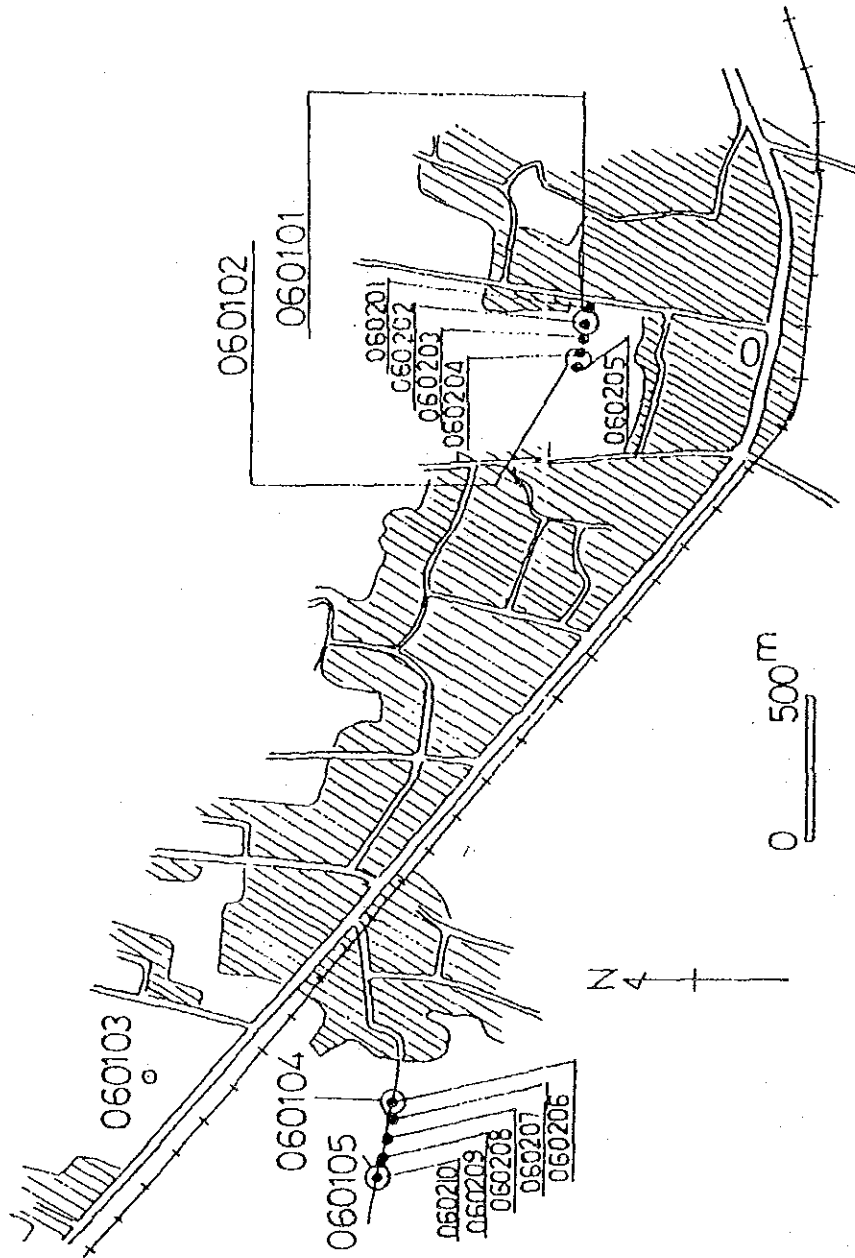


Fig. B-3.2 (f)

○ RESISTIVITY SURVEY POINT

● ELECTROMAGNETIC SURVEY POINT

○ KECAMATAN OFFICE

KAPAS

SCALE 1: 25,000

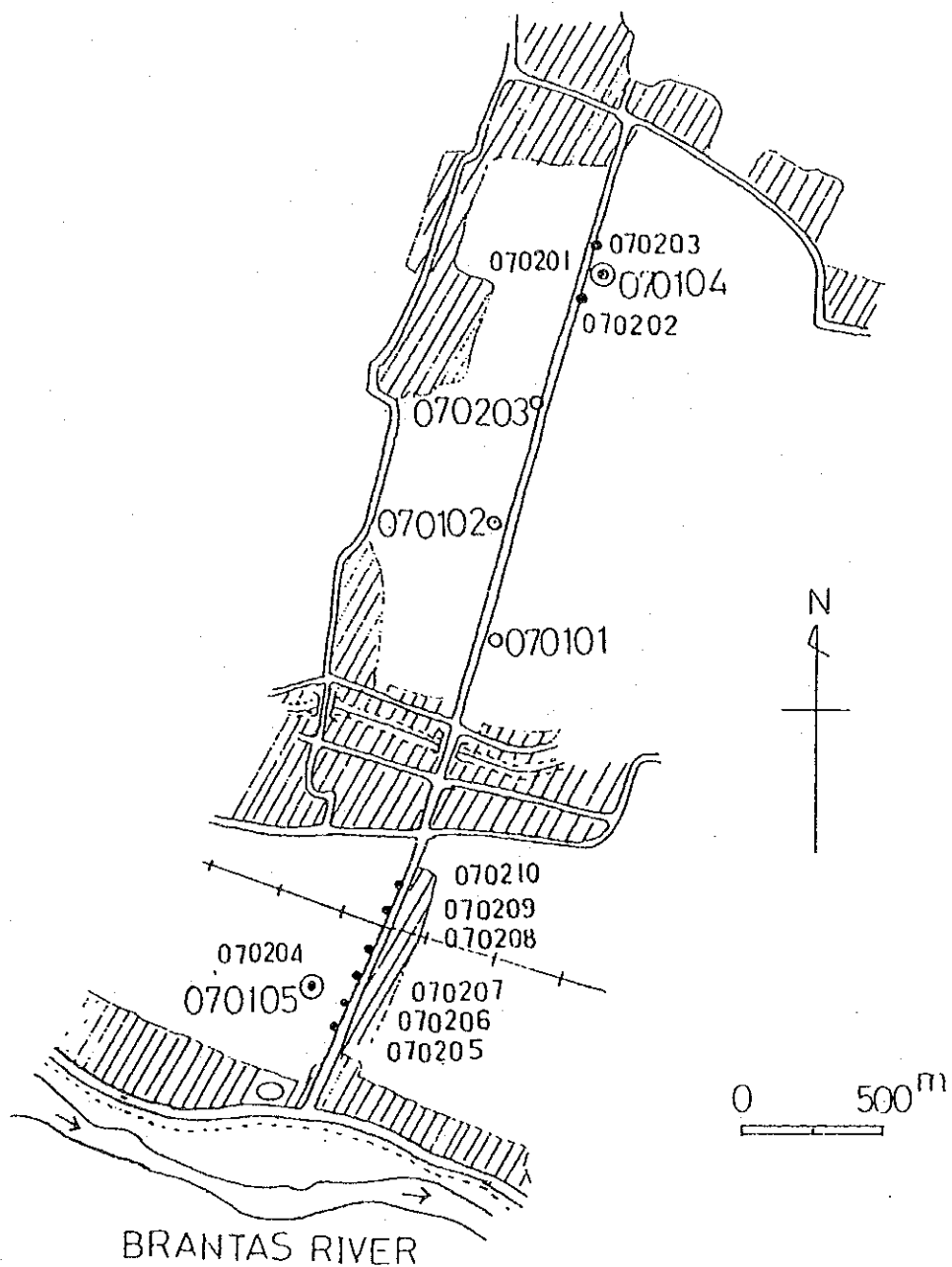


Fig. B-3.2 (g)

- RESISTIVITY SURVEY POINT
- ELECTROMAGNETIC SURVEY POINT
- ◻ KECAMATAN OFFICE

KUDU

SCALE 1: 25,000

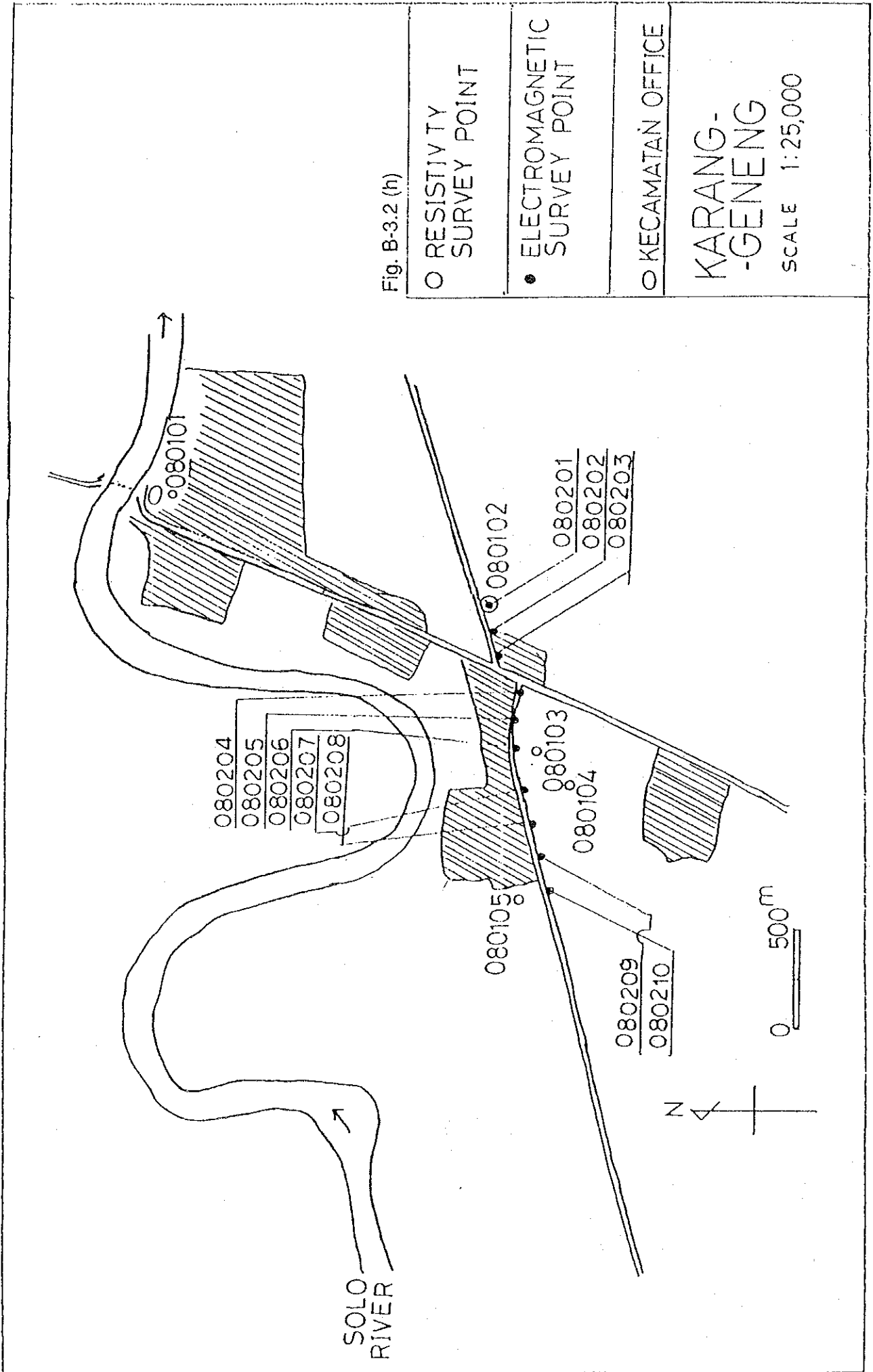


Fig. B-3.2 (h)

○ RESISTIVITY SURVEY POINT

● ELECTROMAGNETIC SURVEY POINT

○ KECAMATAN OFFICE

KARANG-GENENG

SCALE 1:25,000



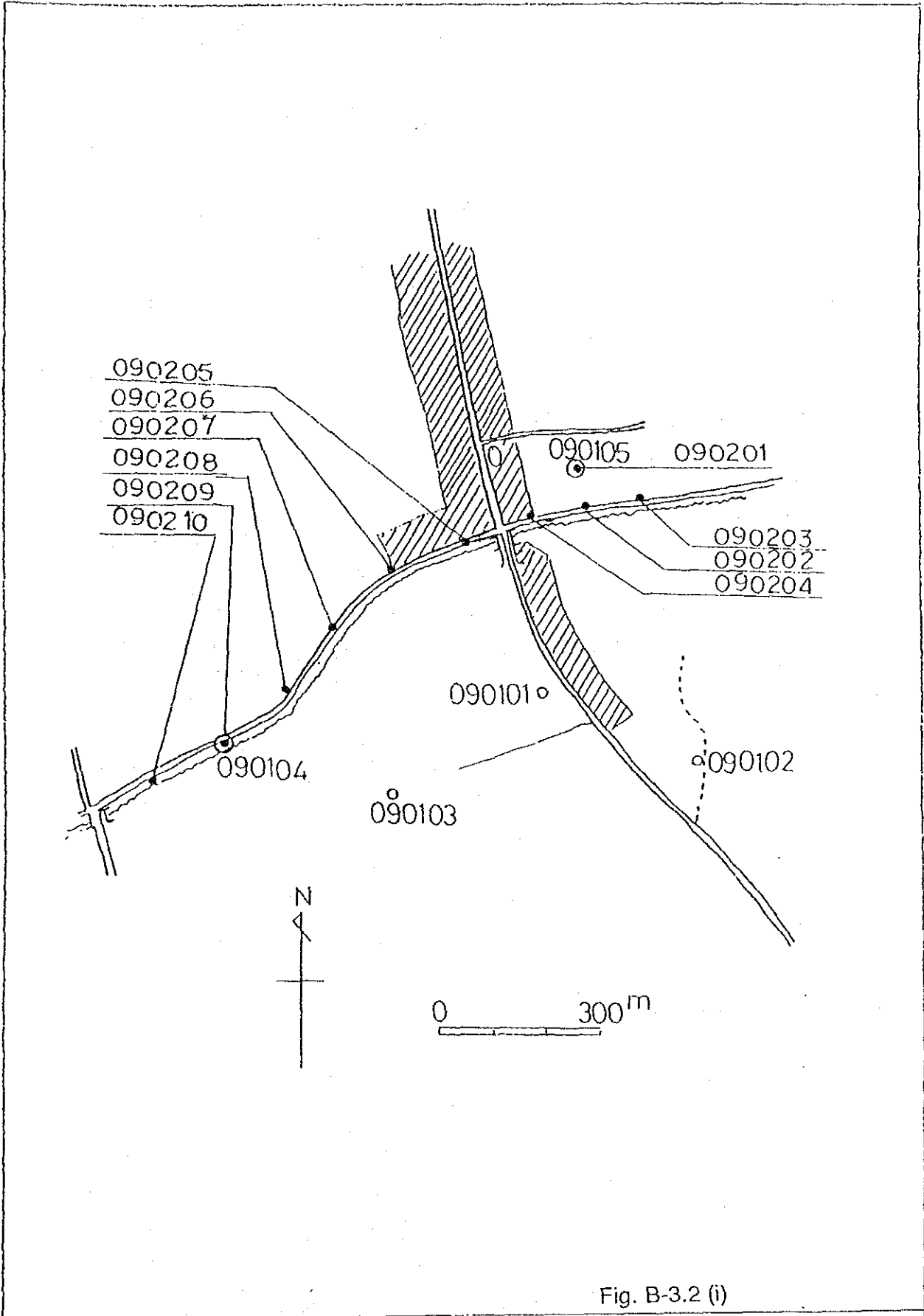


Fig. B-3.2 (i)

- RESISTIVITY SURVEY POINT
- ELECTROMAGNETIC SURVEY POINT
- KECAMATAN OFFICE

BESUK  
SCALE 1:10,000

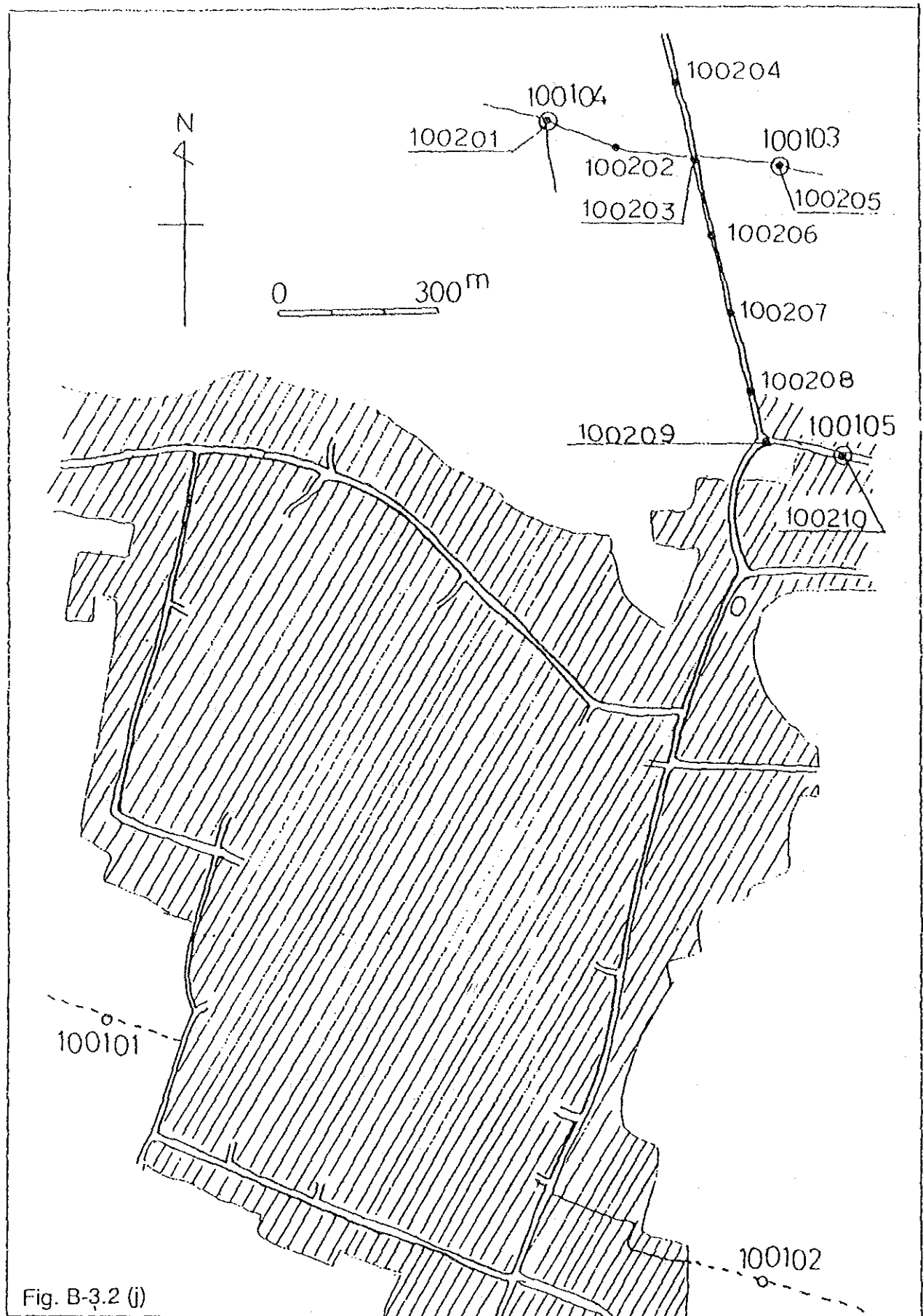


Fig. B-3.2 (i)

- RESISTIVITY SURVEY POINT
- ELECTROMAGNETIC SURVEY POINT
- KECAMATAN OFFICE

KUNIR  
SCALE 1:10,000

Fig. B-3.3 (a) Cross-sectional Resistivity Profile Klegenwonosari

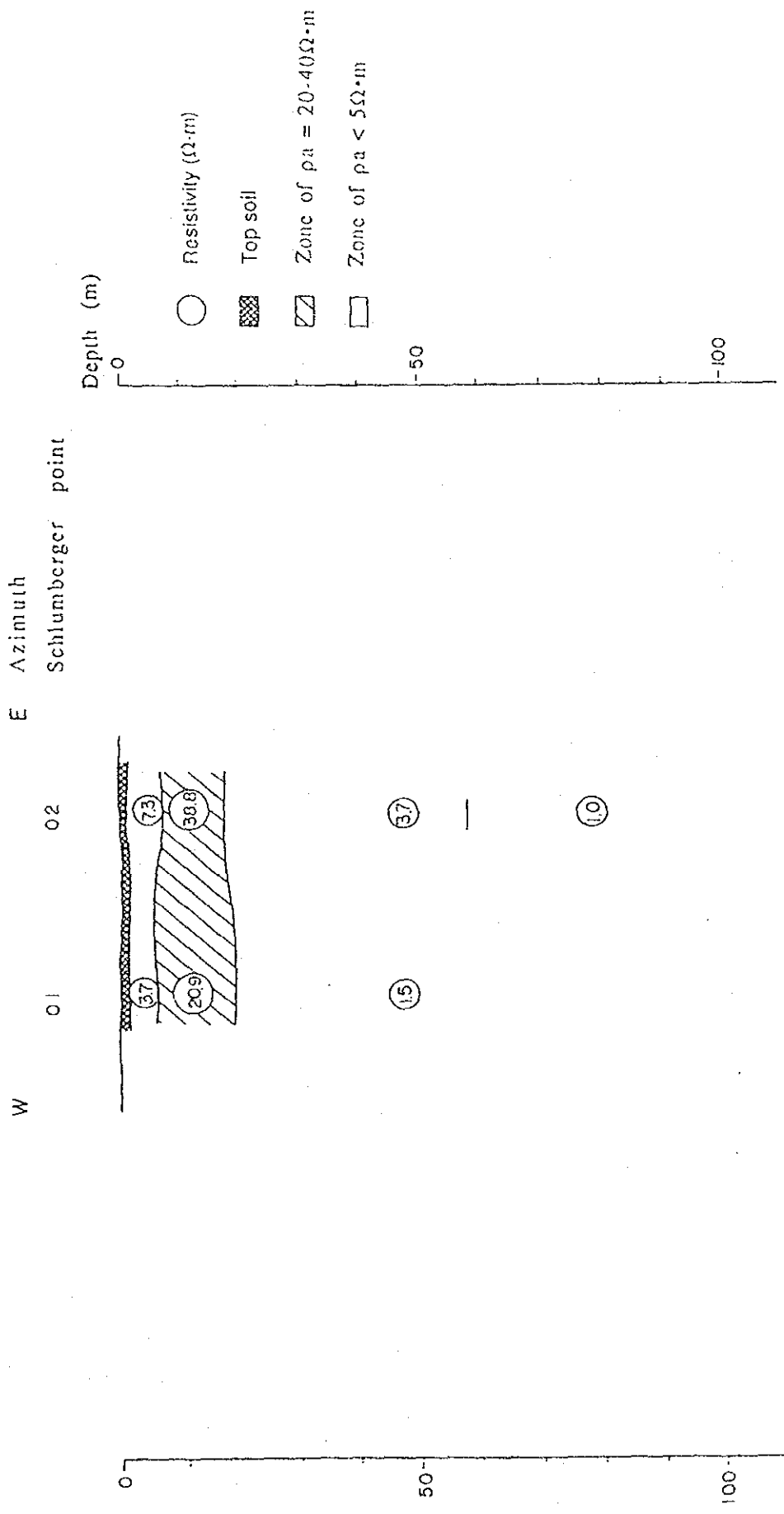


Fig. B-3.3 (b) Cross-sectional Resistivity Profile Butuh

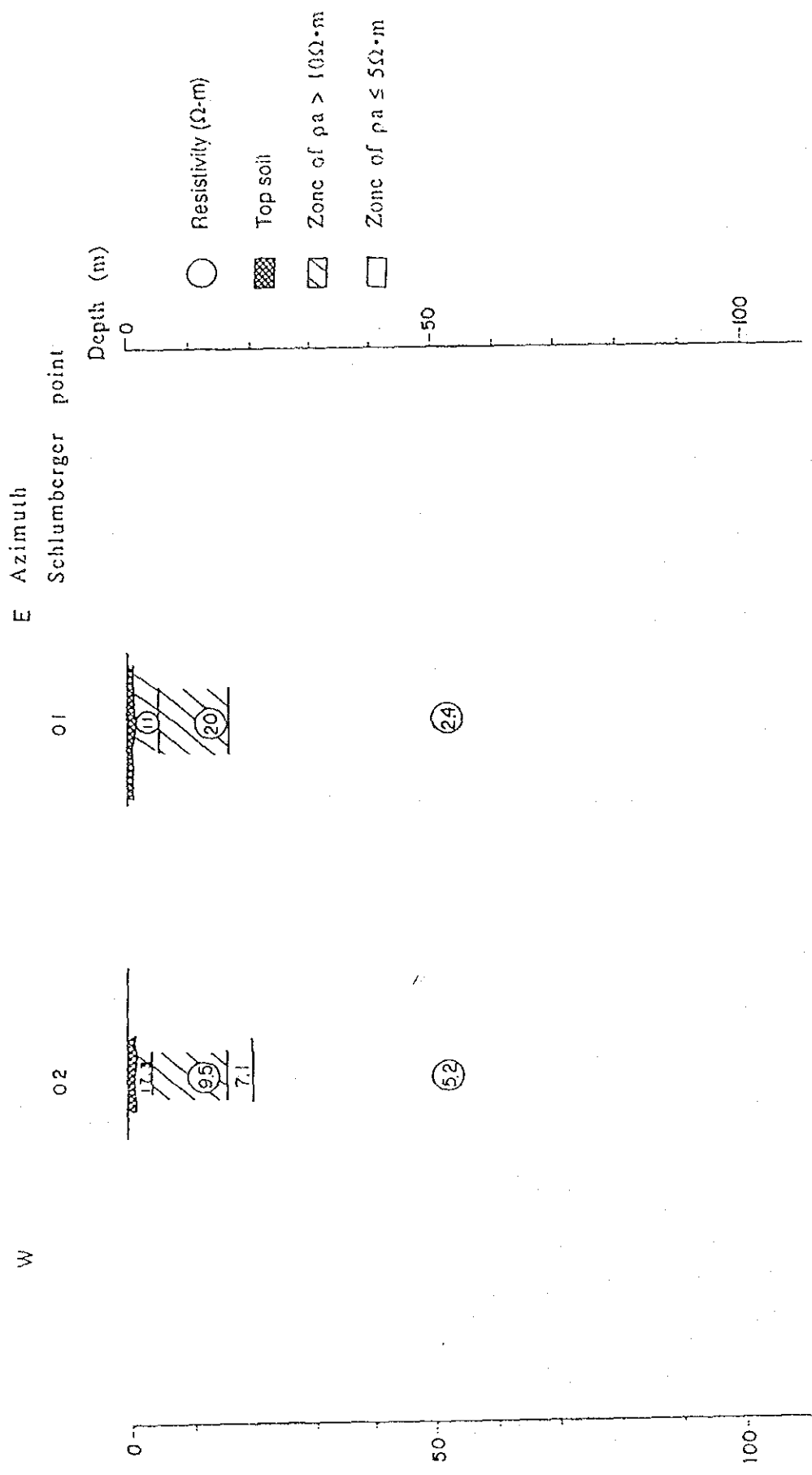


Fig. B-3.3 (c) Cross-sectional Resistivity Profile Purwodadi

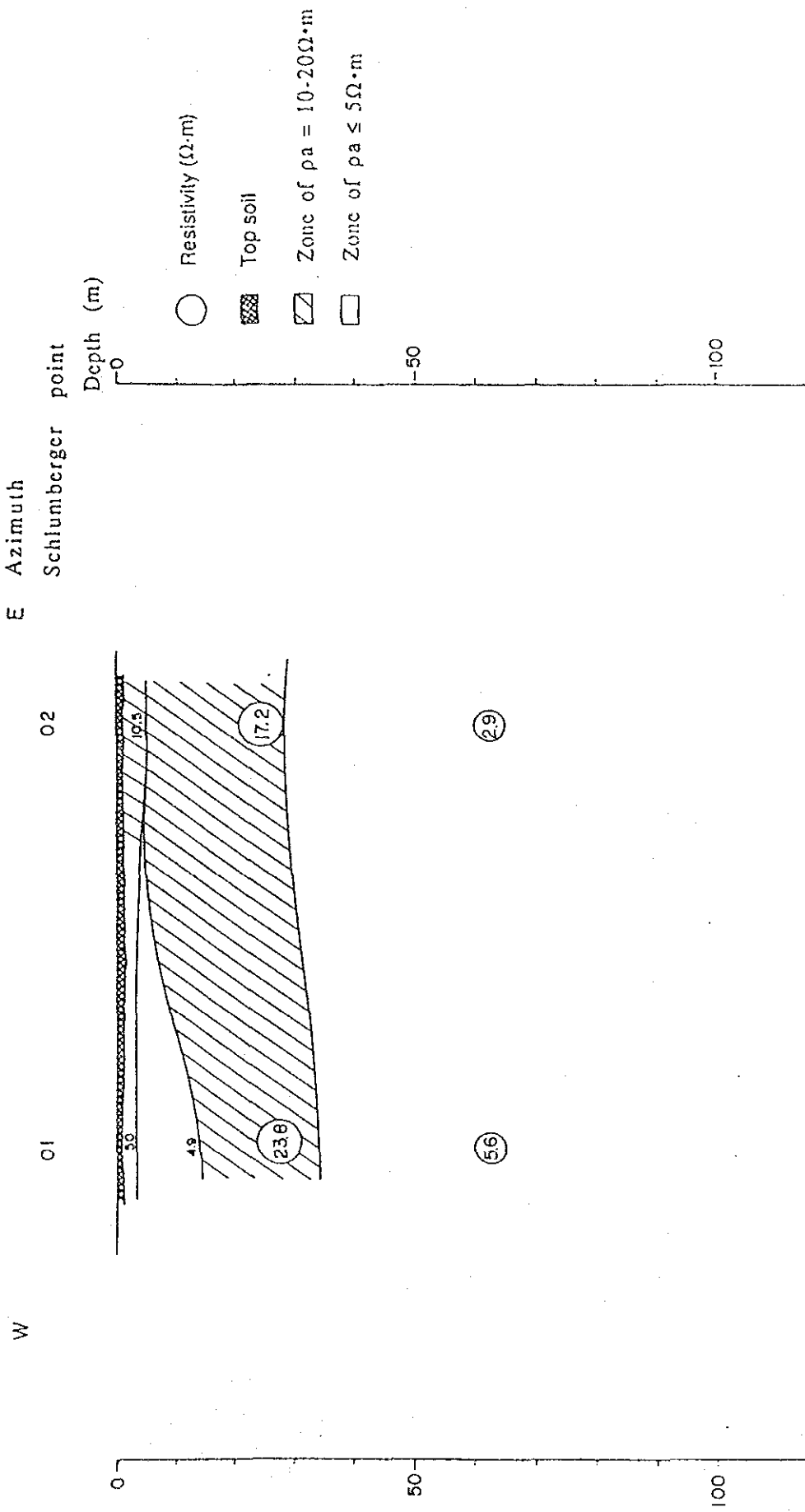


Fig. B-3.3 (d) Cross-sectional Resistivity Profile Gemuh

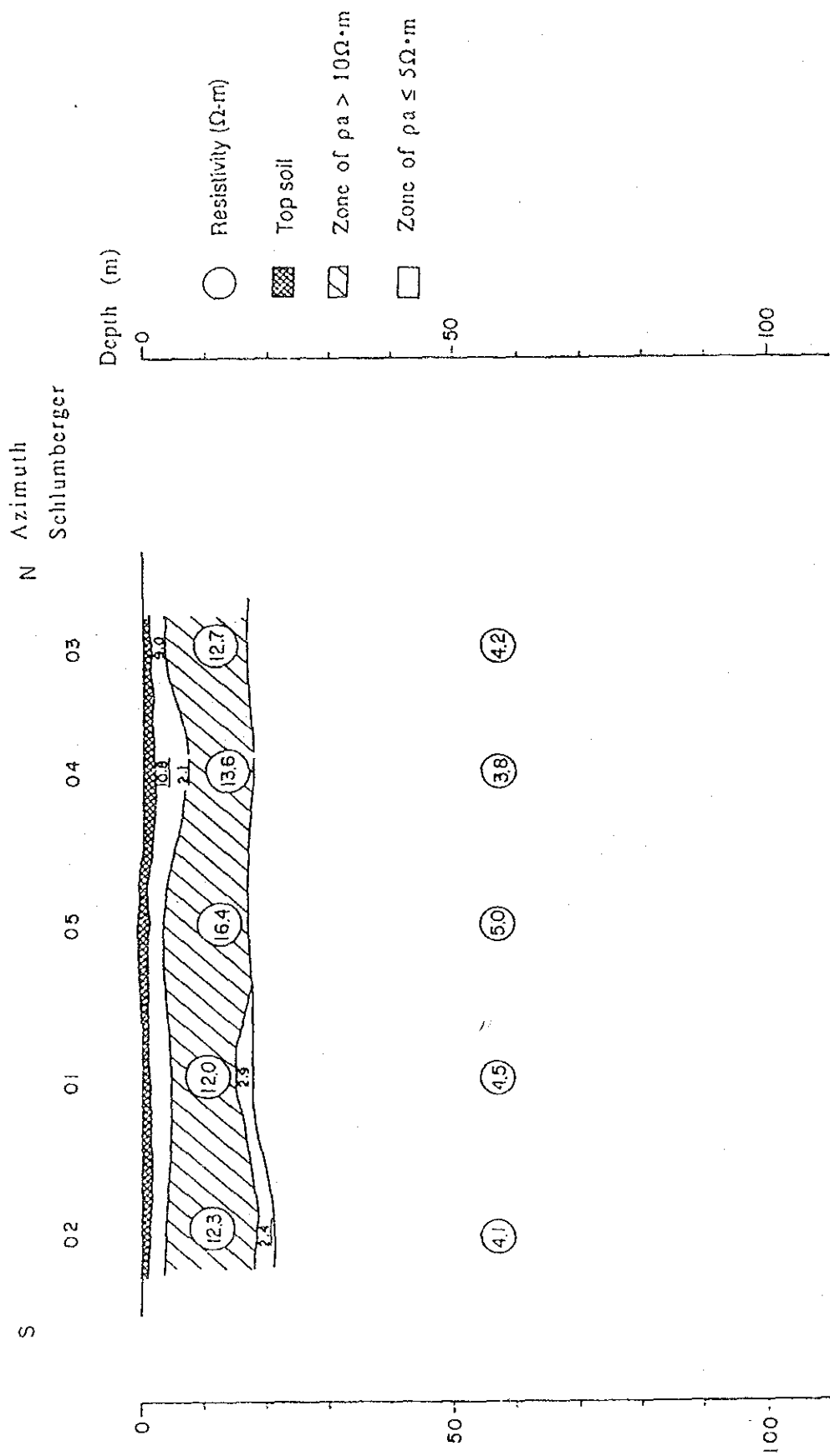


Fig. B-3.3 (c) Cross-sectional Resistivity Profile Jenar

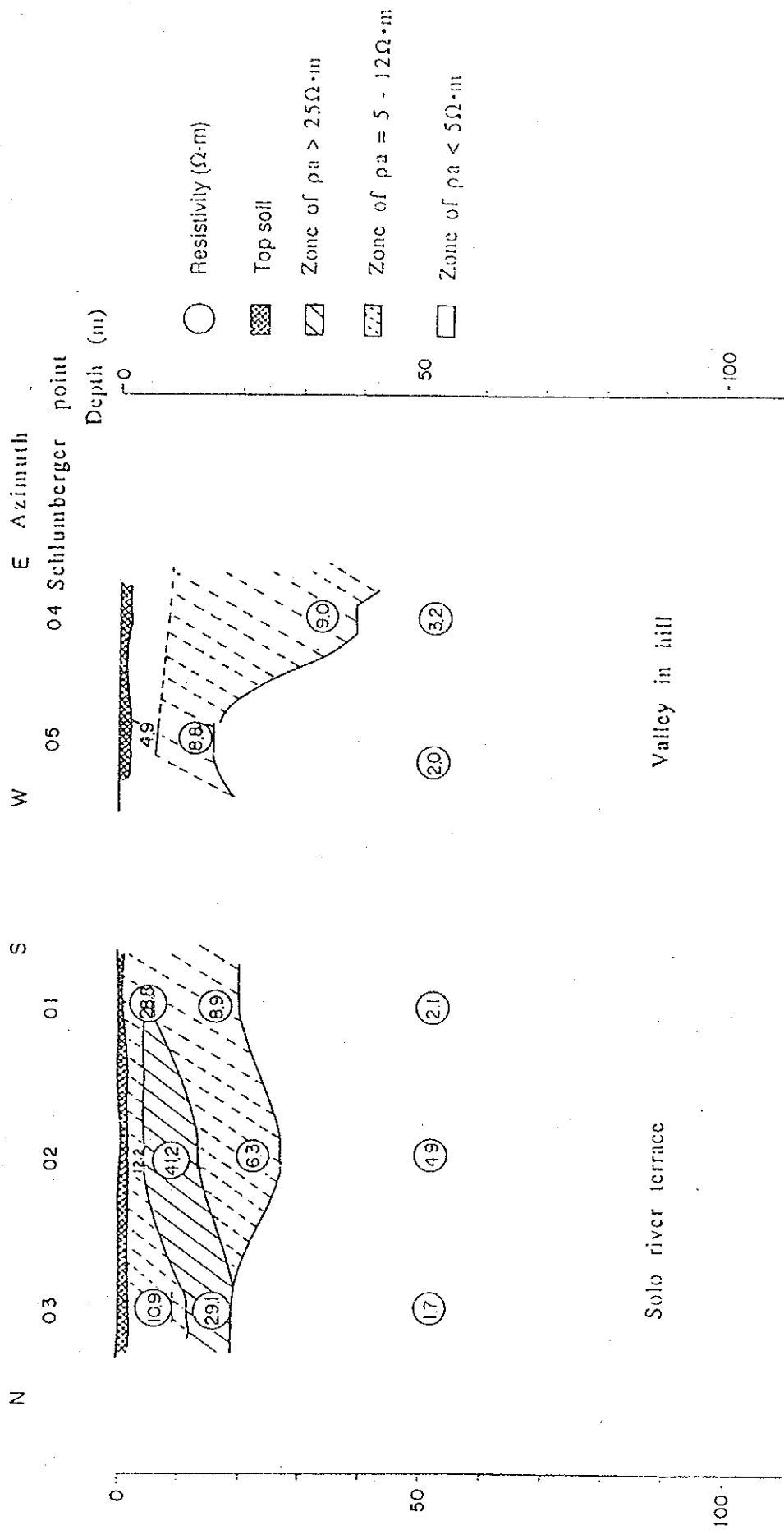


Fig. B-3.3 (D) Cross-sectional Resistivity Profile

Kapas

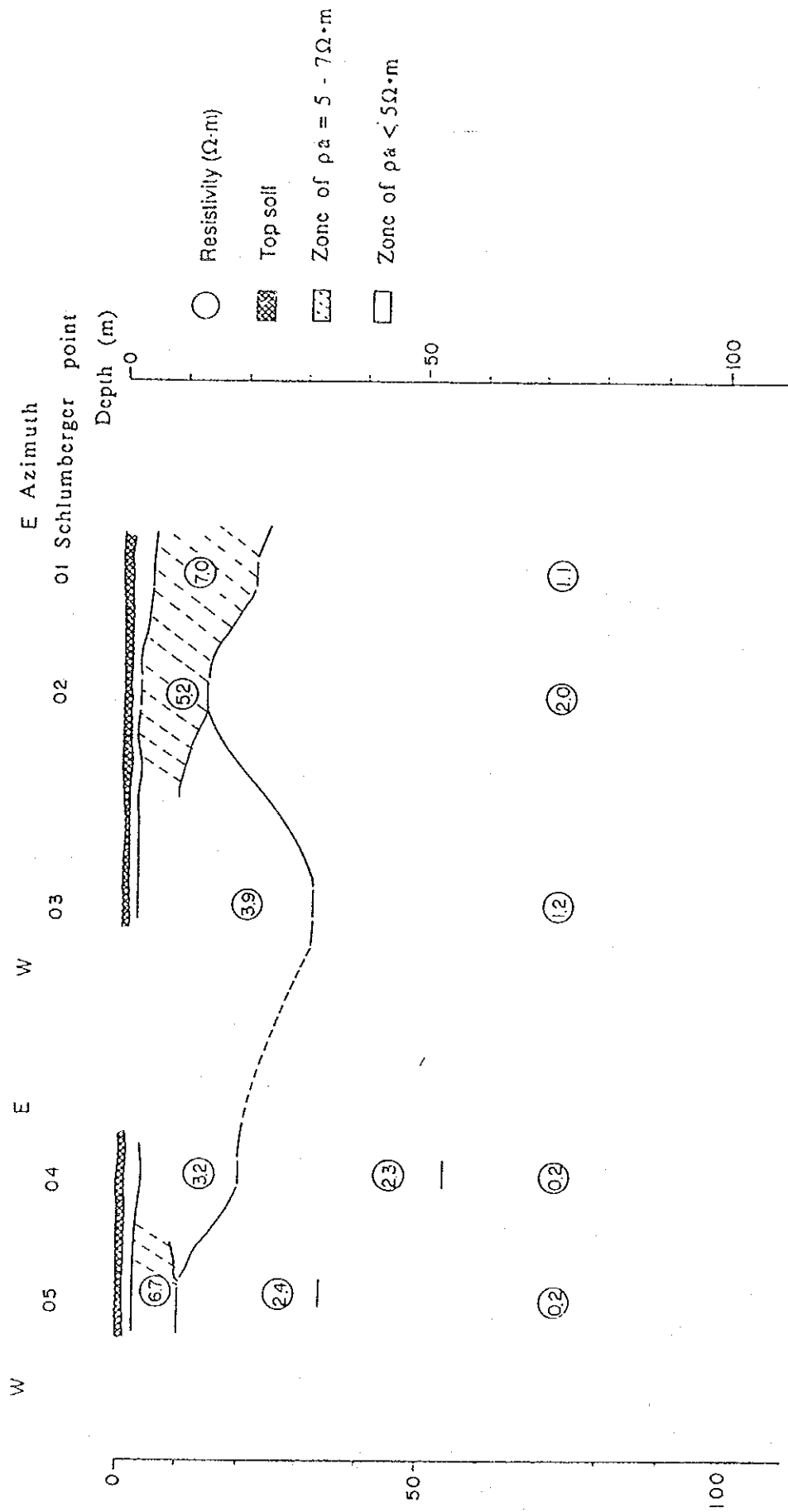




Fig. B-3.3 (B) Cross-sectional Resistivity Profile Kudu

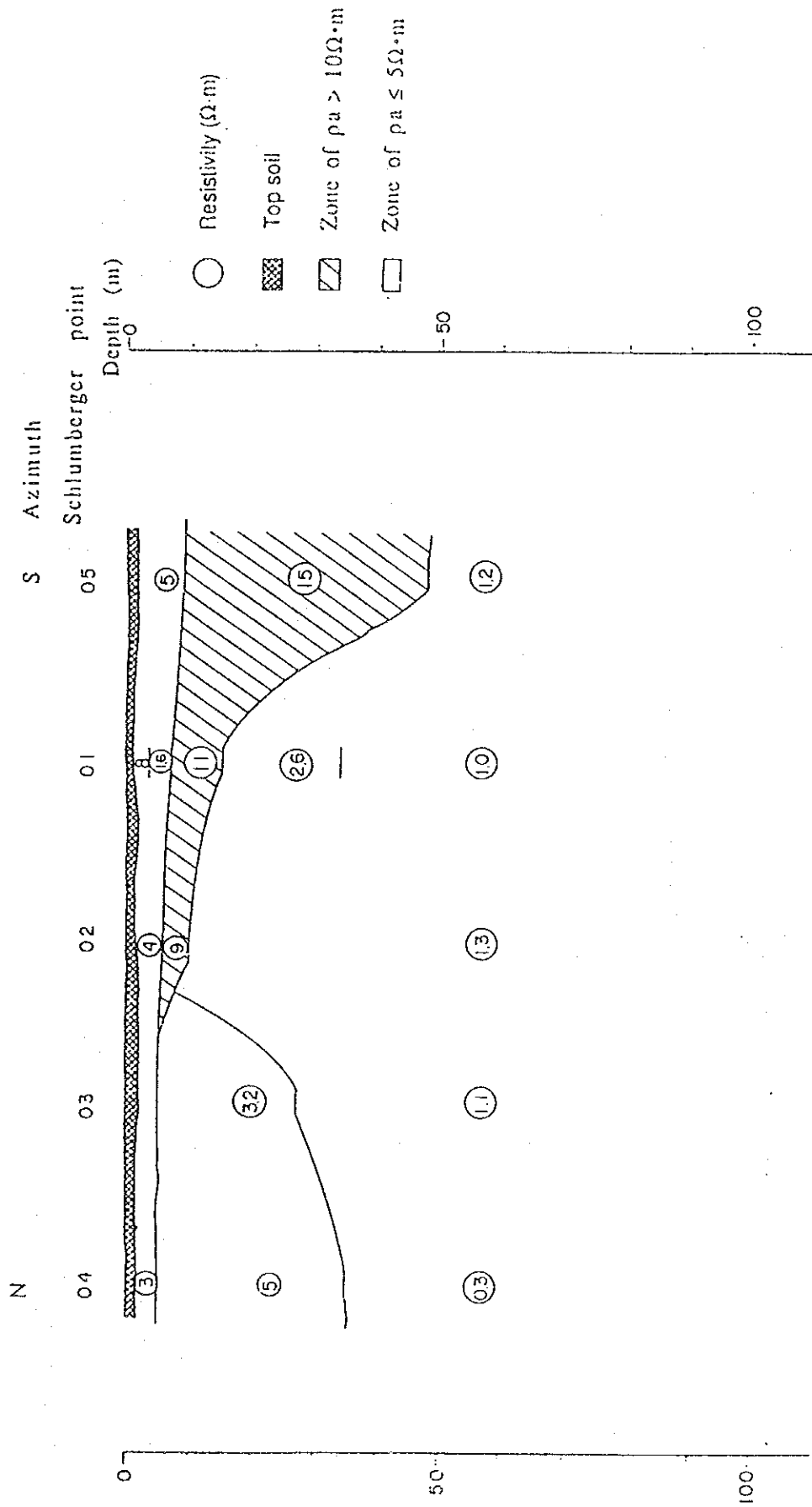


Fig. B-3.3 (h) Cross-sectional Resistivity Profile  
Karanggeng

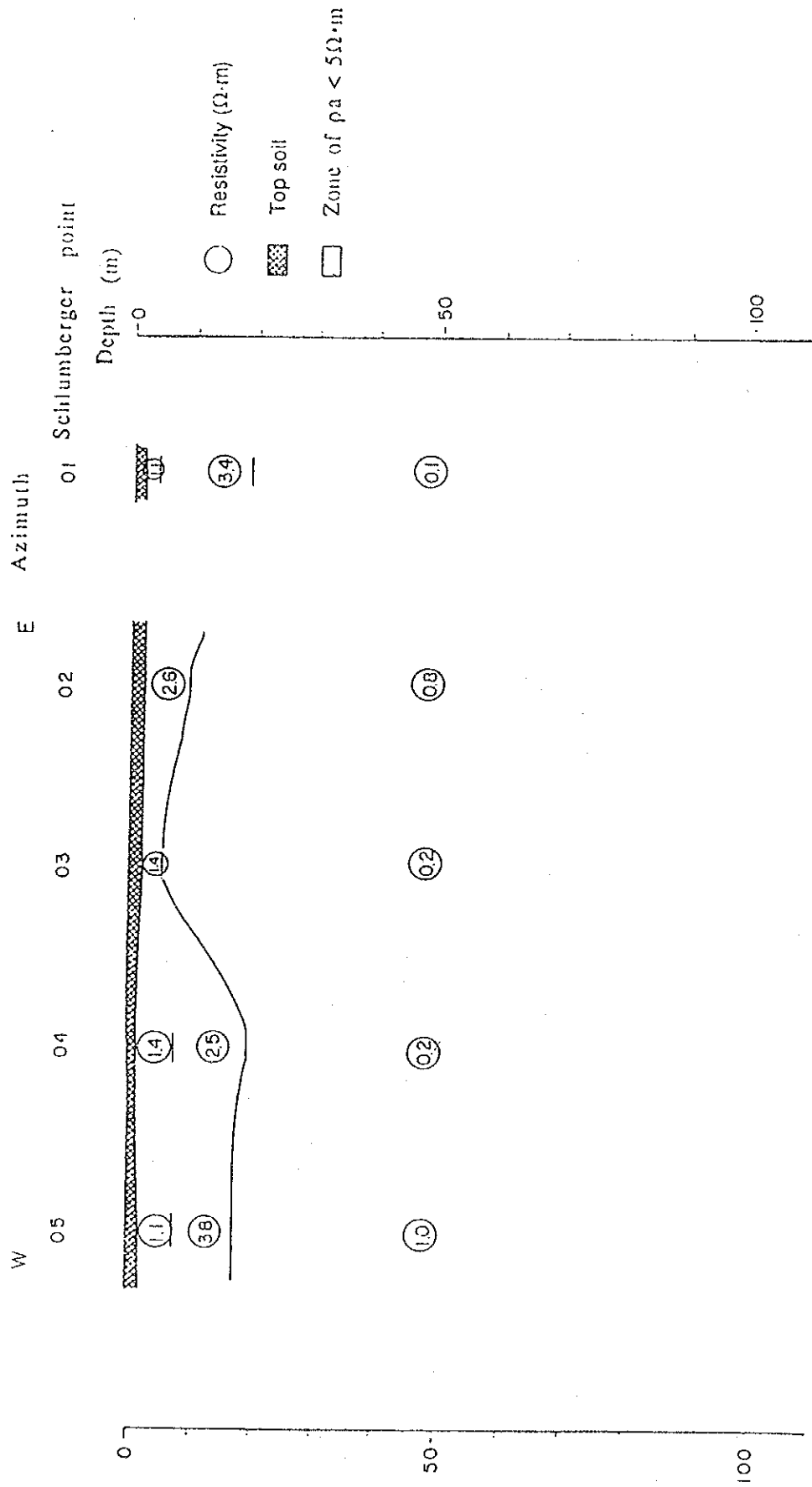


Fig. B-3.3 (I) Cross-sectional Resistivity Profile

Besuk

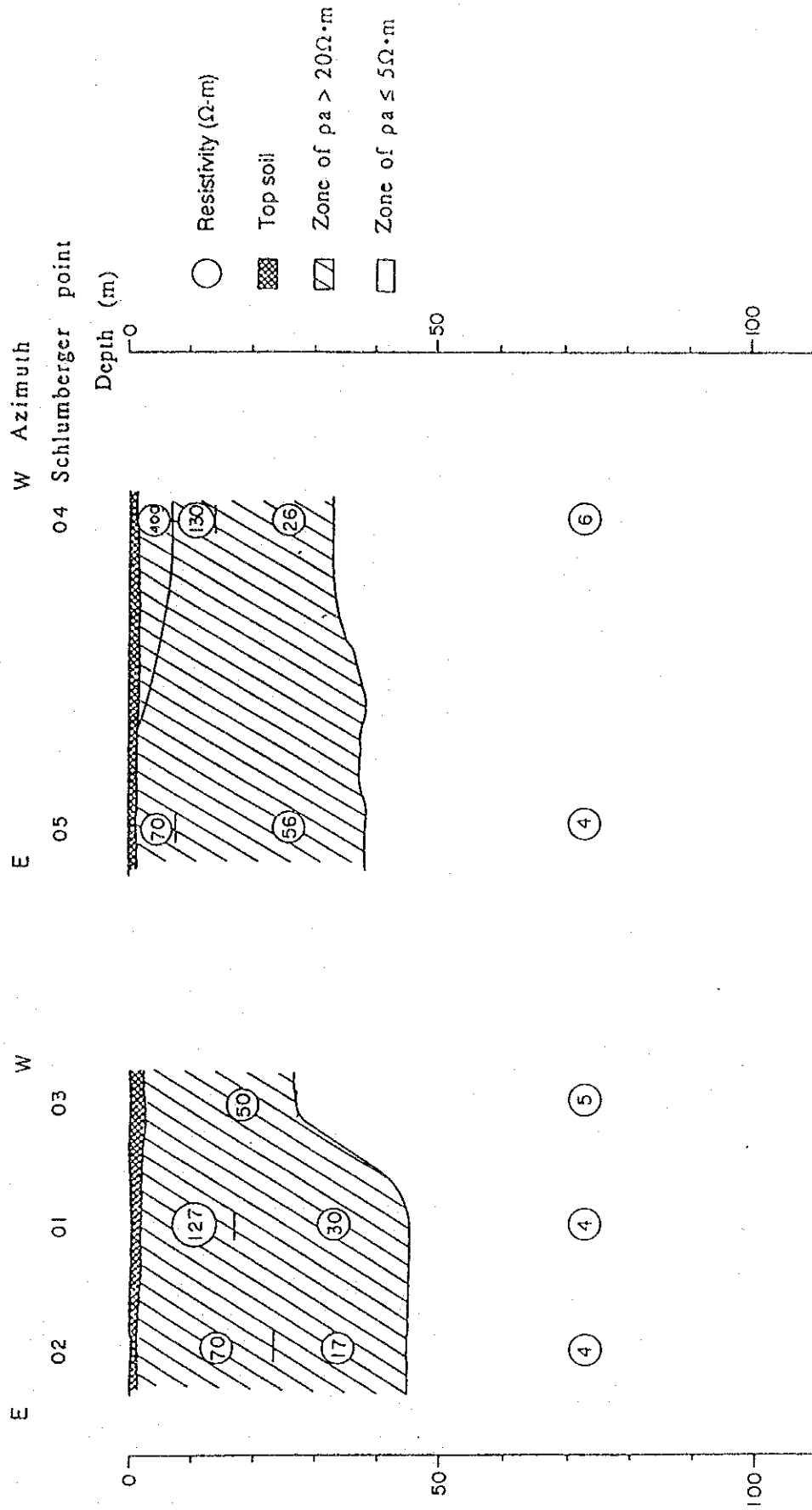
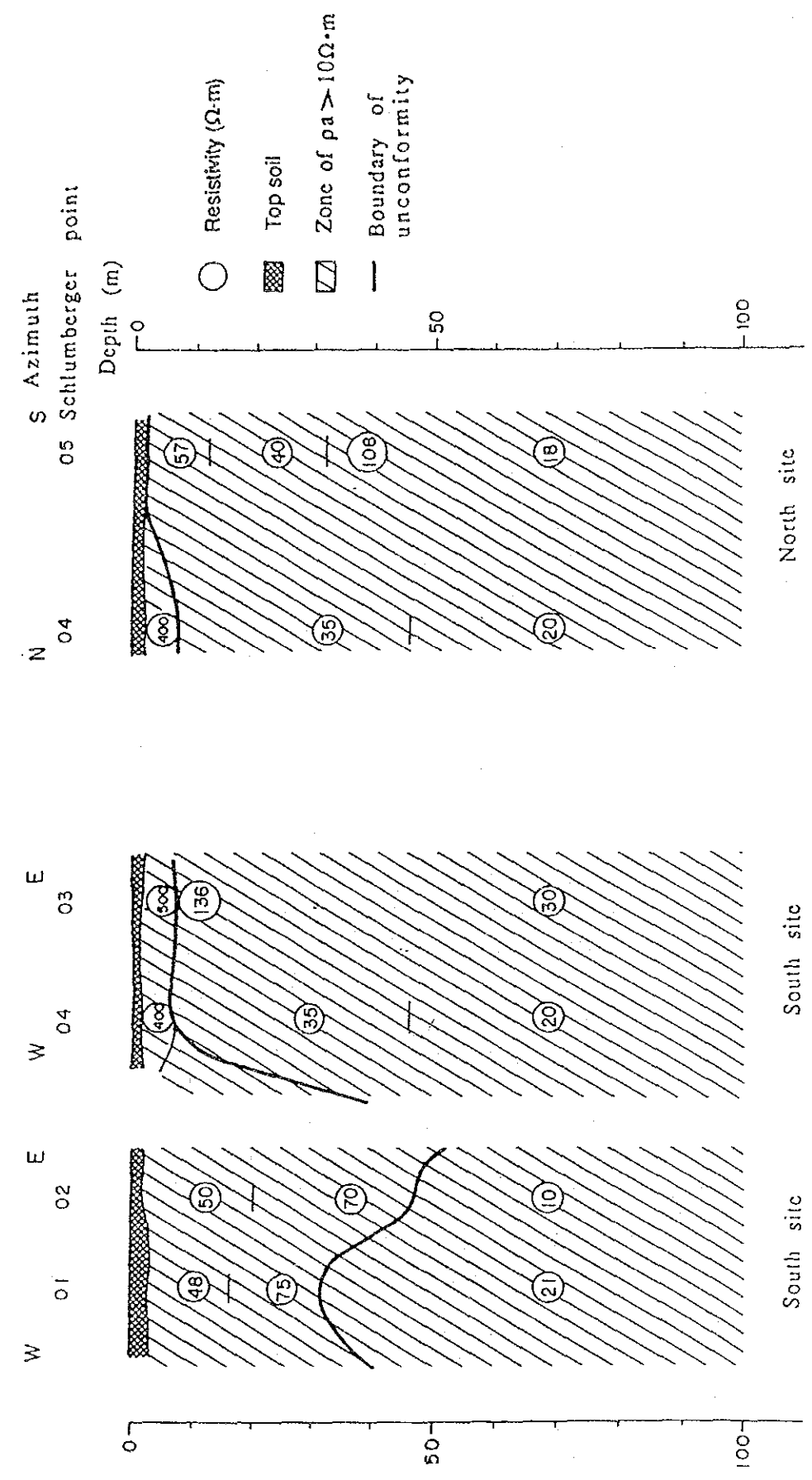


Fig. B-3.3 (i) Cross-sectional Resistivity Profile

Kunir



Photographs: Field Work Scenes of Geophysical Survey



Resistivity survey in Butuh



Resistivity survey in Jenar





Resistivity survey in Kapas



Resistivity survey in Kudu







Resistivity survey in Karanggeneng



Resistivity survey in Besuk





Electromagnetic survey in Klegenwonosari



Electromagnetic survey in Purwodadi





Electromagnetic survey in Gemuh



Electromagnetic survey in Jenar





Electromagnetic survey in Kapas



Electromagnetic survey in Kunir





## 4. TEST WELL DRILLING AND PUMPING TEST

### 4.1 The Process of Conducting Initial Test Wells

#### (1) Work Schedule and Technical Specifications

The works for the test wells have been conducted by the following schedule.

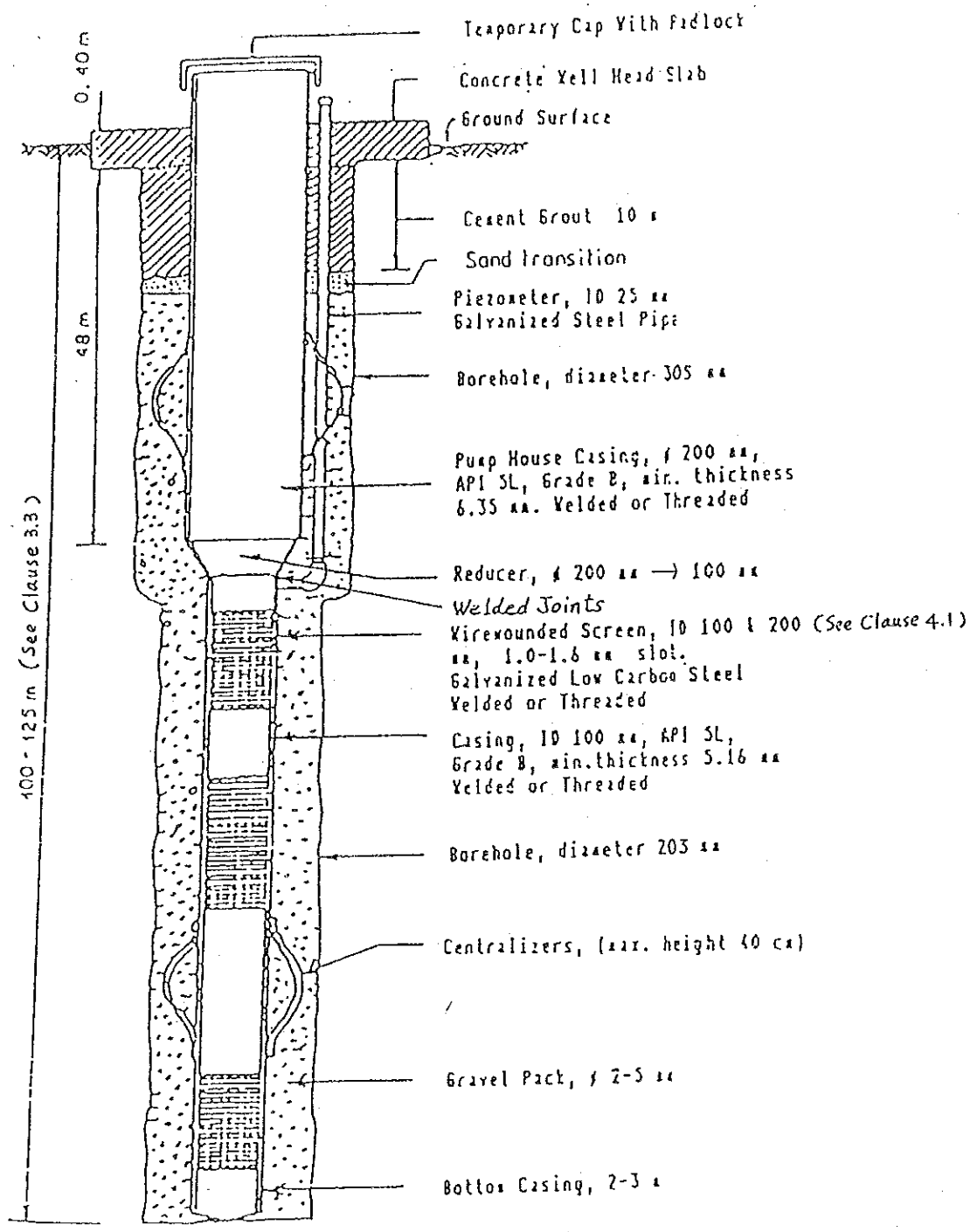
- Step-1 Selection and decision of IKKs for which the test well drilling should be carried out;
- Step-2 Preparation of the Documents for tender call and calling for tenders;
- Step-3 Evaluation of tenders to select Contractors;
- Step-4 Making contract and site guidance to Contractors;
- Step-5 Supervision of the Contractors' field-work performance;
- Step-6 Receiving of the final report from the Contractors

An idea for selecting IKKs for which the test well drilling should be carried out was proposed in the Interim Report, together with a suggestion of 5 IKKs and the ground statement. Meetings were held with officials of Cipta Karya on this subject in February and March, 1991. As a result of these meetings, both parties agreed to conduct test wells at the following 5 IKKs.

Kemiri, Jenar, Jepon, Kembangbahu, and Banyuanyar

In a hydrogeological sense, these IKKs belong to either an area where there is no deep well in/around IKK or an area where it has been classified as low potential aquifer area so that it may not be easy to find a satisfactory aquifer thereabouts although there was a deep well at a distance.

In the consecutive meetings the JICA study team discussed with Cipta Karya about a fundamental points of Technical Specifications for the works. Fig. B.4.1 shows a drawing of test well design that was used in the Technical Specifications. The contracted work consisted of the following working items at each site.



NOT TO SCALE

FIG. B.4.1 TEST WELL DESIGN

- 1) Mobilization and demobilization, with drill rig
- 2) Site preparation and clean up
- 3) Pilot hole drilling; 150 mm dia. hole, 100 m ± deep
- 4) Reaming of drill hole; 300 mm dia. for pump chamber and 200 mm dia. for the lower section
- 5) Sampling of formation materials
- 6) Water level measurement; daily
- 7) Geophysical borehole logging
- 8) Installation of casing and screens, including piezometer pipe
- 9) Plumbness test
- 10) Gravel packing and sealing
- 11) Test well development
- 12) Pumping tests
- 13) Well head construction

Water quality analyses were also conducted on pumped water samples.

The work of Step-2 was made in April and May, 1991. Invitation for tenders was made in accordance with the current procedure used for groundwater development in Indonesia. The JICA team asked Cipta Karya's advice about the competent local well contractors, and 10 qualified contractors were designated for each province of Central and East Javas. Invitation documents were sent to each contractor.

Evaluation of tenders (Step-3) was conducted, including interviews, in the latter part of May, 1991, and in conclusion the following Contractors were selected.

C.V. ITA Engineering; for Central Java

C.V. Cendana; for East Java

Site guidance to Contactors (Step-4) was conducted in the early part of June, 1991. The test well locations were decided by judging such information as topography, outcrops, hydrogeological map, dug well condition and land-use condition, and also by consulting with the kecamatan officials about the local conditions. Refer to the following Paragraph for the location of test wells.

The test well drilling and associated works were carried out by the Contractors under the supervision of one of JICA team members during a period from June toward the end of August, 1991 (Step-5). The final report was received (Step-6); in the middle part of August for Central Java and in the middle part of September for East Java. There were troubles during the drilling at Kembangbahu and Banyuanyar in East Java.

## (2) Intention of Initial Test Wells

### 1) Kemiri

This IKK is located on a high plane of alluvial plain. The Serayu mountains is on the north. A result of geoelectrical survey made in the neighboring IKK Butuh implied that the subsurface materials are divided into 2 major formations, i.e. the upper formation of alluvium mainly of sands about 20 m thick and the lower formation probably of Miocene sedimentary rocks. According to a hydrogeological map, in the meantime, the hill on the north are composed of tuffaceous sandstone, sandstone, conglomerate, tuff, breccia and clay of Miocene series. From this information, the test well was schemed to drill 100 m or more in anticipation of encountering potential aquifers of sandstones and conglomerates in the Miocene mass under alluvium, and the test well was located at on a kecamatan premises in the rice field near the west boundary of the IKK area.

### 2) Jenar

This area belongs mainly to a hilly zone comprising Pliocene marls. The Solo river which forms the south boundary of kecamatan flows near on the south. Locally, there are small and narrow flat lands between them. Geoelectric survey was made on a flat land in the west part of the IKK area. According to a hydrogeological map, a bedded limestone strip is present in the south edge of the hills, of which limestones are karstified to various degrees at low to high permeability. Also indicated are that there are faults and groundwater flow is limited to fracture zone. On the Solo river banks near the kecamatan office, outcrops of limestone formation with frequent sandstone beds can be seen. Its bedding planes are sloped down toward north. The folding can also be seen on the opposite bank. Therefore, a scheme was made to position the test well of 100 m or more on a folding axis as much as possible to hit a fracture zone or otherwise potential aquifers of sandstones. Considering the location of

folding axis the test well was positioned on a farm land at 50 m from the kecamatan office.

### 3) Jepon

This area is underlain by Tertiary-Quaternary deposits of mudstone and marl that are interbedded with quartz sandstone and limestone. A hydrogeological map indicates that there is a belt of Miocene sedimentary rocks being composed of sandstone and limestone near the east boundary of this kecamatan. In the meantime, there are two P2AT test wells in desa Soko at 9 km north of IKK. Although the pumping test data of them have not yet obtained, they may be acquired some time anyway, so a scheme was made to locate the test hole on a rice field in the eastern part of IKK expecting Miocene rocks with some potential aquifers be encountered in the deep.

### 4) Kembangbahu

This IKK is situated near the southern edge of a vast alluvial plain or the Lamongan lowlands. A hydrogeological map indicates that this area is underlain by poorly sorted Quaternary sandstone and conglomerate of low to medium permeability and the northern part of IKK belongs to a strip zone of 2.5-10 l/s well yield. From this information, a 100 m deep test well was positioned on a farm land in the north part of IKK within said moderate potential zone to make clear the groundwater productivity.

### 5) Banyuanyar

This IKK is situated on a part of submontane slope - a gentle downward slope in the direction of north - developed on the north of Mt. Tarub. Outcrops on the riverbank and riverbed in the west part of IKK shows the land materials are composed of young Quaternary volcanic products including their flow deposits. A groundwater potential map indicates that the well yield capacity of this area is more than 10 l/s, which implies that the test well may be drilled at any place within the IKK. However, from a topographic point of view, it was conjectured that the groundwater level is deep. Consequently, a scheme was made to drill a 100 m deep test hole at a dry farm land near the kecamatan office in order to ascertain the groundwater potential.

### (3) Work Quantities Performed

The final drilling depth and the well construction depth at each site were as follows:

| <u>Item</u> ↓     | <u>Site</u> ⇒ | <u>Kemiri</u> | <u>Jenar</u> | <u>Jepon</u> | <u>Kembangbahu</u> | <u>Banyuanyar</u> |
|-------------------|---------------|---------------|--------------|--------------|--------------------|-------------------|
| Pilot hole        |               | 125m          | 125m         | 127m         | 103m               | 84m               |
| Reaming, 300mm    |               | 0-33m         | 0-51m        | 0-51m        | 0-50m              | 0-42.5m           |
| Reaming, 200mm    |               | 33-63m        | 51-125m      | 51-130m      | 50-103m            | 42.5-84m          |
| Well construction |               | 60m           | 105m         | 127m         | 102m               | 84m               |

The results of pumping tests in these test wells inferred that the test wells, except for that at Kembangbahu, cannot be used as a production well because of low or poor yield capacity.

## 4.2 Plan for Additional Well Tests

### (1) Introduction

As an inevitable consequence of said test well performance, detection of another aquifers (groundwater source) became an issue of necessity. In order to accomplish this work, plans for additional works were made by contemplation after supplementary field survey and by discussion with the Contractors. The necessity of additional investigation was arisen not only for IKKs of Kemiri, Jenar, Jepon, and Banyuanyar but also for IKK Batangan.

As for IKK Batangan, there is no spring, and river water & groundwater in/around the IKK area is saline, so the use of existing Juwana water supply facilities has been planned. But, recently it was clarified that for the use of this system it is required to upgrade pump capacity of existing Intake and to provide another water treatment plant. Therefore, it became an important issue here for the feasibility study to conduct an investigation by a new well to confirm whether there is a potential aquifer near the IKK that will make the project cost economical.

## (2) Additional Well Test Plans

### 1) Kemiri

It was inferred from the initial test well that there are alluvial sand strata in the upper part of ground, so here a plan was made to drill an additional 30 m deep test well by the initial test well to investigate the groundwater productivity of the sand strata in a shallow depth.

### 2) Jenar

It was estimated from available information that there would be alluvial sand strata in Dusun Praayunan within the IKK, so a plan was made to conduct pumping tests using existing dug well and bored well being in Prayunan to confirm the hydraulic properties of alluvium sand stratum.

### 3) Jepon

The initial test well inferred that there is no productive aquifer there, so it became necessary to gain the pumping tests data of an existing flowing P2AT test well in Desa Soko at 9 m north of IKK. But, according to the recent information, it is said that pumping test has not been carried out in this flowing well. Consequently, it became inevitable to conduct pumping test in this well to confirm its productivity. Permission for it was obtained in November, 1991.

### 4) Banyuanyar

It was disclosed by the initial test well that there is a basaltic lava mass below 37 m and it has little groundwater productivity; but according to lithology overlying strata seem to be of moderately productive aquifers. Therefore, a scheme was made to conduct pumping tests using existing dug wells in the IKK area to determine the hydraulic property of shallow aquifer.

### 5) Batangan

Water drawn up from dug wells in desa Gunungsari at 3 km south of the IKK has been used by the town people as one of water acquisition means during the dry season. Therefore, a scheme was made to drill a 30 m deep test well here to investigate the potential of shallow aquifers.

#### 4.3 Test Well Completion Report

This section provides a summary of test well completion reports submitted by the Contractors. Some photographs that show drilling work are also attached. Analysis of shallow well pumping tests is provided later in Section 4.4.

The summarized reports are being prepared separately based on test type in the following order.

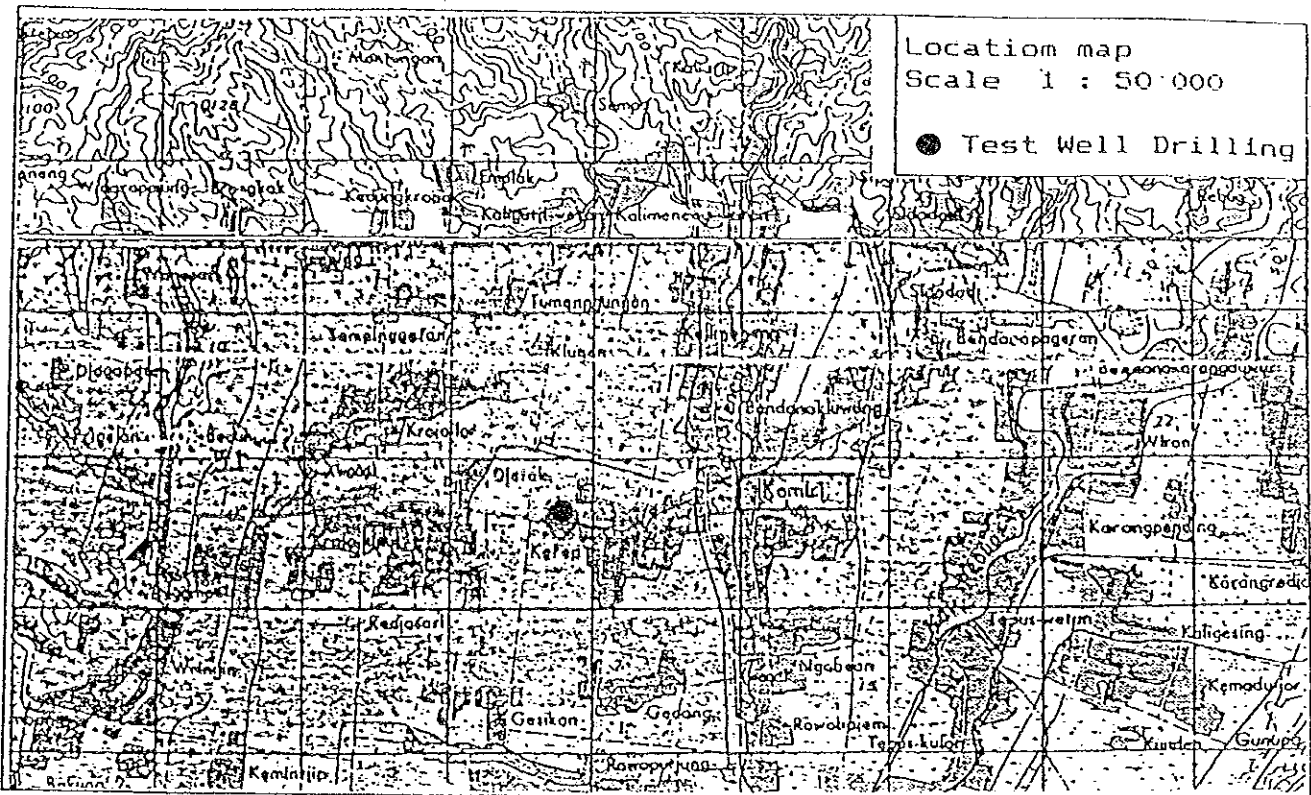
1. Initial Test Well (TW-1) in Kemiri
2. Additional Test Well (TW-2) in Kemiri
3. Initial Test Well in Jenar
4. Initial Test Well in Jepon
5. Additional Pumping Test of P2AT TW in Jepon
6. Additional Test Well in Batangan
7. Initial Test Well in Kembangbahu
8. Initial Test Well in Banyuanyar

Each summarized report consists of site plan, test results including comments and data analysis if any, borehole log, test well detail, and water quality analysis results.



4.3.1 Initial Test Well (TW-1) in Kemiri

TEST WELL COMPLETION REPORT  
KEMIRI - PURWOREJO KABUPATEN



TEST WELL RESULT

Estimated maximum dry season static water level : 1.50 m below ground level

Nominal maximum well capacity : 1.00 l/s at 25.00 m drawdown

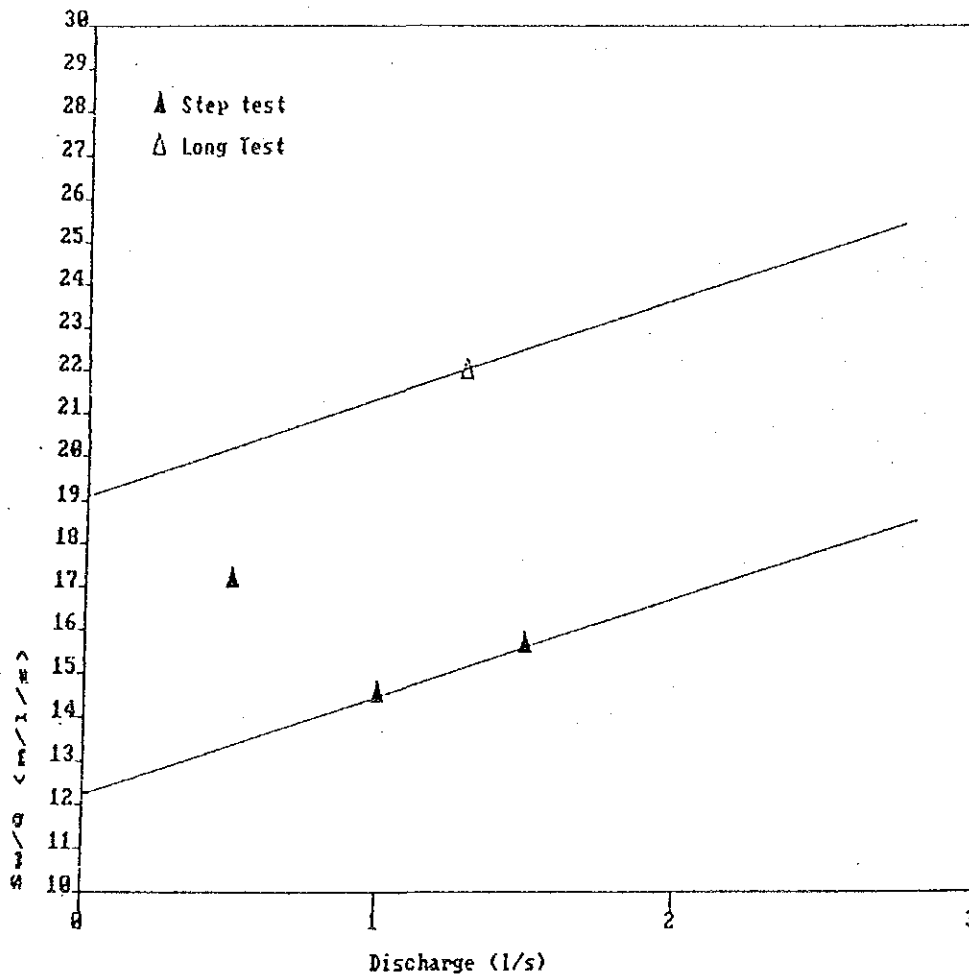
Pump requirements for well capacity :

|                       |   |    |       |
|-----------------------|---|----|-------|
| Flow                  | : | -- | l/s   |
| Drawdown              | : | -- | m     |
| Operating water level | : | -- | m bgl |

Remarks :

- Very poor aquifer limits yield to 1 l/s. not suitable for water supply system.
- Suggested to carry out additional test in the upper part aquifer or unconfined aquifer zone

### KEMIRI STEP TEST ANALYSIS



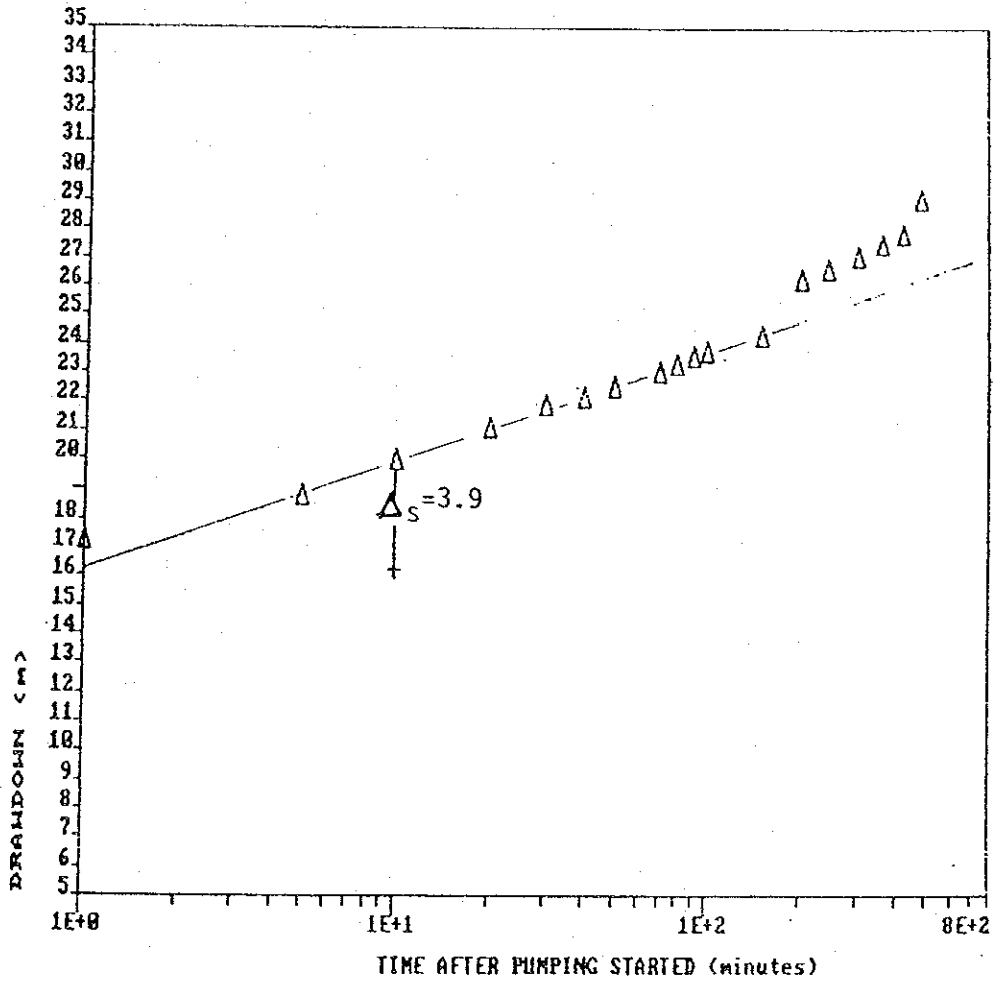
Aquifer loss coefficient  $B = 19.2 \text{ ms/l}$

Well loss coefficient  $C = 2.12 \text{ m}/(1/\text{s})^2$

$$kD \text{ (Logan's)} = \frac{105.4}{19.2} = 5.4 \text{ m}^2/\text{day}$$

Permeability through screen section  $k = 0.3 \text{ m/day}$

KEMIRI LONG PERIOD PUMPING TEST

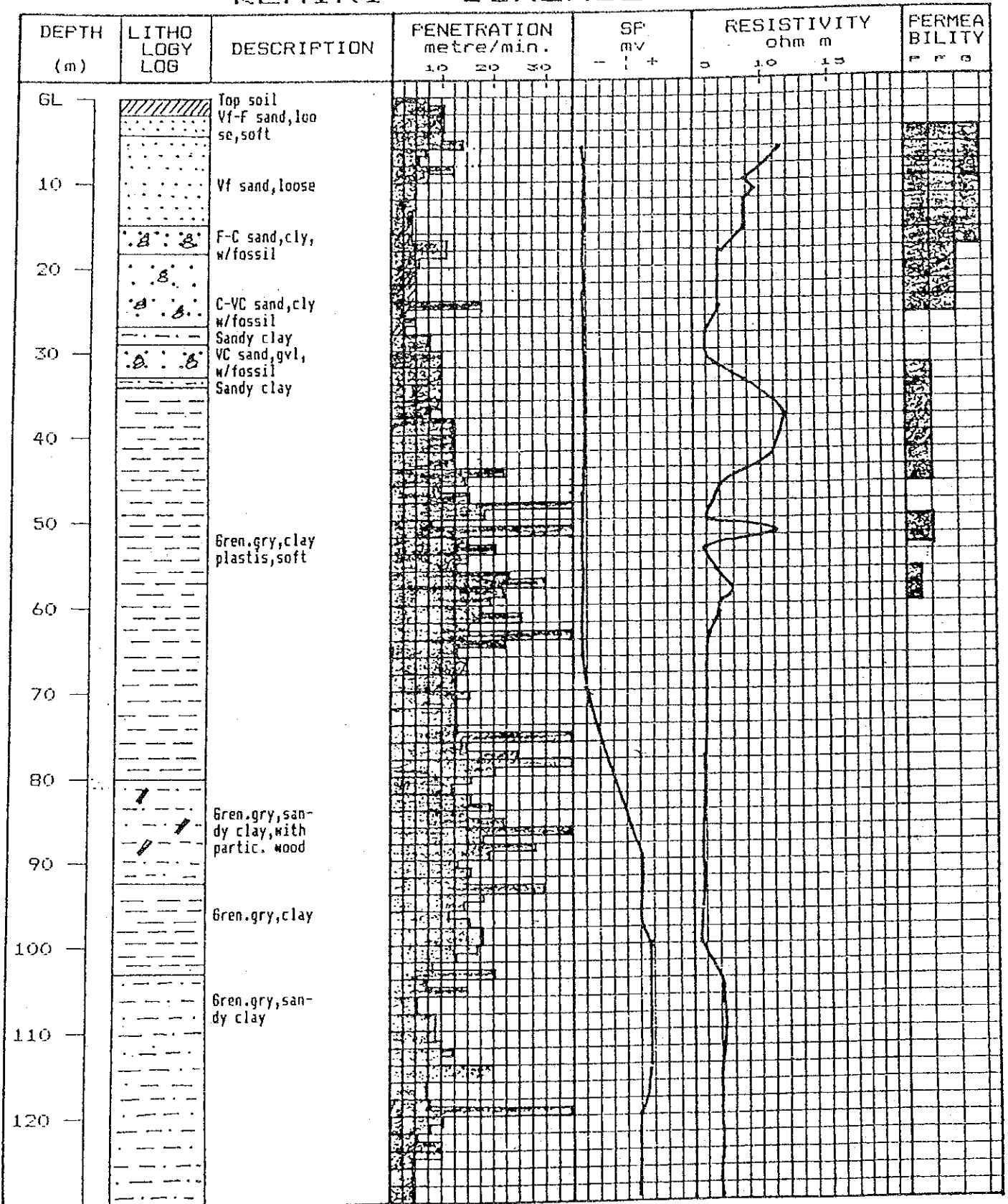


$$\Delta_s = 3.9$$

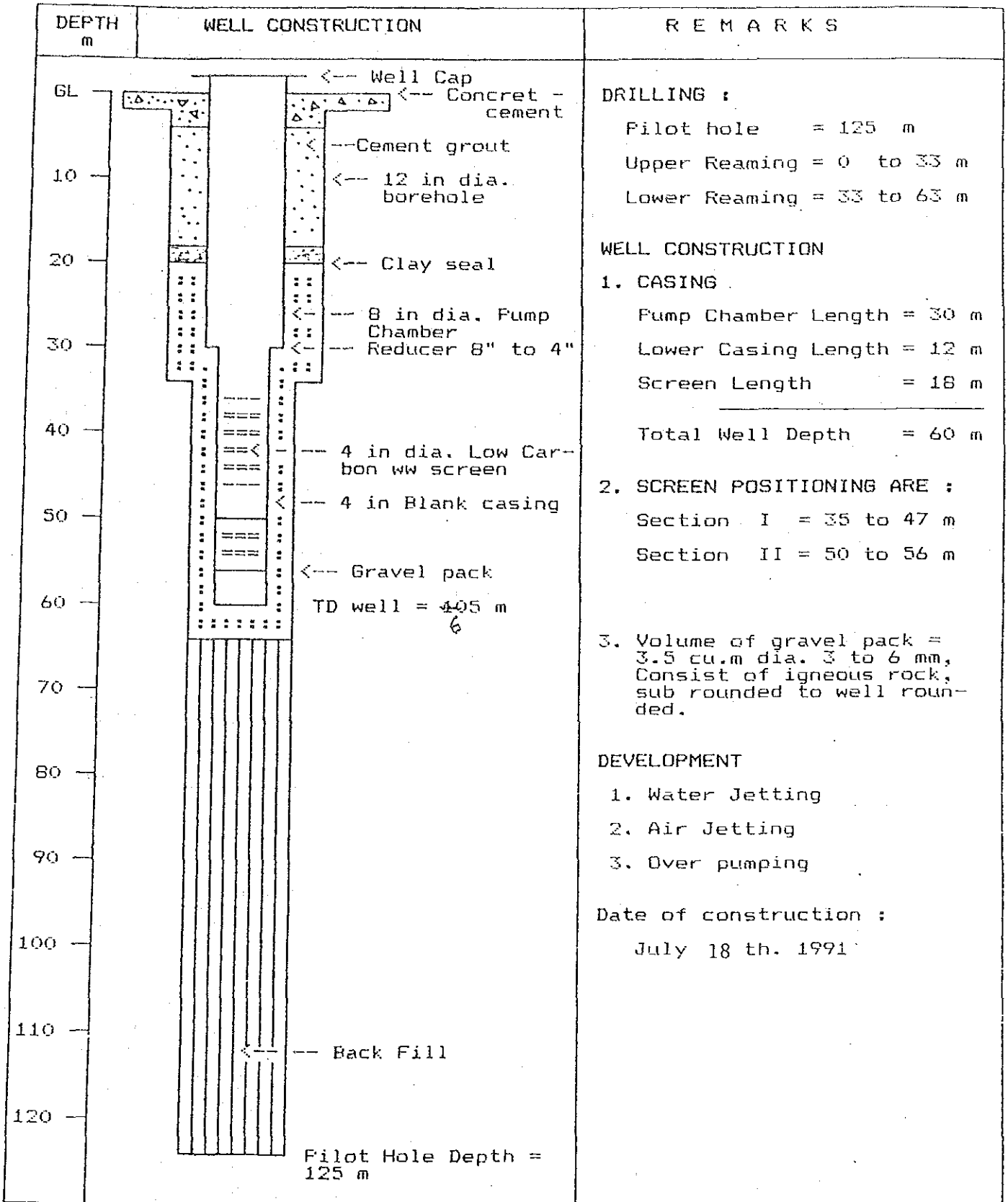
$$Q = 1.3 \text{ l/s}$$

$$kD \text{ (Jacobs)} = \frac{2.3 \times 86.4 \times 1.3}{4 \times 3.14 \times 3.9} = 5.27 \text{ m}^2/\text{day}$$

## KEMIRI - BOREHOLE LOG



## KEMIRI - TEST WELL CONSTRUCTION

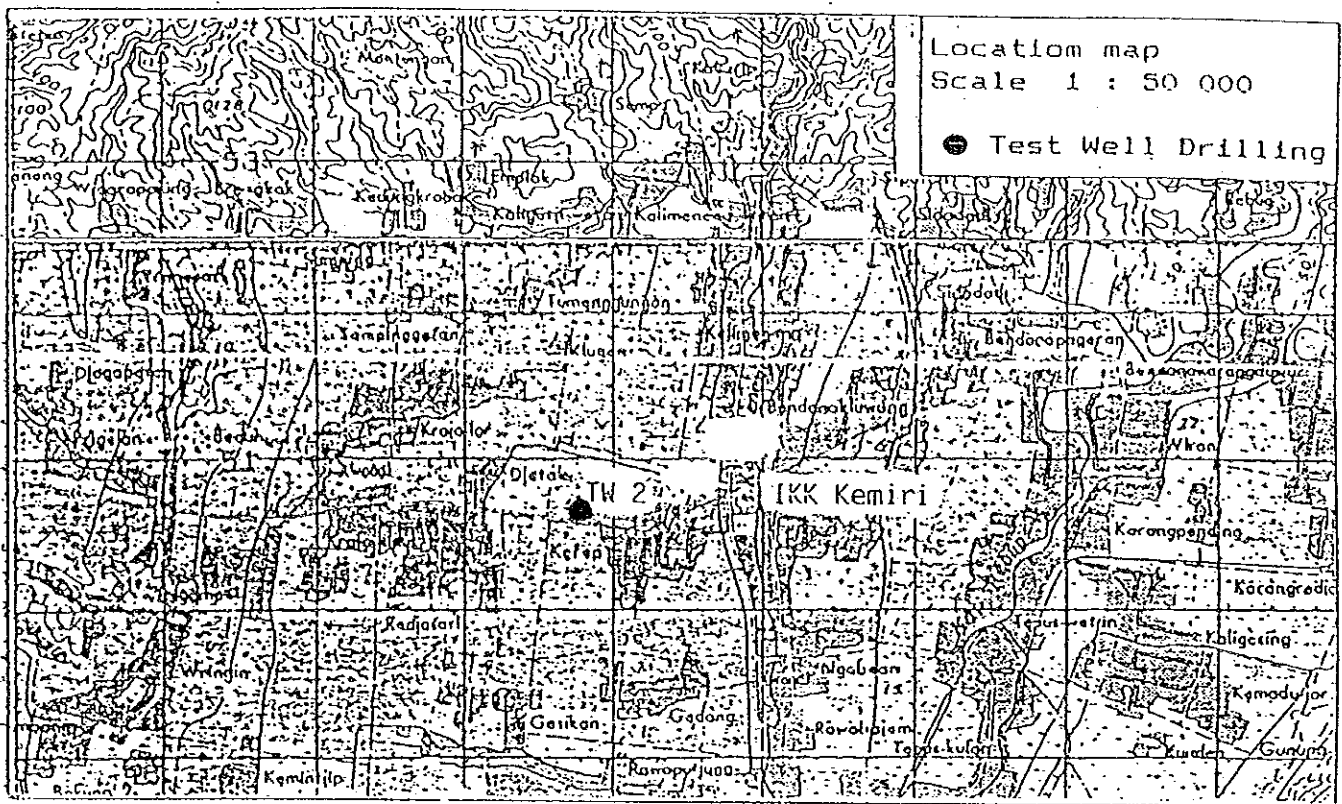


## KEMIRI WATER ANALYSIS RESULTS

| CHARACTERISTIC                             | UNIT | STANDARD                |           | SAMPLE FROM TEST WELL |
|--|------|-------------------------|-----------|-----------------------|
|  |      | WHO MAXIMUM PERMISSIBLE | INDONESIA |                       |
| <b>PHYSICAL</b>                            |      |                         |           |                       |
| 1. Colour                                  | Unit | 50                      | 50        | 2                     |
| 2. Taste                                   | "    | unobjectionable         | normal    | normal                |
| 3. Odour                                   | "    | unobjectionable         | normal    | normal                |
| 4. Turbidity as SiO <sub>2</sub>           | mg/l | 25                      | 25        | 3                     |
| <b>CHEMICAL</b>                            |      |                         |           |                       |
| 1. pH                                      | -    | 6.5 - 9.2               | 6.5-9.2   | 7.35                  |
| 2. Total Dissolved Solids                  | mg/l | 1500                    | 1500      | 183.9                 |
| 3. Permanganate value as KMnO <sub>4</sub> | "    | -                       | 10        | 3.92                  |
| 4. Carbon Dioxide as CO <sub>2</sub>       | "    | -                       | 0.0       | -                     |
| 5. Total Hardness as CaCO <sub>3</sub>     | "    | 500                     | 500       | 66.64                 |
| 6. Calcium Ca                              | "    | 200                     | 200       | 14.99                 |
| 7. Magnesium Mg                            | "    | 150                     | 120       | 7.07                  |
| 8. Iron/Total Fe                           | "    | 1.0                     | 1.0       | 0.20                  |
| 9. Manganese Mn                            | "    | 0.5                     | 0.5       | 0.24                  |
| 10. Copper Cu                              | "    | 1.5                     | 1.0       | not detected          |
| 11. Zinc Zn                                | "    | 15                      | 15        | not detected          |
| 12. Chloride Cl                            | "    | 600                     | 600       | 133.93                |
| 13. Sulphate SO <sub>4</sub>               | "    | 400                     | 400       | not detected          |
| 14. Sulphide H <sub>2</sub> S              | "    | -                       | 0.0       | -                     |
| 15. Fluoride F                             | "    | -                       | 1.5       | 0.50                  |
| 16. Ammonia NH <sub>4</sub>                | "    | -                       | 0.0       | -                     |
| 17. Nitrate NO <sub>3</sub>                | "    | -                       | 10        | not detected          |
| 18. Nitrite NO <sub>2</sub>                | "    | -                       | 0.0       | not detected          |
| 19. Phenol Phenol                          | "    | 0.002                   | 0.002     | -                     |
| 20. Arsenic As                             | "    | 0.05                    | 0.05      | not detected          |
| 21. Lead Pb                                | "    | 0.10                    | 0.05      | not detected          |
| 22. Selenium Se                            | "    | 0.01                    | 0.01      | not detected          |
| 23. Chromium Cr                            | "    | -                       | 0.05      | -                     |
| 24. Cyanide Cn                             | "    | -                       | 0.10      | not detected          |
| 25. Cadmium Cd                             | "    | -                       | 0.005     | not detected          |
| 26. Mercury Hg                             | "    | -                       | 0.001     | not detected          |

4.3.2 Additional Test Well (TW-2) in Kemiri

TEST WELL COMPLETION REPORT  
KEMIRI - PURWOREJO KABUPATEN



TEST WELL RESULT

Estimated maximum dry season static water level : 2.0 m below ground level

Nominal maximum well capacity : 2.0 l/s at m drawdown

Pump requirements for well capacity :  
 Flow : 2.0 l/s  
 Drawdown : 10 m  
 Operating water level : 12 m bgl

Remarks :

- Well is enough for Desa (Village) water supply system
- For IKK should be constructed new production well as following recommendation, based on Test Well Drilling results.

e. Conclusion

Based on pumping test analysis results, Kecamatan Kemiri (IKK Kemiri) can be developed for water supply system with source of water from shallow well.

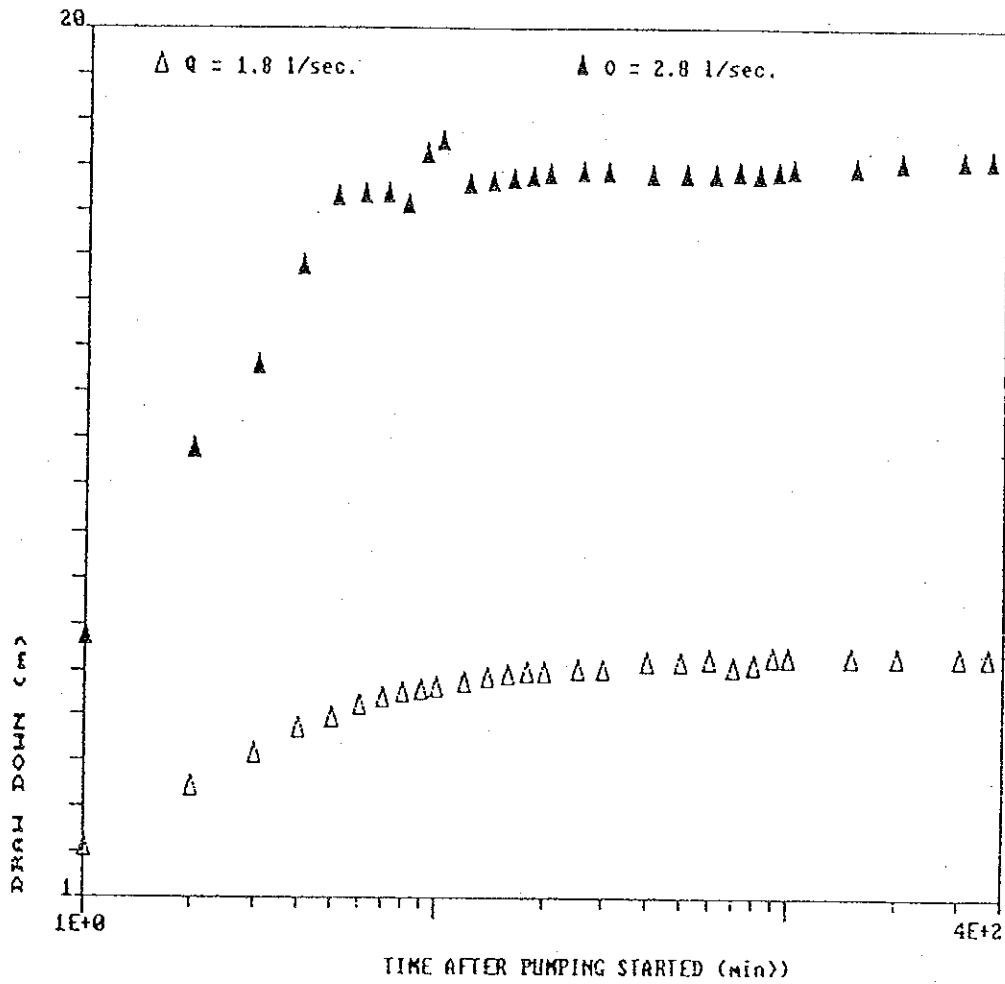
Recommendation for new well capacity is about 5 to 10 l/sec each well, distance between well should be reanalyzed after first production well completed. The suggestion for production well design is given as follows:

- Depth : 60 m based on Kemiri 1 dan Kemiri 2
- Screen length : 9 m wire wound screen #30 and #40 dia. 8 inch.  
12 m wire sound screen #40 dia. 4 inch.

- 1/. Fig. 1 Test well results, we should like added in the section of remarks another comment are : Water Treatment Plan is Required for reduce of Iron and Management contents.



KENIRI 2 PUMPING TEST



FOR 1.8 l/sec.:

$$\Delta s = 0.6 \text{ circle log meter}$$

$$\text{Jacob } kD = \frac{2.3 \times 1.8 \times 86.4}{4 \times 3.14 \times 0.6} = 47.46 \text{ m}^2/\text{day}$$

$$k \text{ through selotted section} = 4.75 \text{ m/day}$$

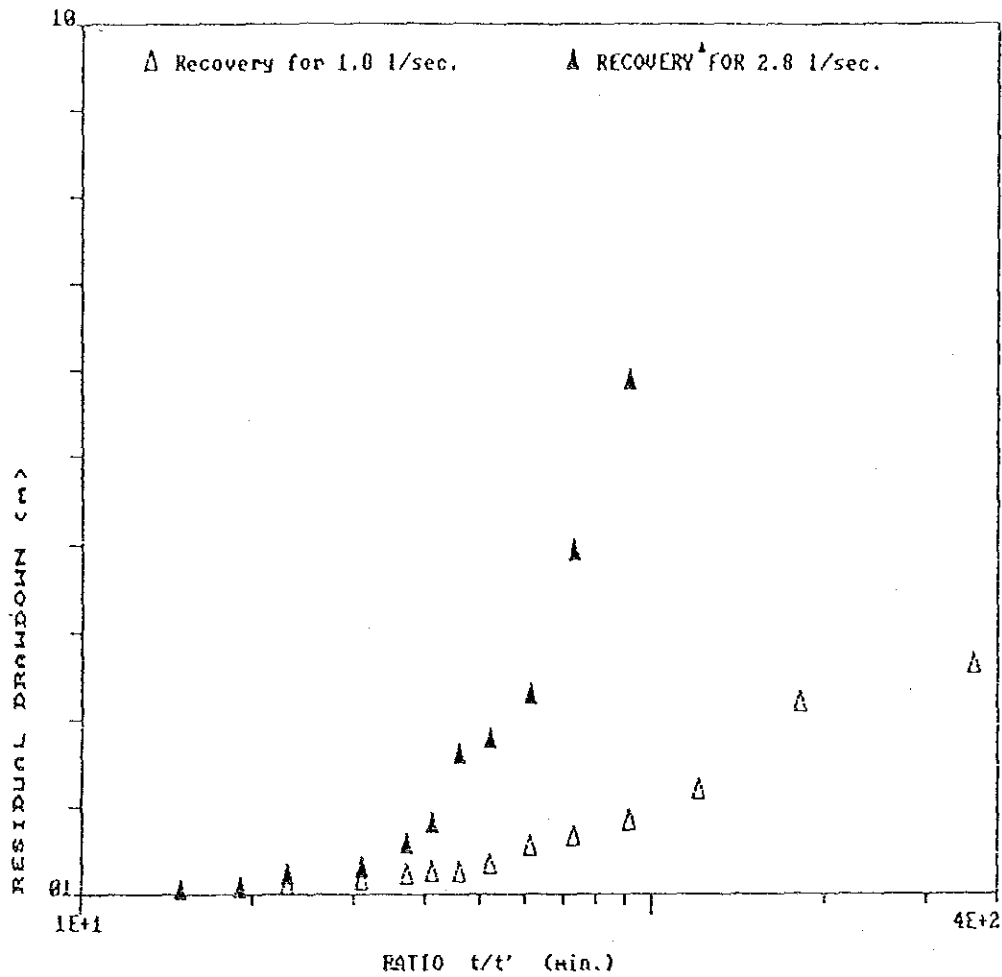
FOR 2.8 l/sec. :

$$\Delta s = 0.8 \text{ circle log meter}$$

$$\text{Jacob } kD = \frac{2.3 \times 2.8 \times 86.4}{4 \times 3.14 \times 0.8} = 53.37 \text{ m}^2/\text{day}$$

$$k \text{ through slotted section} = 5.3 \text{ m/day}$$

KEMIRI 2 RECOVERY ANALYSIS



FOR  $Q = 1.8$  l/sec. :

$$\Delta_s = 0.42$$

$$\text{Jacob } kD = \frac{2.3 \times 1.8 \times 86.4}{4 \times 3.14 \times 0.42} = 67.80 \text{ m}^2/\text{day}$$

$k$  through slotted section = 6.78 m/day

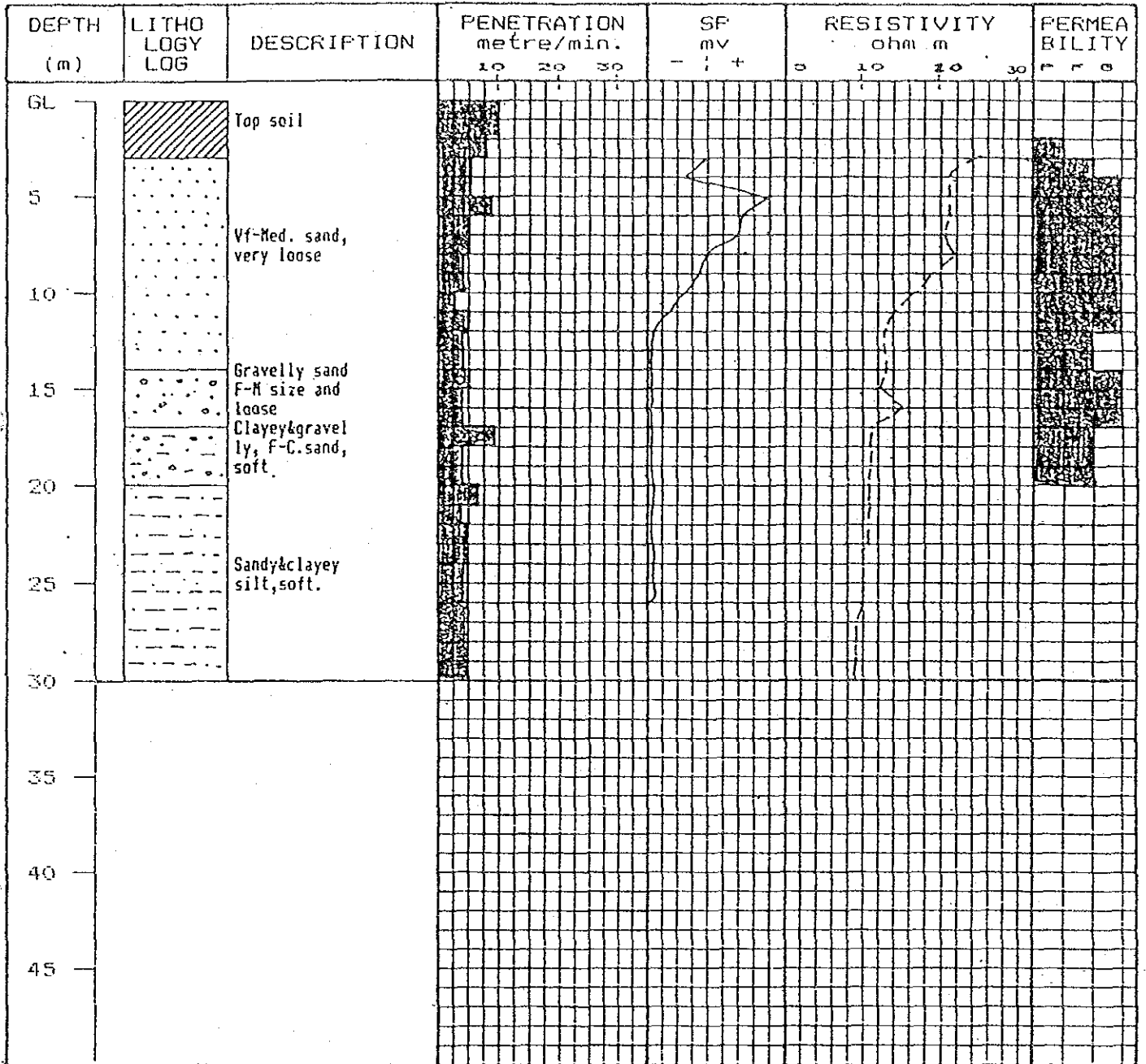
FOR  $Q = 2.8$  l/sec.:

$$\Delta_s = 0.83$$

$$\text{Jacob } kD = \frac{2.3 \times 2.8 \times 86.4}{4 \times 3.14 \times 0.83} = 53.37 \text{ m}^2/\text{day}$$

$k$  through selotted section = 5.4 m/day

## KEMIRI 2 — BOREHOLE LOG



## KEMIRI 2 - TEST WELL CONSTRUCTION

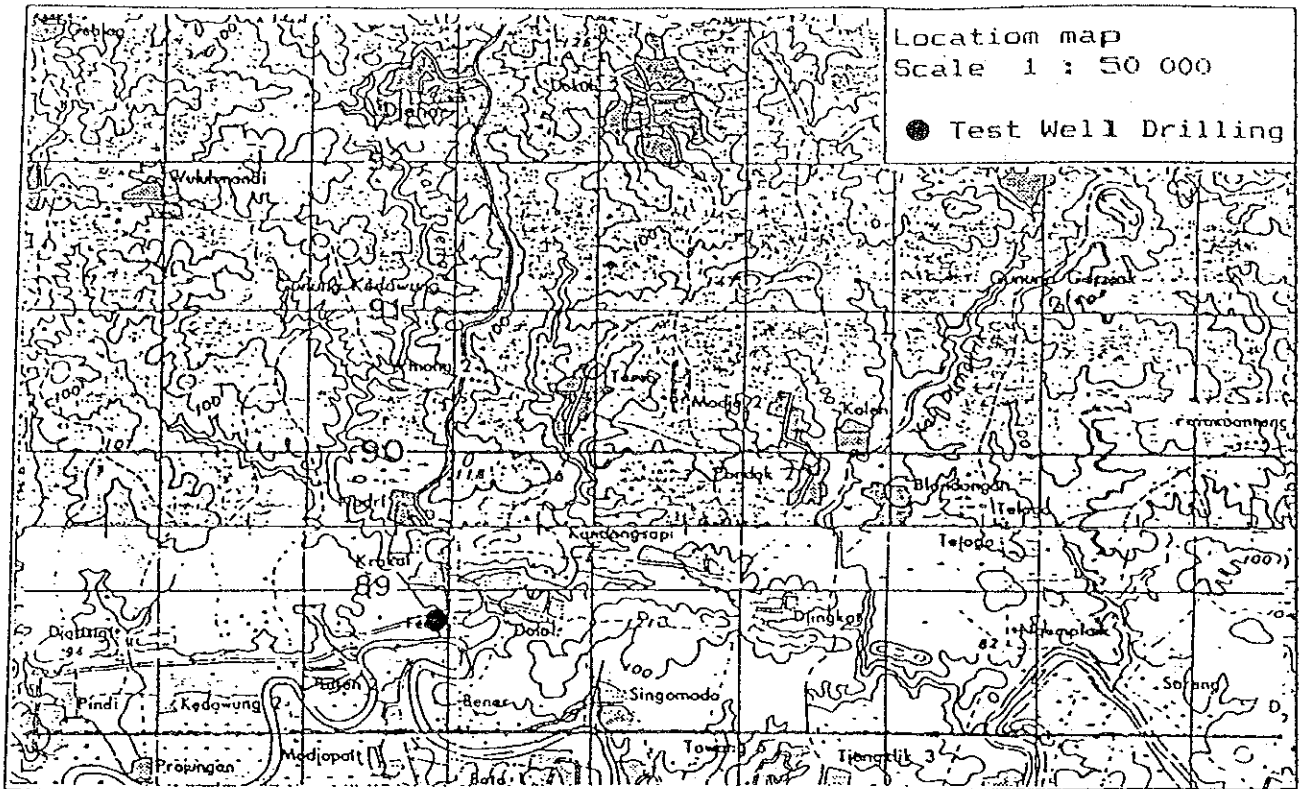
| DEPTH<br>m  | WELL CONSTRUCTION   | REMARKS  |
|---|---|--|
| GL<br>5<br>10<br>15<br>20<br>25<br>30<br>35<br>40<br>45<br>50<br>55<br>60 | <p style="text-align: right;">             &lt;-- Well Cap<br/>             &lt;-- Apron<br/>             &lt;-- C.Casing 14 in<br/>             &lt;-- Cement grout<br/>             &lt;-- Clay seal<br/>             &lt;-- PVC Pipe 6 inch dia.<br/>             &lt;-- 6 in dia. PVC Slotted pipe, 4.2 % opening area<br/>             &lt;-- 12 in dia. Bore hole.<br/>             &lt;-- Td = 24 m<br/>             &lt;-- Td = 30 m           </p> | <p><b>DRILLING :</b></p> <p>Borehole 14 in = 3 m<br/>           borehole 12 in = 3 to 30 m</p> <p><b>WELL CONSTRUCTION</b></p> <p><b>1. CASING</b></p> <p>PVC Pipe 6 inch dia. = 10 m<br/>           Slotted PVC Pipe 6in = 10 m<br/>           Bottom plug = 4 m</p> <p style="text-align: right;">Total Well Depth = 24 m</p> <p><b>2. SCREEN POSITIONING ARE :</b></p> <p>Section I = 10 to 20 m</p> <p><b>3. Volume of gravel pack =</b><br/>           2.0 cu.m dia. 3 to 6 mm,<br/>           Consist of igneous rock,<br/>           sub rounded to well rounded.</p> <p><b>DEVELOPMENT</b></p> <p>1. Water Jetting<br/>           2. Air Jetting</p> <p><b>Date of construction :</b><br/>           August 24th. 1991</p> |

## KEMIRI 2 WATER ANALYSIS RESULTS

| CHARACTERISTIC                             | UNIT | STANDARD                |           | SAMPLE FROM TEST WELL |
|--|------|-------------------------|-----------|-----------------------|
|  |      | WHO MAXIMUM PERMISSIBLE | INDONESIA |                       |
| <b>PHYSICAL</b>                            |      |                         |           |                       |
| 1. Colour                                  | Unit | 50                      | 50        | 12                    |
| 2. Taste                                   | "    | unobjectionable         | normal    | normal                |
| 3. Odour                                   | "    | unobjectionable         | normal    | normal                |
| 4. Turbidity as SiO <sub>2</sub>           | mg/l | 25                      | 25        | 10                    |
| <b>CHEMICAL</b>                            |      |                         |           |                       |
| 1. pH                                      | -    | 6.5 - 9.2               | 6.5-9.2   | 6.81                  |
| 2. Total Dissolved Solids                  | mg/l | 1500                    | 1500      | 200.5                 |
| 3. Permanganate value as KMnO <sub>4</sub> | "    | -                       | 10        | 3.67                  |
| 4. Carbon Dioxide as CO <sub>2</sub>       | "    | -                       | 0.0       | -                     |
| 5. Total Hardness as CaCO <sub>3</sub>     | "    | 500                     | 500       | 140.4                 |
| 6. Calcium Ca                              | "    | 200                     | 200       | -                     |
| 7. Magnesium Mg                            | "    | 150                     | 120       | -                     |
| 8. Iron/Total Fe                           | "    | 1.0                     | 1.0       | 3.5                   |
| 9. Manganese Mn                            | "    | 0.5                     | 0.5       | 0.61                  |
| 10. Copper Cu                              | "    | 1.5                     | 1.0       | not detected          |
| 11. Zinc Zn                                | "    | 15                      | 15        | not detected          |
| 12. Chloride Cl                            | "    | 500                     | 500       | 49.53                 |
| 13. Sulphate SO <sub>4</sub>               | "    | 400                     | 400       | not detected          |
| 14. Sulphide H <sub>2</sub> S              | "    | -                       | 0.0       | -                     |
| 15. Fluoride F                             | "    | -                       | 1.5       | 0                     |
| 16. Ammonia NH <sub>4</sub>                | "    | -                       | 0.0       | -                     |
| 17. Nitrate NO <sub>3</sub>                | "    | -                       | 10        | not detected          |
| 18. Nitrite NO <sub>2</sub>                | "    | -                       | 0.0       | not detected          |
| 19. Phenol Phenol                          | "    | 0.002                   | 0.002     | -                     |
| 20. Arsenic As                             | "    | 0.05                    | 0.05      | not detected          |
| 21. Lead Pb                                | "    | 0.10                    | 0.05      | not detected          |
| 22. Selenium Se                            | "    | 0.01                    | 0.01      | not detected          |
| 23. Chromium Cr                            | "    | -                       | 0.05      | -                     |
| 24. Cyanide Cn                             | "    | -                       | 0.10      | not detected          |
| 25. Cadmium Cd                             | "    | -                       | 0.005     | not detected          |
| 26. Mercury Hg                             | "    | -                       | 0.001     | not detected          |

4.3.3 Initial Test Well in Jenar

TEST WELL COMPLETION REPORT  
JENAR - SRAGEN KABUPATEN



TEST WELL RESULT

Estimated maximum dry season static water level : 12 m below ground level

Nominal maximum well capacity : 2.00 l/s at 30 m drawdown

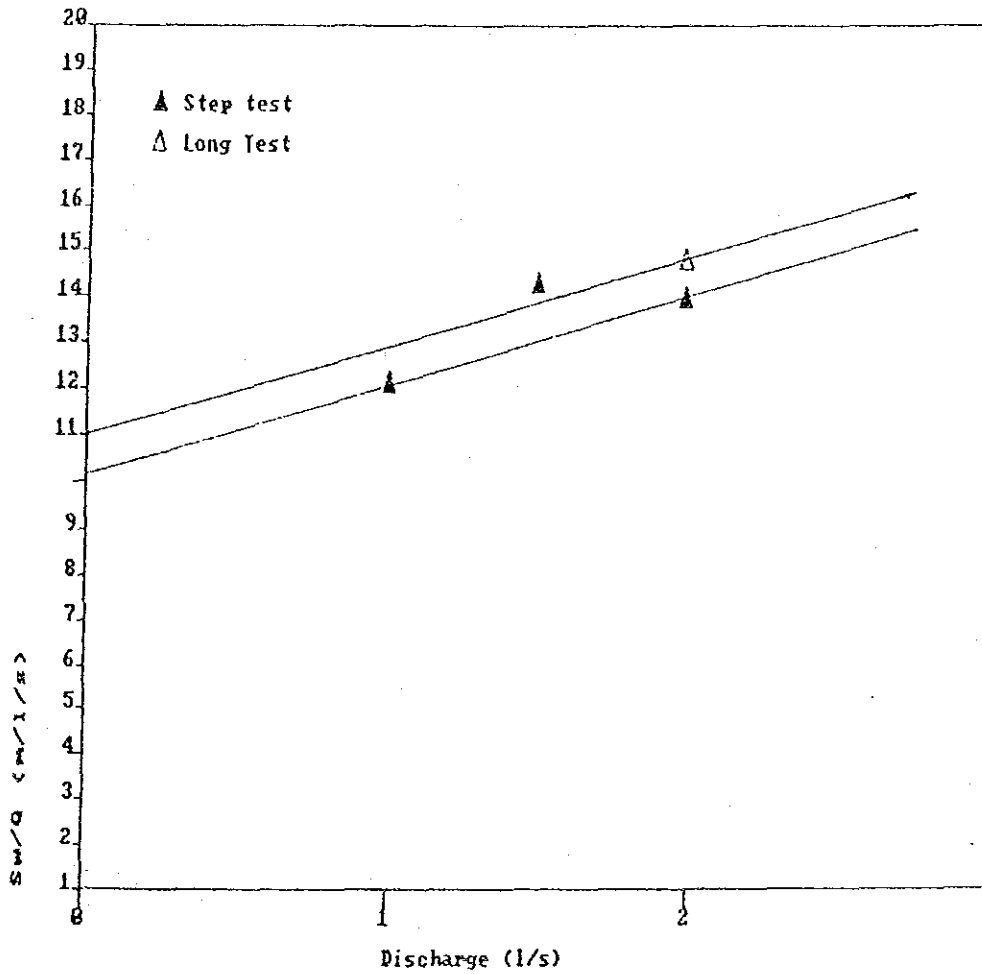
Pump requirements for well capacity :

|                       |   |     |       |
|-----------------------|---|-----|-------|
| Flow                  | : | --- | l/s   |
| Drawdown              | : | --- | m     |
| Operating water level | : | --- | m bgl |

Remarks :

- Poor aquifer limits yield to 2 l/s. not suitable for water supply system.
- Suggested to make new well with extended pump chamber length to 76 m.

JENAR STEP TEST ANALYSIS



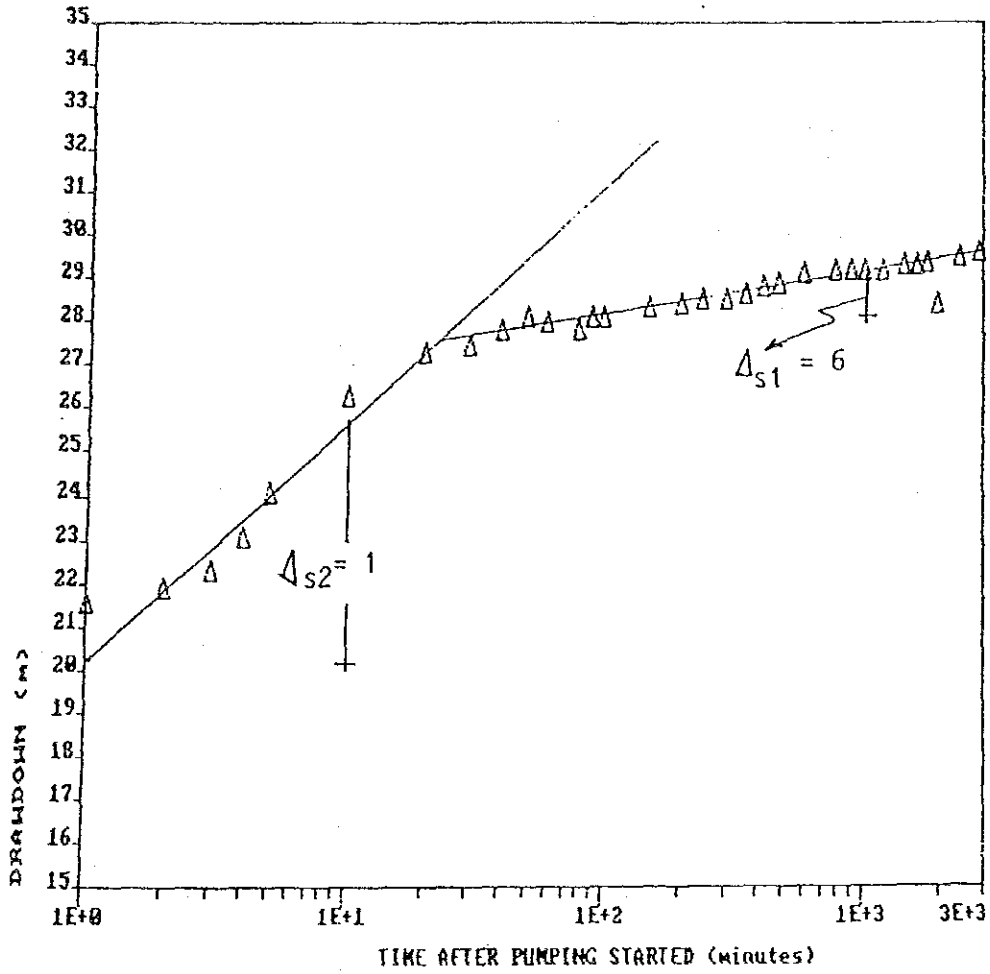
Aquifer loss coefficient  $B = 11 \text{ ms/l}$

Well loss coefficient  $C = 29.46 \text{ m}/(1/\text{s})^2$

$$kD \text{ (Logan's)} = \frac{105.4}{29.46} = 9.58 \text{ m}^2/\text{day}$$

Permeability through screen section  $k = 0.53 \text{ m/day}$

JENAR LONG PERIOD PUMPING TEST



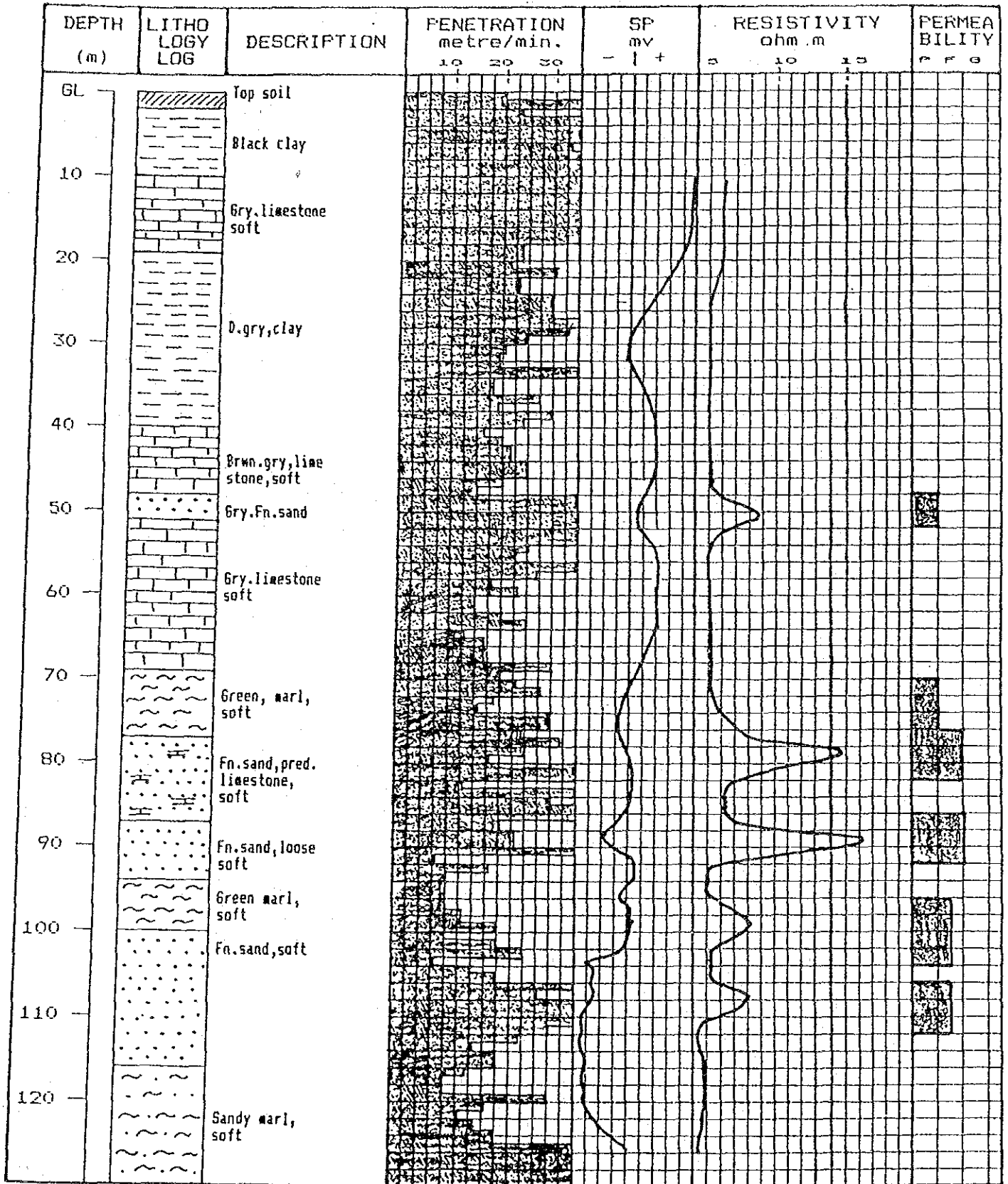
Averaged  $\Delta s = 3.5$

Discharge  $Q = 2 \text{ l/s}$

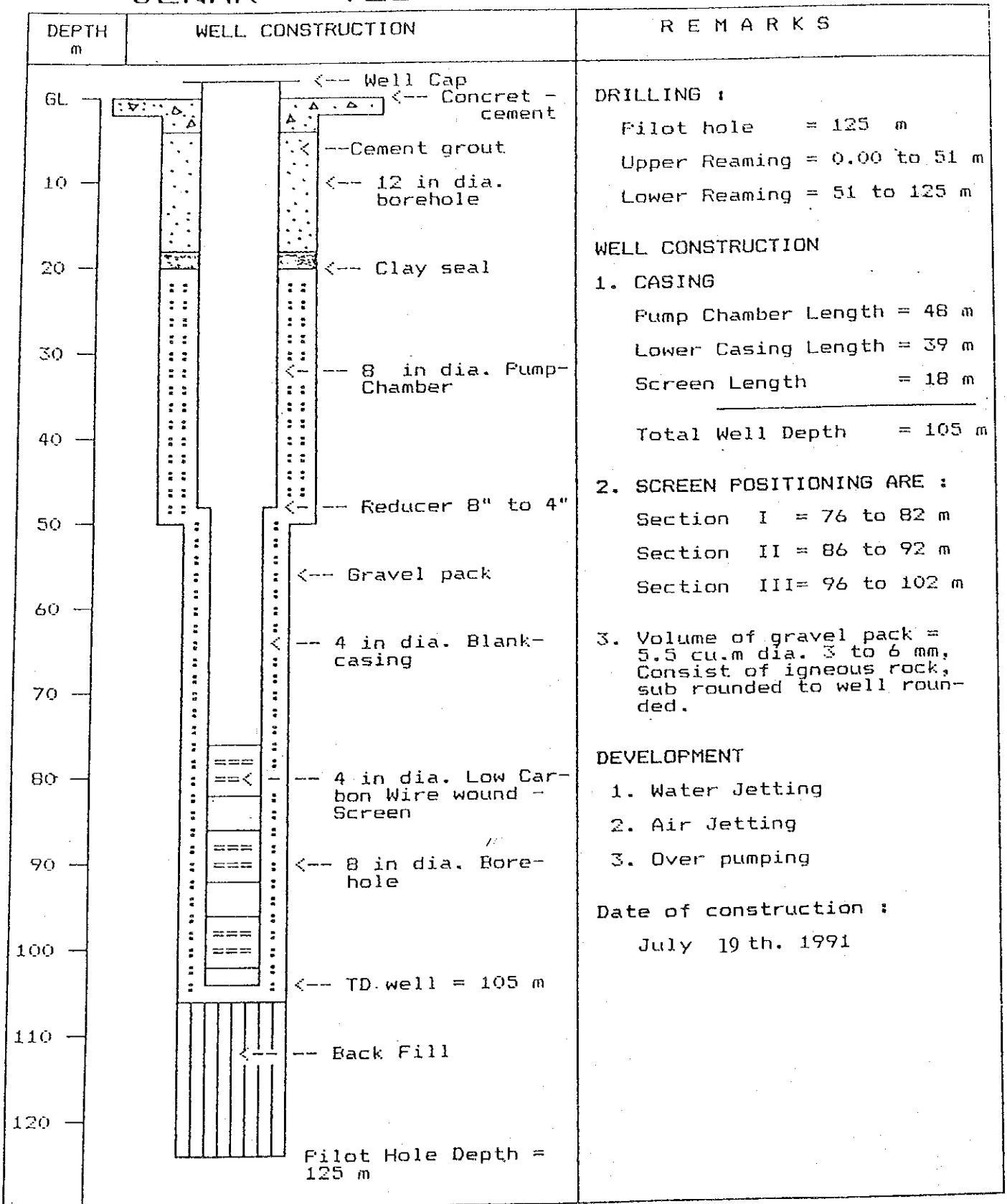
$$kD \text{ (Jacob)} = \frac{2.3 \times 86.4 \times 2}{4 \times 3.14 \times 3.5} \approx 9 \text{ m}^2/\text{day}$$



## JENAR - BOREHOLE LOG



## JENAR - TEST WELL CONSTRUCTION

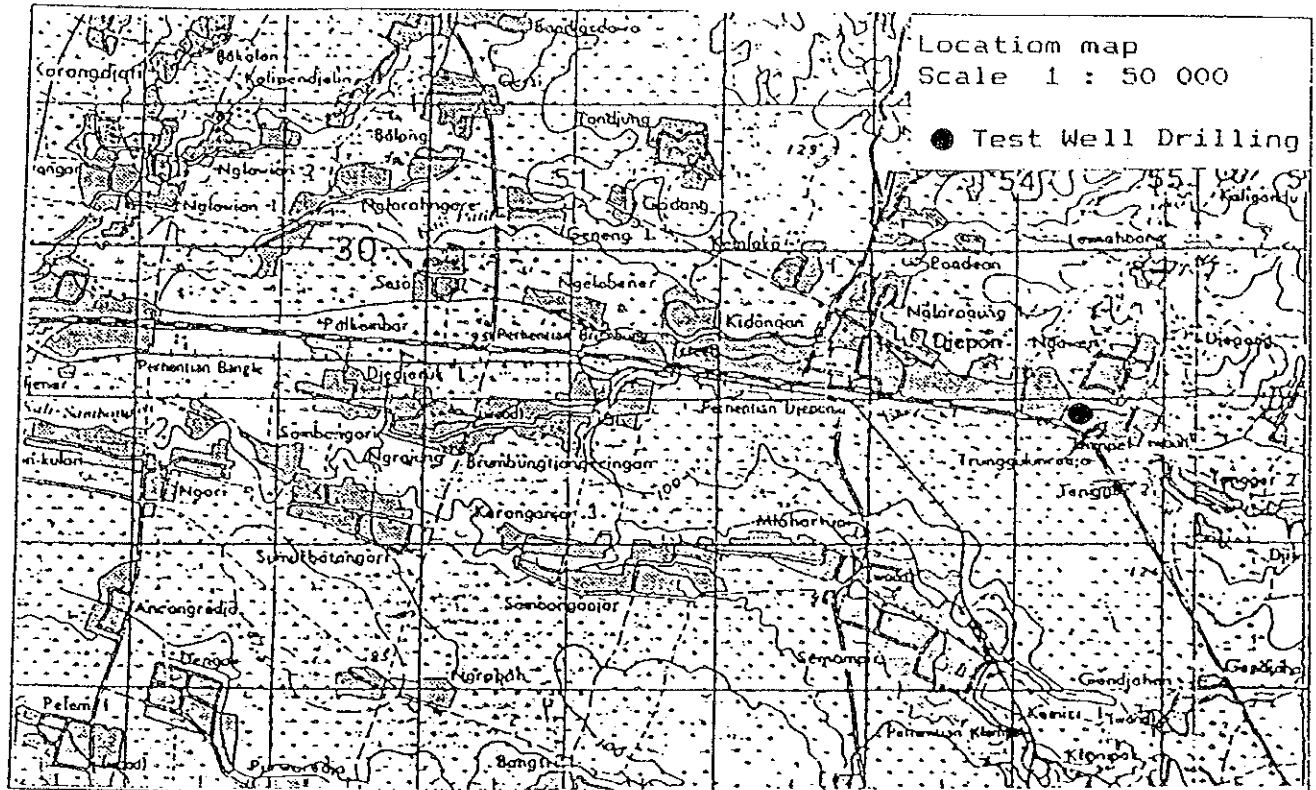


## JENAR WATER ANALYSIS RESULTS

| CHARACTERISTIC                             | UNIT | STANDARD                |           | SAMPLE FROM TEST WELL |
|--|------|-------------------------|-----------|-----------------------|
|  |      | WHO MAXIMUM PERMISSIBLE | INDONESIA |                       |
| <b>PHYSICAL</b>                            |      |                         |           |                       |
| 1. Colour                                  | Unit | 50                      | 50        | 2                     |
| 2. Taste                                   | "    | unobjectionable         | normal    | normal                |
| 3. Odour                                   | "    | unobjectionable         | normal    | normal                |
| 4. Turbidity as SiO <sub>2</sub>           | mg/l | 25                      | 25        | 3                     |
| <b>CHEMICAL</b>                            |      |                         |           |                       |
| 1. pH                                      | -    | 6.5 - 9.2               | 6.5-9.2   | 7.72                  |
| 2. Total Dissolved Solids                  | mg/l | 1500                    | 1500      | 560                   |
| 3. Fermanganate value as KMnO <sub>4</sub> | "    | -                       | 10        | 6.70                  |
| 4. Carbon Dioxide as CO <sub>2</sub>       | "    | -                       | 0.0       | -                     |
| 5. Total Hardness as CaCo <sub>3</sub>     | "    | 500                     | 500       | 109.48                |
| 6. Calcium Ca                              | "    | 200                     | 200       | 24.99                 |
| 7. Magnesium Mg                            | "    | 150                     | 120       | 11.28                 |
| 8. Iron/Total Fe                           | "    | 1.0                     | 1.0       | 0.01                  |
| 9. Manganese Mn                            | "    | 0.5                     | 0.5       | not detected          |
| 10. Copper Cu                              | "    | 1.5                     | 1.0       | not detected          |
| 11. Zinc Zn                                | "    | 15                      | 15        | not detected          |
| 12. Chloride Cl                            | "    | 600                     | 600       | 133.93                |
| 13. Sulphate SO <sub>4</sub>               | "    | 400                     | 400       | not detected          |
| 14. Sulphide H <sub>2</sub> S              | "    | -                       | 0.0       | -                     |
| 15. Fluoride F                             | "    | -                       | 1.5       | not detected          |
| 16. Ammonia NH <sub>4</sub>                | "    | -                       | 0.0       | -                     |
| 17. Nitrate NO <sub>3</sub>                | "    | -                       | 10        | not detected          |
| 18. Nitrite NO <sub>2</sub>                | "    | -                       | 0.0       | not detected          |
| 19. Phenol Phenol                          | "    | 0.002                   | 0.002     | -                     |
| 20. Arsenic As                             | "    | 0.05                    | 0.05      | not detected          |
| 21. Lead Pb                                | "    | 0.10                    | 0.05      | not detected          |
| 22. Selenium Se                            | "    | 0.01                    | 0.01      | not detected          |
| 23. Chromium Cr                            | "    | -                       | 0.05      | -                     |
| 24. Cyanide Cn                             | "    | -                       | 0.10      | not detected          |
| 25. Cadmium Cd                             | "    | -                       | 0.005     | not detected          |
| 26. Mercury Hg                             | "    | -                       | 0.001     | not detected          |

4.3.4 Initial Test Well in Jepon

TEST WELL COMPLETION REPORT  
JEPON - BLORA KABUPATEN



TEST WELL RESULT

Estimated maximum dry season  
static water level : -- m below ground level

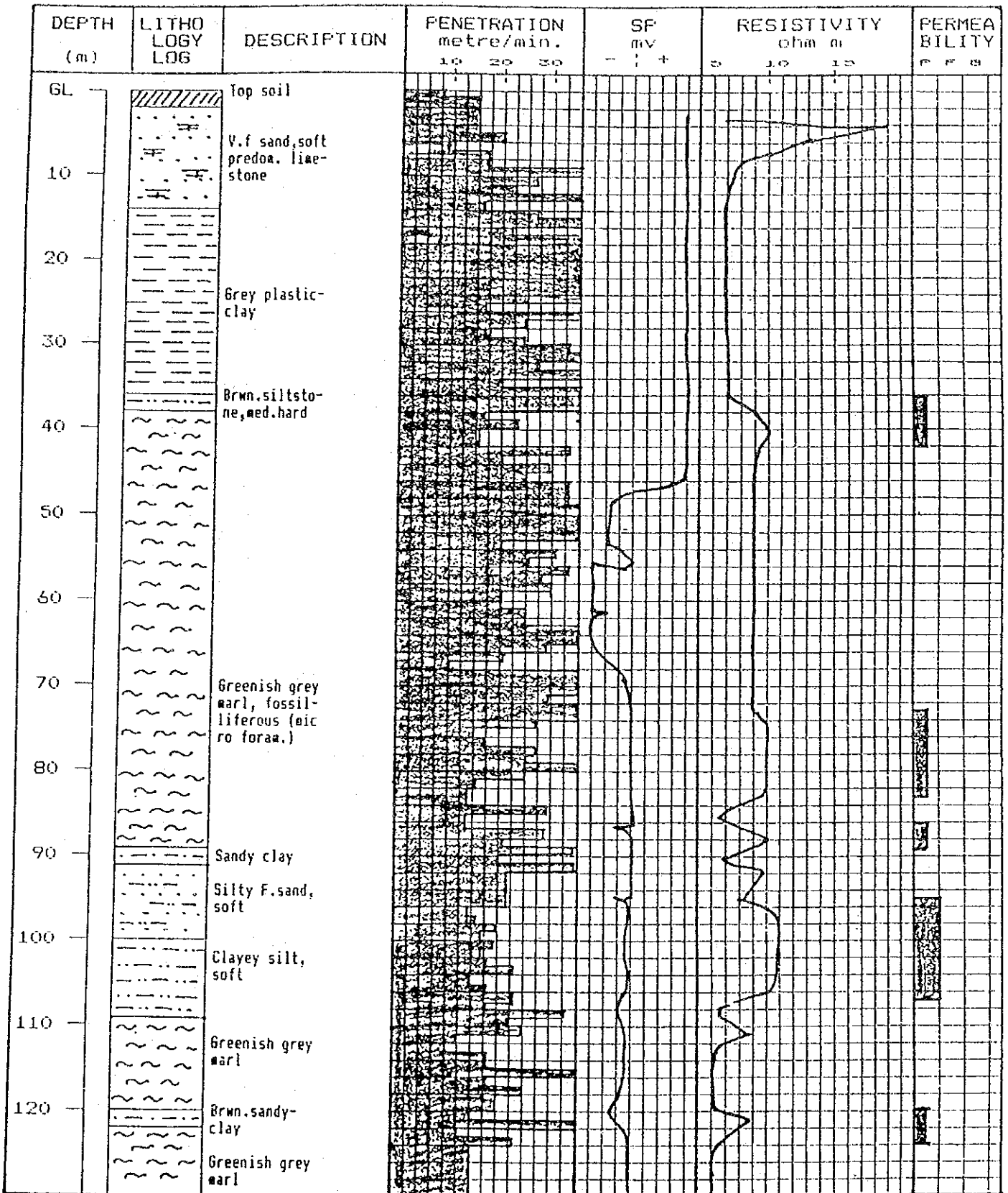
Nominal maximum well capacity : -- l/s at  
-- m drawdown

Pump requirements for well  
capacity : Flow : -- l/s  
Drawdown : -- m  
Operating  
water level : -- m bgl

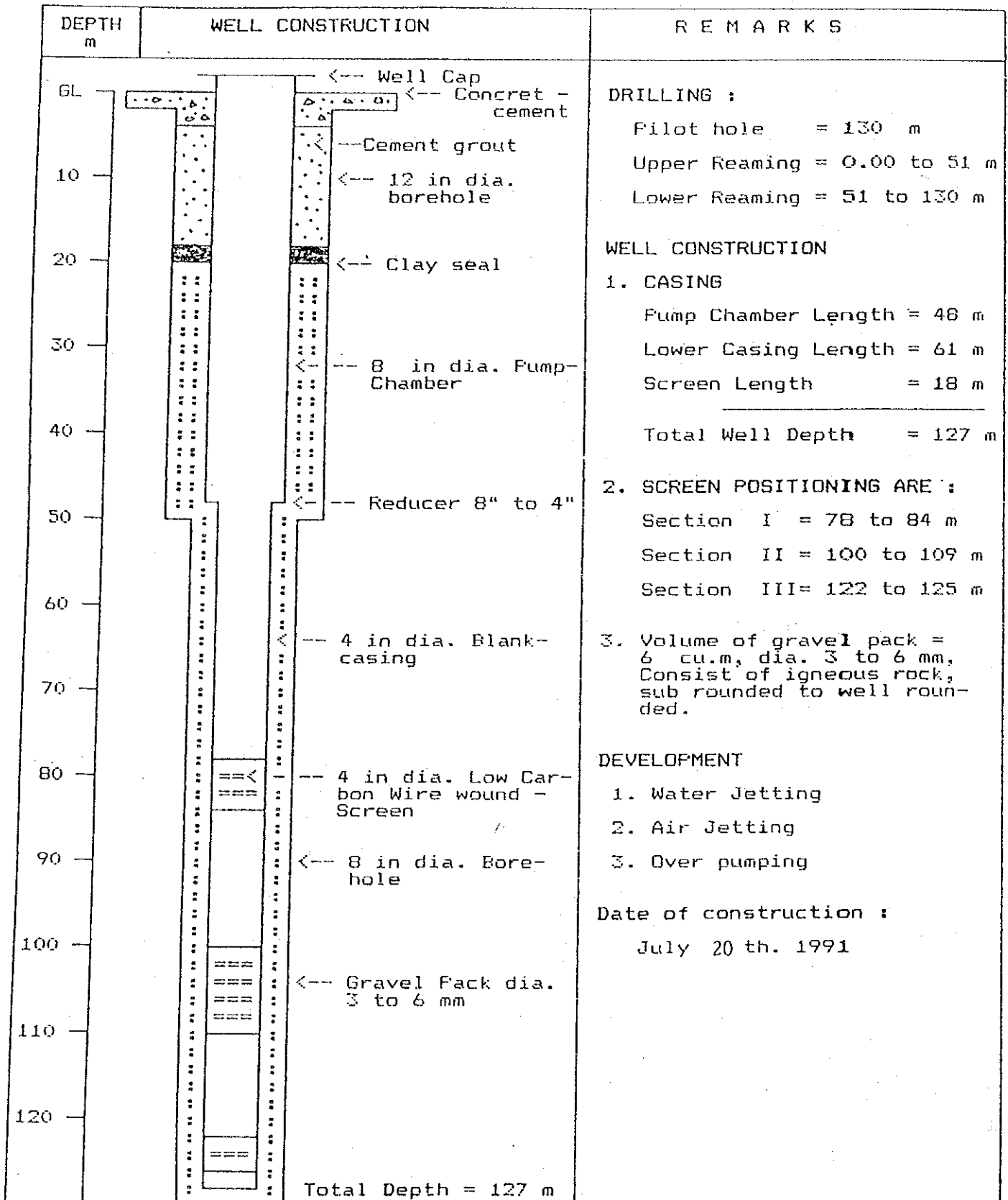
Remarks :

WELL IS DRY

## JEFON - BOREHOLE LOG



## JEPON - TEST WELL CONSTRUCTION



#### 4.3.5 Additional Pumping Test of P2AT TW in Jepon

|   |
|---|
| <p style="text-align: center;">PUMPING TEST REPORT</p> <p style="text-align: center;">ADDITIONAL PUMPING TEST OF P2AT TW</p> <p style="text-align: center;">AT DESA SOKO</p> <p style="text-align: center;">JEPON - BLORA KABUPATEN</p> |
|---|

#### I. Introduction

The objective of this project is a presentation of the pumping test in the existing well to establish a possible source for water supply system.

The existing well is located about 9 km northern of IKK Jepon, and the well is lied on the limestone formation of the Rembang zone.

No data of geological borehole log and well design are available. However well depth observed was 125 m, 10 in. dia. of surface casing an 8 in. dia. of fiber pipe with top 0.5 m below top surface casing.

## II. Aquifer Test

### (a) Step Drawdown Test

Step drawdown test was conducted on 29 November 1991. The test consist of 4 steps, each step of 120 minutes duration. Specific capacity results are:

| <u>Step</u> | <u>Q (l/s)</u> | <u>Sp. Cp (l/s/m)</u> |
|-------------|----------------|-----------------------|
| I           | 2.001          | 0.230                 |
| II          | 2.014          | 0.225                 |
| III         | 4.073          | 0.259                 |
| IV          | 5.205          | 0.296                 |

### (b) Long Period Test

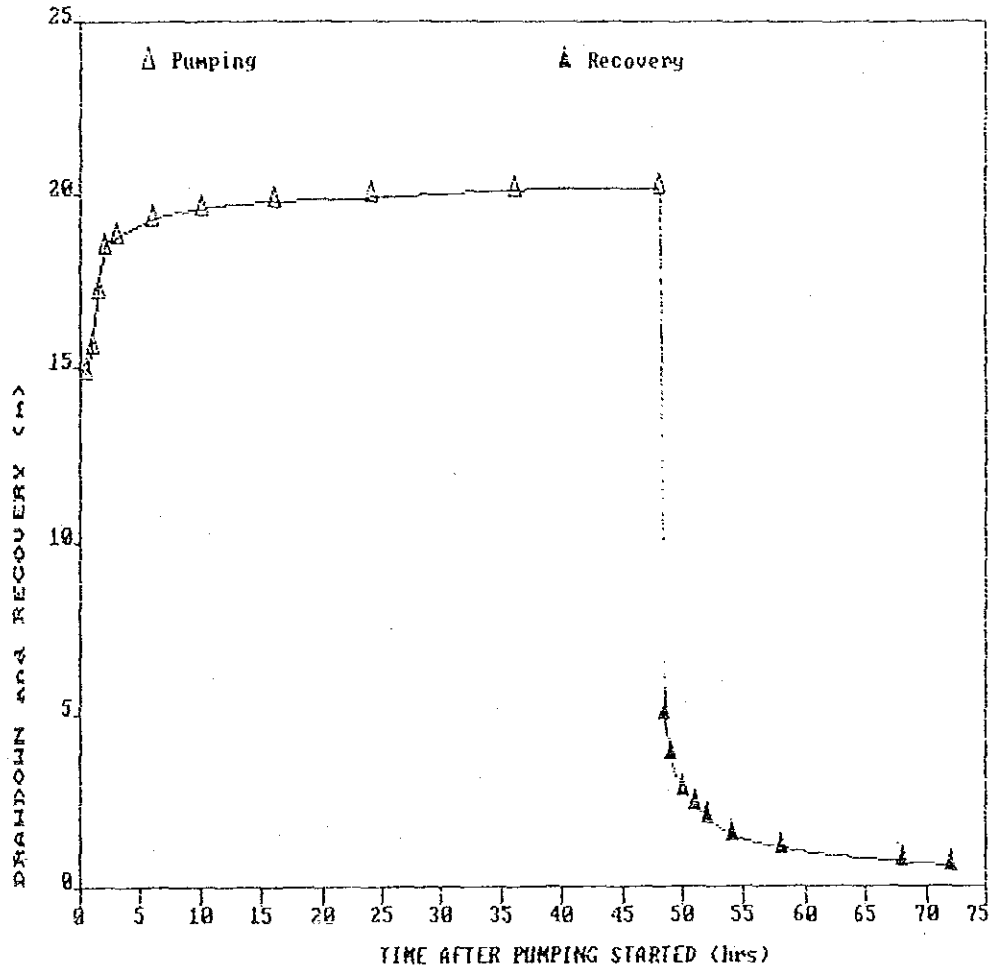
Long period test included recovery were conducted during the period 30 November 1991 to 2 November 1991.

The well was pumped with a discharge of 5.025 l/s constant rate 48 hours and recovery 24 hours. The piezometer head is about 1 m above ground level or self flowing on the ground surface.

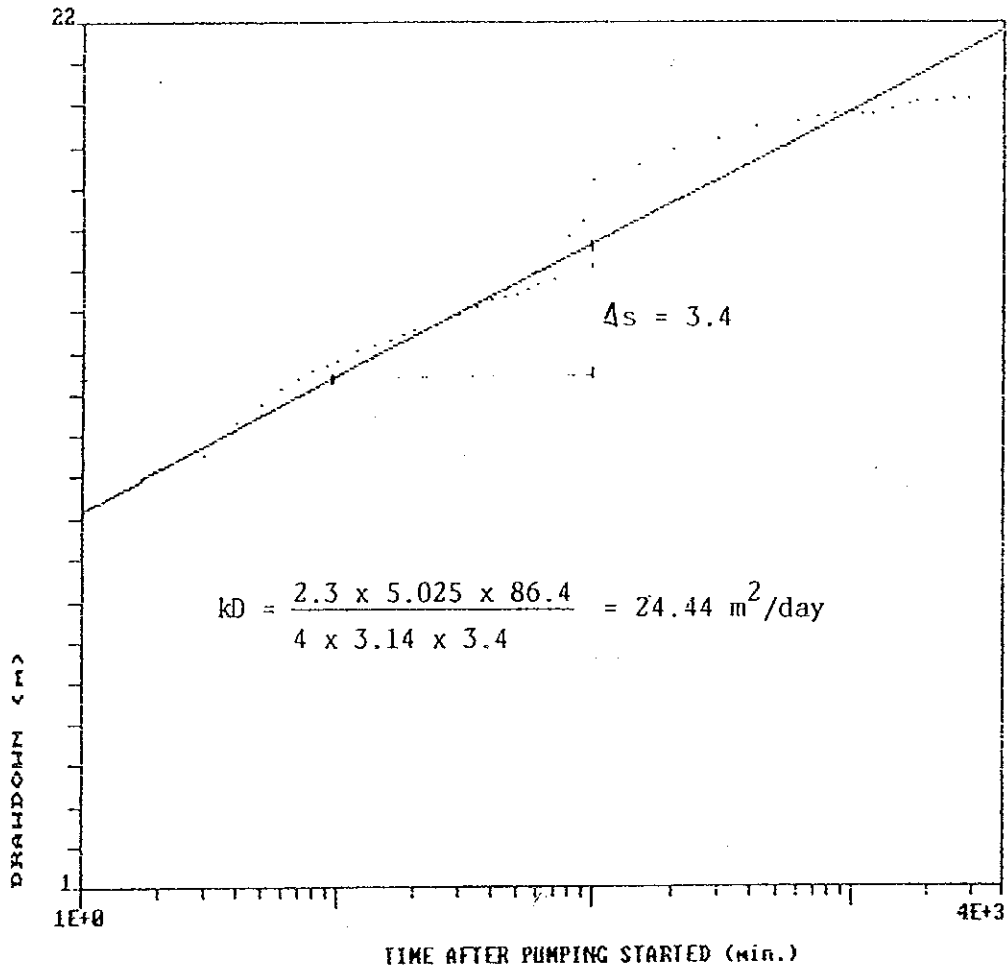
Transmissivity of well was estimated by Jacob's formula based on graphic straight line between drawdown versus time is about 24 m<sup>2</sup>/day, it is very low. Other value of parameter aquifer could not be estimated due to no well data is available.



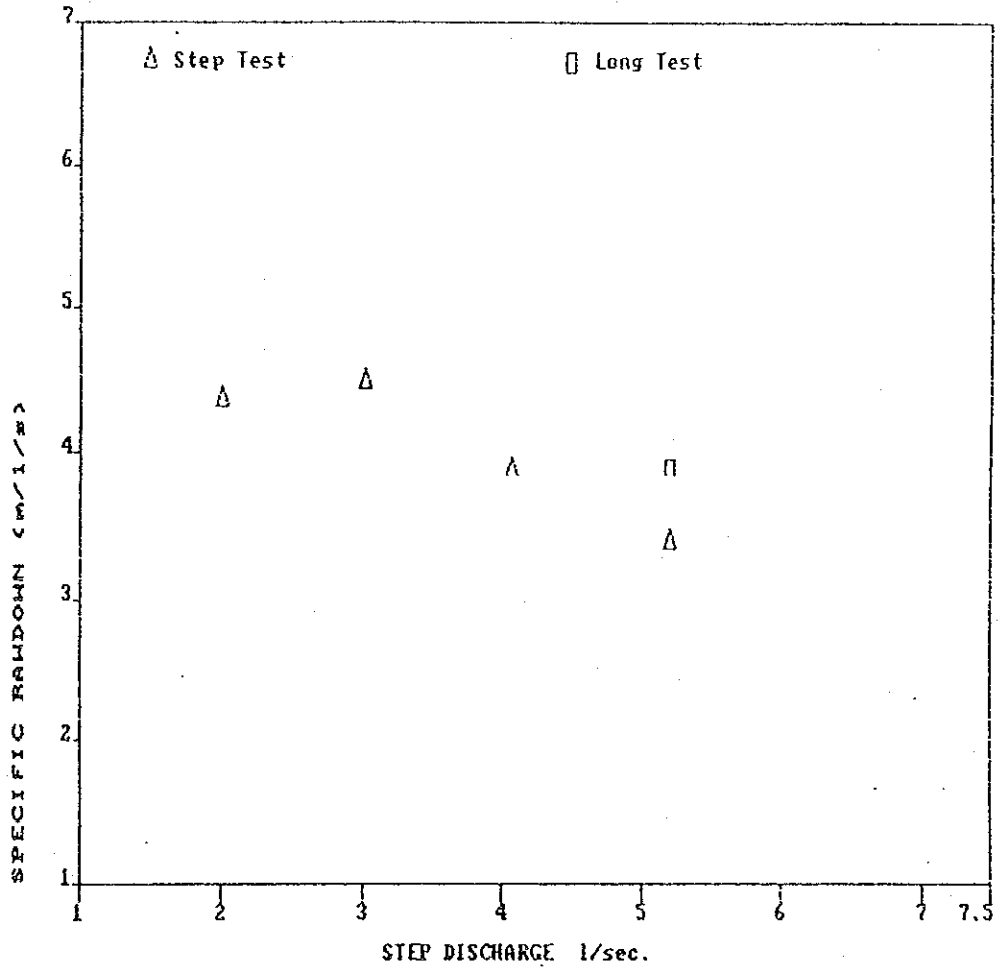
GRAPHIC OF LONG DURATION OBSERVED



LONG DURATION PUMPING TEST



STEP DRAWDOWN PUMPING TEST ANALYSIS

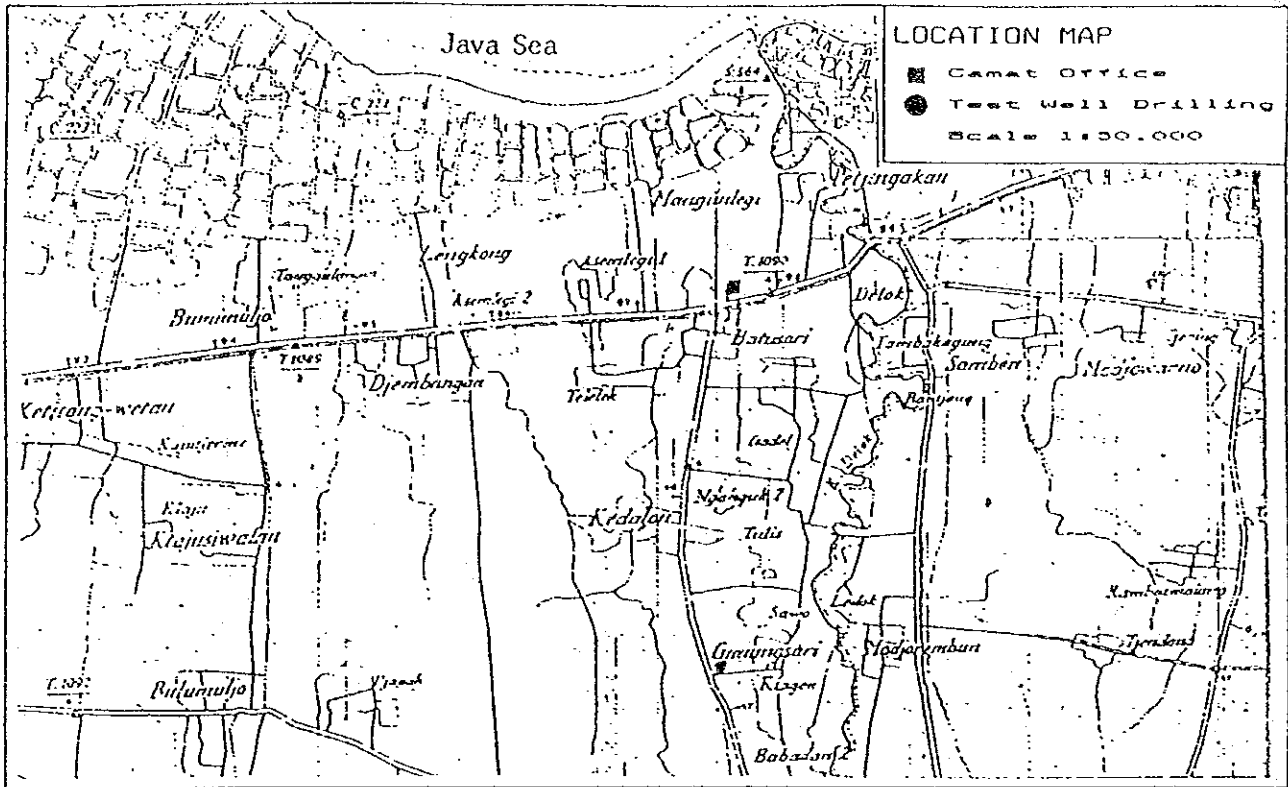


**JEPON EXISTING WELL  
WATER ANALYSIS RESULTS**

| CHARACTERISTIC                             | UNIT | STANDARD                      |           | SAMPLE FROM<br>TEST WELL |
|--|------|-------------------------------|-----------|--------------------------|
|  |      | WHO<br>MAXIMUM<br>PERMISSIBLE | INDONESIA |                          |
| <b>PHYSICAL</b>                            |      |                               |           |                          |
| 1. Colour                                  | Unit | 50                            | 50        | 3.0                      |
| 2. Taste                                   | "    | unobjectionable               | normal    | normal                   |
| 3. Odour                                   | "    | unobjectionable               | normal    | normal                   |
| 4. Turbidity as SiO <sub>2</sub>           | mg/l | 25                            | 25        | 5.0                      |
| <b>CHEMICAL</b>                            |      |                               |           |                          |
| 1. pH                                      | -    | 6.5 - 9.2                     | 6.5-9.2   | 6.76                     |
| 2. Total Dissolved Solids                  | mg/l | 1500                          | 1500      | 508.5                    |
| 3. Permanganate value as KMnO <sub>4</sub> | "    | -                             | 10        | 2.0                      |
| 4. Carbon Dioxide as CO <sub>2</sub>       | "    | -                             | 0.0       | -                        |
| 5. Total Hardness as CaCO <sub>3</sub>     | "    | 500                           | 500       | 476.19                   |
| 6. Calcium Ca                              | "    | 200                           | 200       | 128.8                    |
| 7. Magnesium Mg                            | "    | 150                           | 120       | 37.66                    |
| 8. Iron/Total Fe                           | "    | 1.0                           | 1.0       | 1.4                      |
| 9. Manganese Mn                            | "    | 0.5                           | 0.5       | 0.0                      |
| 10. Copper Cu                              | "    | 1.5                           | 1.0       | 0.08                     |
| 11. Zinc Zn                                | "    | 15                            | 15        | 0.99                     |
| 12. Chloride Cl                            | "    | 600                           | 600       | 17.08                    |
| 13. Sulphate SO <sub>4</sub>               | "    | 400                           | 400       | 237                      |
| 14. Sulphide H <sub>2</sub> S              | "    | -                             | 0.0       | -                        |
| 15. Fluoride F                             | "    | -                             | 1.5       | 0.12                     |
| 16. Ammonia NH <sub>4</sub>                | "    | -                             | 0.0       | not detected             |
| 17. Nitrate NO <sub>3</sub>                | "    | -                             | 10        | 0.00                     |
| 18. Nitrite NO <sub>2</sub>                | "    | -                             | 0.0       | 0.00                     |
| 19. Phenol Phenol                          | "    | 0.002                         | 0.002     | -                        |
| 20. Arsenic As                             | "    | 0.05                          | 0.05      | not detected             |
| 21. Lead Pb                                | "    | 0.10                          | 0.05      | 0.00                     |
| 22. Selenium Se                            | "    | 0.01                          | 0.01      | not detected             |
| 23. Chromium Cr                            | "    | -                             | 0.05      | 0.00                     |
| 24. Cyanide Cn                             | "    | -                             | 0.10      | 0.00                     |
| 25. Cadmium Cd                             | "    | -                             | 0.005     | 0.00                     |
| 26. Mercury Hg                             | "    | -                             | 0.001     | not detected             |

4.3.6 Additional Test Well in Batangan

TEST WELL COMPLETION REPORT  
BATANGAN - PATI KABUPATEN



TEST WELL RESULT

Estimated maximum dry season static water level : 4.40 m below ground level

Nominal maximum well capacity : 1.50 l/s at 14 m drawdown

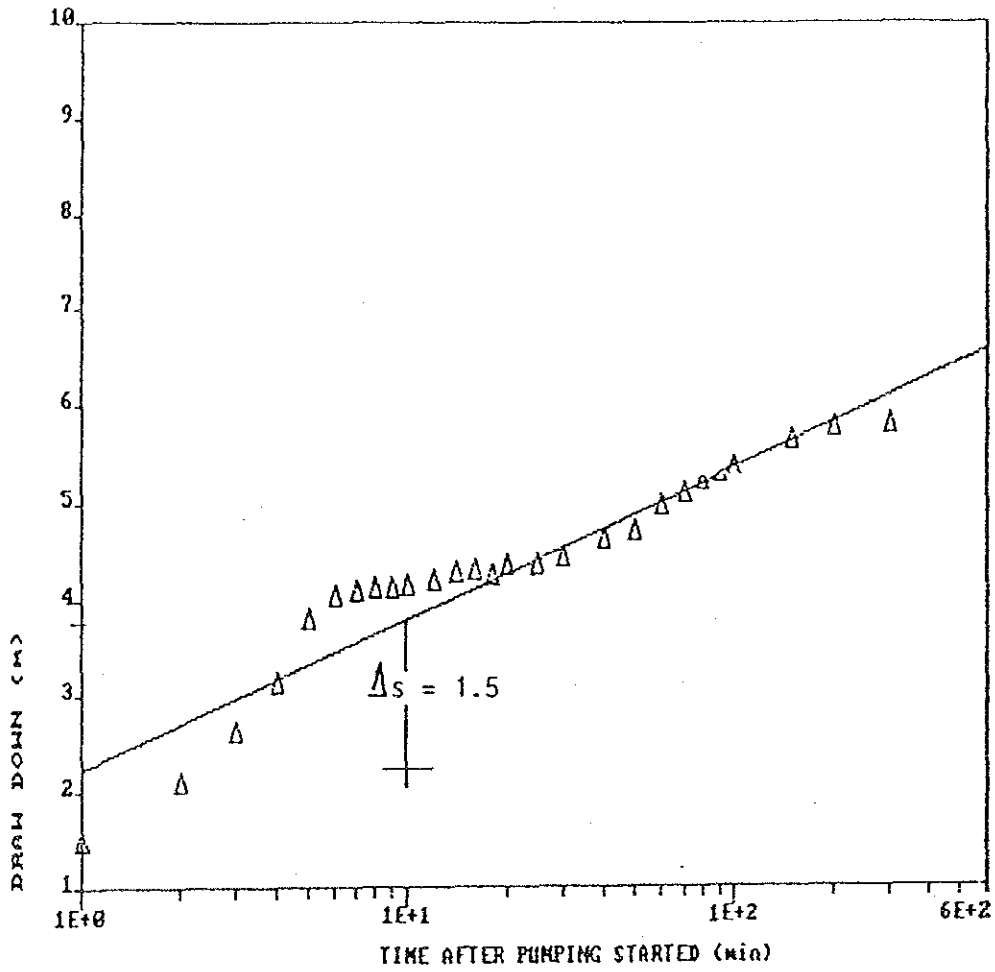
Pump requirements for well capacity :

|                       |   |    |       |
|-----------------------|---|----|-------|
| Flow                  | : | -- | l/s   |
| Drawdown              | : | -- | m     |
| Operating water level | : | -- | m bgl |

Remarks :

- Water is slightly saline and not suitable for drinking
- Alternative source required

BATANGAN - LONG PERIOD PUMPING TEST



Discharge  $Q = 0.66$  l/sec

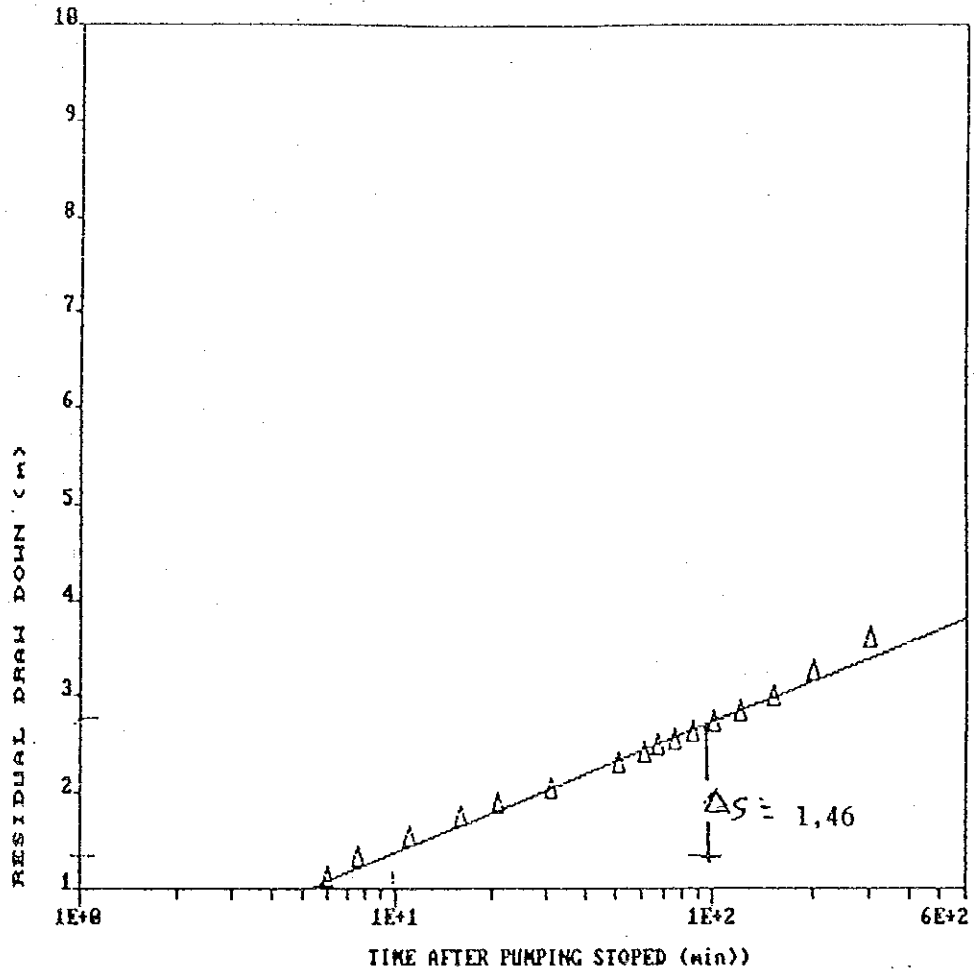
$$\Delta s = 1.5$$

$$\text{- Jacob } kD = \frac{2.3 \times 0.66 \times 86.4}{4 \times 3.14 \times 1.5}$$

$$= 7 \text{ m}^2/\text{day}$$

- Permeability through screen section  $k = 2.3$  m/day

BATANGAN RECOVERY ANALYSIS



Discharge  $Q = 0,66$  l/sec

$s = 1,46$  l/sec

-Jacob KD  $= \frac{2,3 \times 0,66 \times 86,4}{4 \times 3,14 \times 1,46} = 7$  m<sup>2</sup> /day

-Permeability through screen section

$k = 2,3$  m/day

## BATANGAN - TEST WELL CONSTRUCTION

| DEPTH<br>m  | WELL CONSTRUCTION   | REMARKS  |
|---|---|--|
| GL<br><br>5<br><br>10<br><br>15<br><br>20<br><br>25<br><br>30<br><br>35<br><br>40<br><br>45 | <p style="text-align: right;">       ← Well Cap<br/>       ← Apron<br/>       ← C.Casing 10 in<br/>       ← Cement grout<br/>       ← Clay seal<br/>       ← 8 in dia. Borehole<br/>       ← 4 in dia. blank pipe<br/>       ← 4 in dia. slotted pipe<br/>       ← 4 in dia. wire-wound screen<br/>       ← TD = 27 m<br/>       ← Td = 30 m     </p> | <p><b>DRILLING :</b></p> <p>Borehole 12 in = 3 m</p> <p>borehole 8 in = 3 to 30 m</p> <p><b>WELL CONSTRUCTION</b></p> <p><b>1. CASING AND SCREEN</b></p> <p>Blank pipe 4 in dia. = 16 m</p> <p>Slotted pipe 4 inch = 6 m</p> <p>Wire wound screen = 3 m</p> <p>Bottom plug = 2 m</p> <hr/> <p>Total Depth of Well = 27 m</p> <p><b>2. SCREEN POSITIONING ARE :</b></p> <p>14 to 18 m = slotted pipe</p> <p>20 to 22 m = slotted pipe</p> <p>22 to 25 m = ww. screen</p> <p><b>3. GRAVEL FILTER</b></p> <p>Volume installed is 2.5 c.m with size 3 to 6 mm.</p> <p><b>4. DEVELOPMENT</b></p> <p>1. Water Jetting</p> <p>2. Air Jetting</p> <p><b>5. DATE OF CONSTRUCTION :</b></p> <p style="text-align: center;">September 1991.</p> |

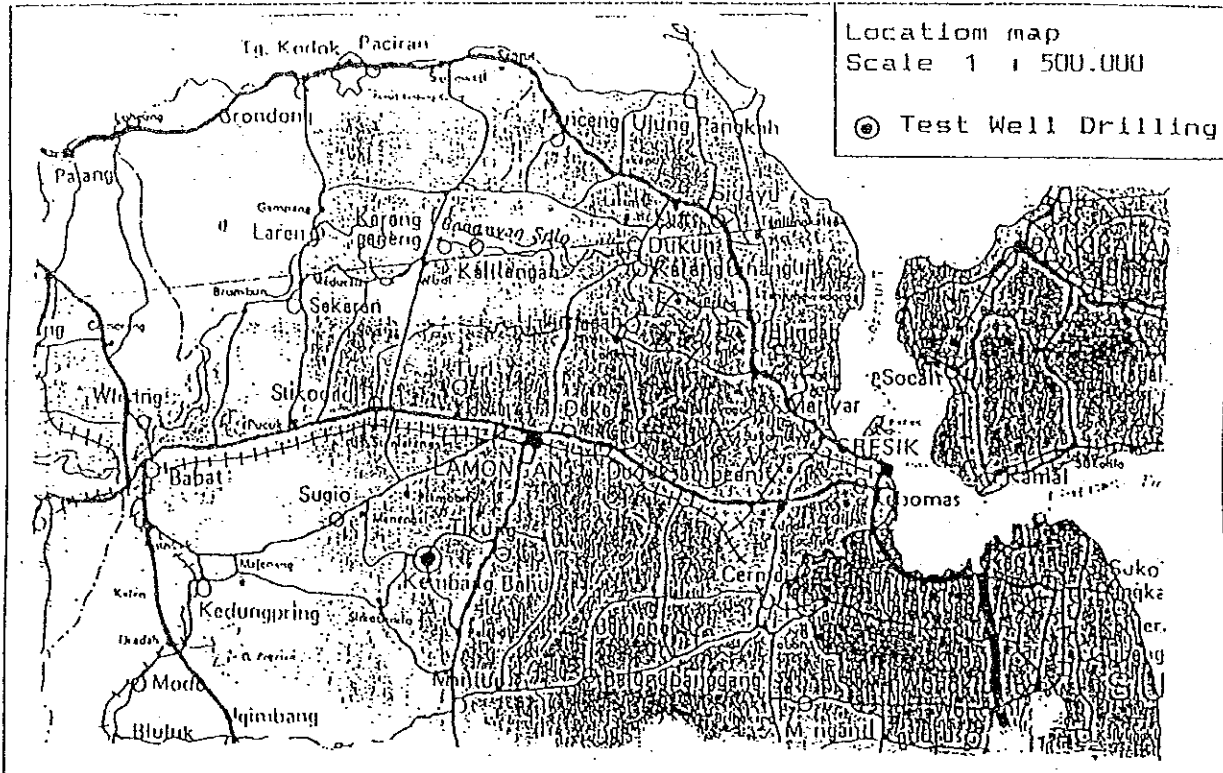


## BATANGAN WATER ANALYSIS RESULTS

| CHARACTERISTIC                             | UNIT | STANDARD                |           | SAMPLE FROM TEST WELL |
|--|------|-------------------------|-----------|-----------------------|
|  |      | WHO MAXIMUM PERMISSIBLE | INDONESIA |                       |
| <b>PHYSICAL</b>                            |      |                         |           |                       |
| 1. Colour                                  | Unit | 50                      | 50        | 17                    |
| 2. Taste                                   | "    | unobjectionable         | normal    | normal                |
| 3. Odour                                   | "    | unobjectionable         | normal    | normal                |
| 4. Turbidity as SiO <sub>2</sub>           | mg/l | 25                      | 25        | 26.5                  |
| <b>CHEMICAL</b>                            |      |                         |           |                       |
| 1. pH                                      | -    | 6.5 - 9.2               | 6.5-9.2   | 7.17                  |
| 2. Total Dissolved Solids                  | mg/l | 1500                    | 1500      | 2211                  |
| 3. Permanganate value as KMnO <sub>4</sub> | "    | -                       | 10        | -                     |
| 4. Carbon Dioxide as CO <sub>2</sub>       | "    | -                       | 0.0       | -                     |
| 5. Total Hardness as CaCO <sub>3</sub>     | "    | 500                     | 500       | 1422.82               |
| 6. Calcium Ca                              | "    | 200                     | 200       | 318.40                |
| 7. Magnesium Mg                            | "    | 150                     | 120       | 152.71                |
| 8. Iron/Total Fe                           | "    | 1.0                     | 1.0       | 1.2                   |
| 9. Manganese Mn                            | "    | 0.5                     | 0.5       | not detected          |
| 10. Copper Cu                              | "    | 1.5                     | 1.0       | not detected          |
| 11. Zinc Zn                                | "    | 15                      | 15        | not detected          |
| 12. Chloride Cl                            | "    | 600                     | 600       | 2410.72               |
| 13. Sulphate SO <sub>4</sub>               | "    | 400                     | 400       | 550                   |
| 14. Sulphide H <sub>2</sub> S              | "    | -                       | 0.0       | -                     |
| 15. Fluoride F                             | "    | -                       | 1.5       | 3.95                  |
| 16. Ammonia NH <sub>4</sub>                | "    | -                       | 0.0       | not detected          |
| 17. Nitrate NO <sub>3</sub>                | "    | -                       | 10        | not detected          |
| 18. Nitrite NO <sub>2</sub>                | "    | -                       | 0.0       | not detected          |
| 19. Phenol Phenol                          | "    | 0.002                   | 0.002     | -                     |
| 20. Arsenic As                             | "    | 0.05                    | 0.05      | not detected          |
| 21. Lead Pb                                | "    | 0.10                    | 0.05      | not detected          |
| 22. Selenium Se                            | "    | 0.01                    | 0.01      | not detected          |
| 23. Chromium Cr                            | "    | -                       | 0.05      | -                     |
| 24. Cyanide Cn                             | "    | -                       | 0.10      | not detected          |
| 25. Cadmium Cd                             | "    | -                       | 0.005     | not detected          |
| 26. Mercury Hg                             | "    | -                       | 0.001     | not detected          |

4.3.7 Initial Test Well in Kembangbahu

TEST WELL COMPLETION REPORT  
KEMBANG BAHU — LAMONGAN KABUPATEN



TEST WELL RESULT

Scheme Demand 2000 : 7.04 l/sec.

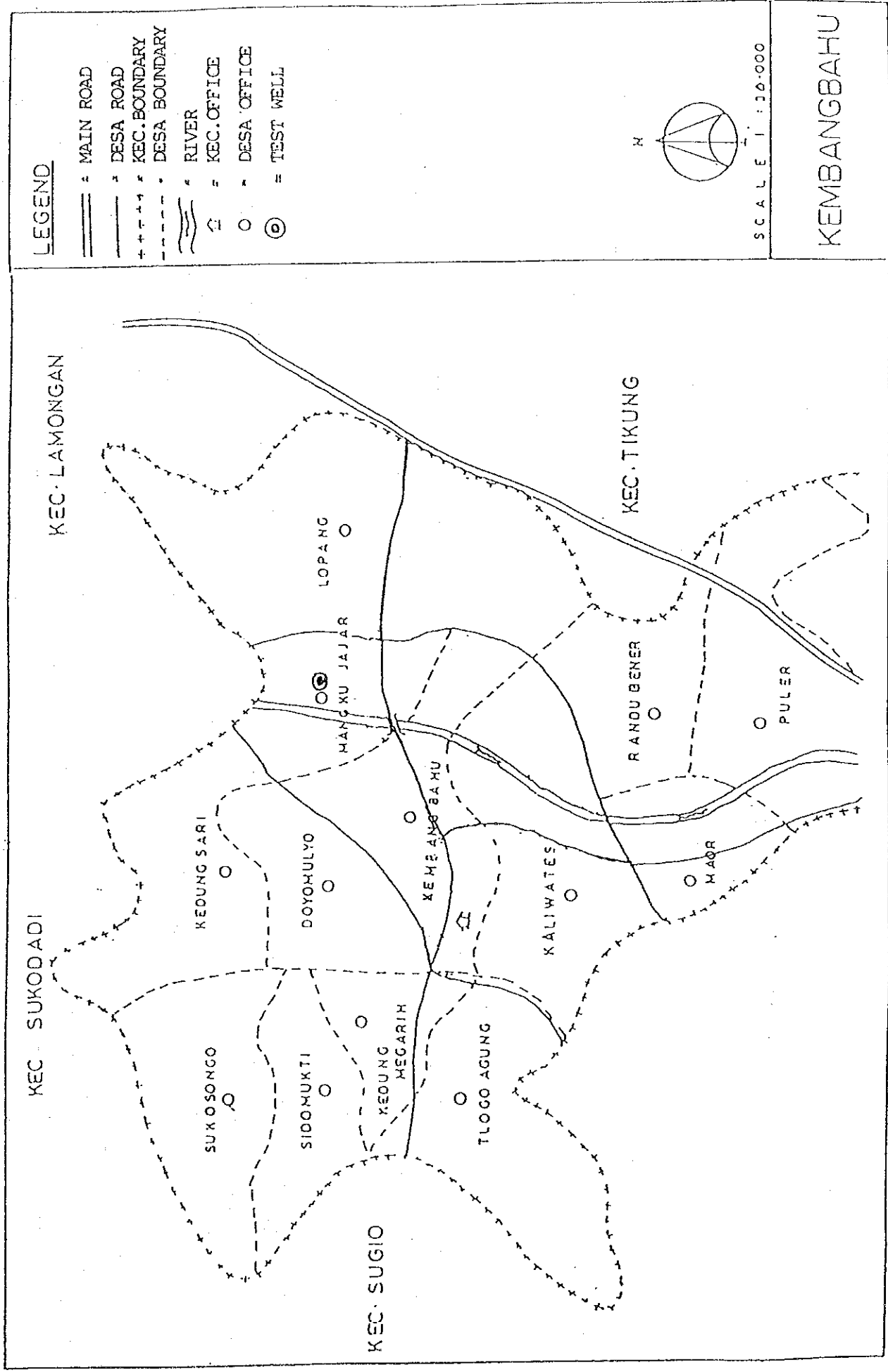
Estimated maximum dry season : 4.2 m  
(Static Water Level)

Nominal Maximum well capacity : 4.5 l/sec.

35 m Draw down

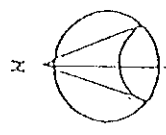
Remarks :

- Water is brackish (EC = 2700 mh mos/cm.
- Additional 1 (one) Production Well is required



LEGEND

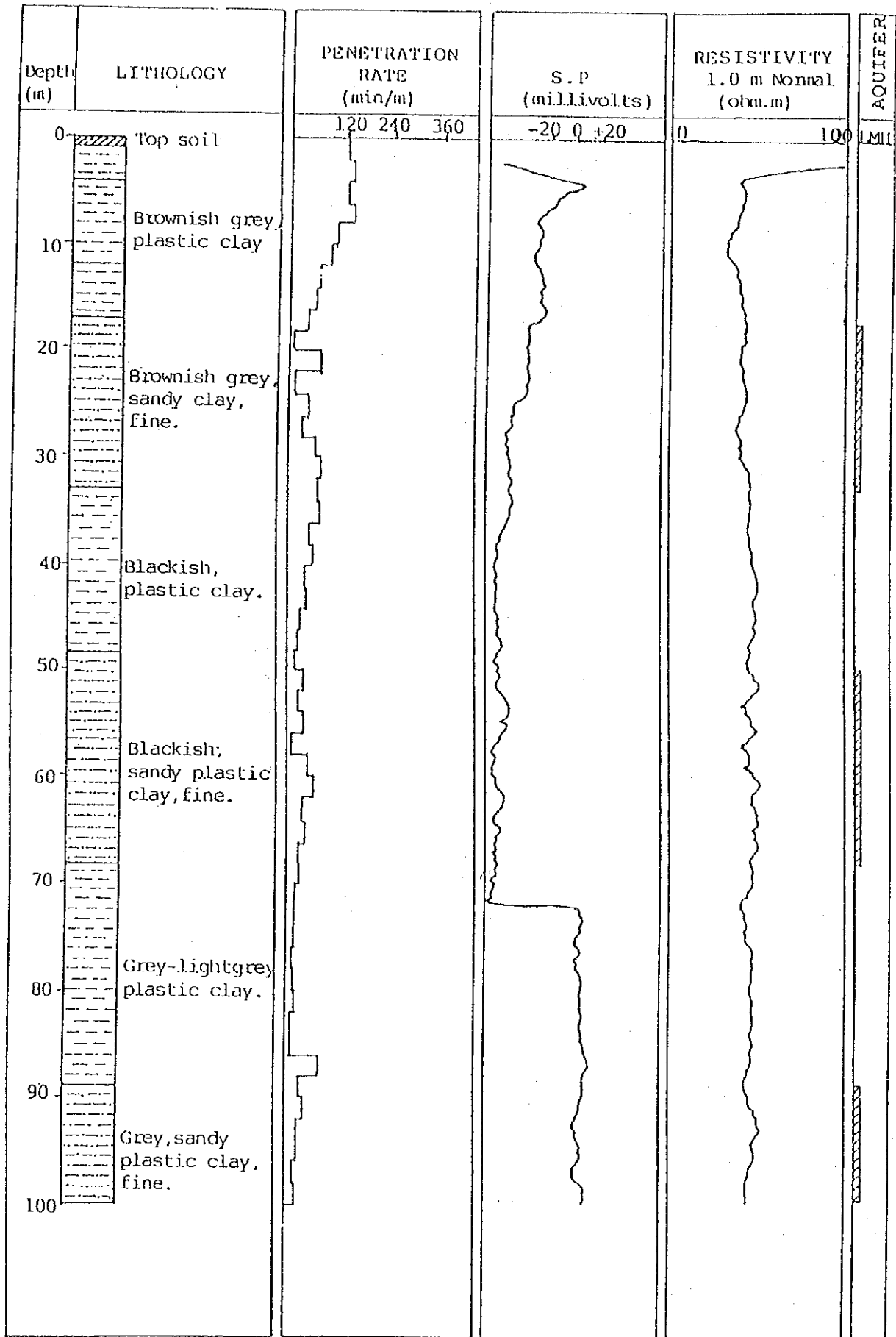
- ==== = MAIN ROAD
- = DESA ROAD
- - - - = KEC. BOUNDARY
- - - - = DESA BOUNDARY
- ~~~~ = RIVER
- ⊙ = KEC. OFFICE
- = DESA OFFICE
- ⊙ = TEST WELL



SCALE 1 : 30.000

KEMBANGBAHU

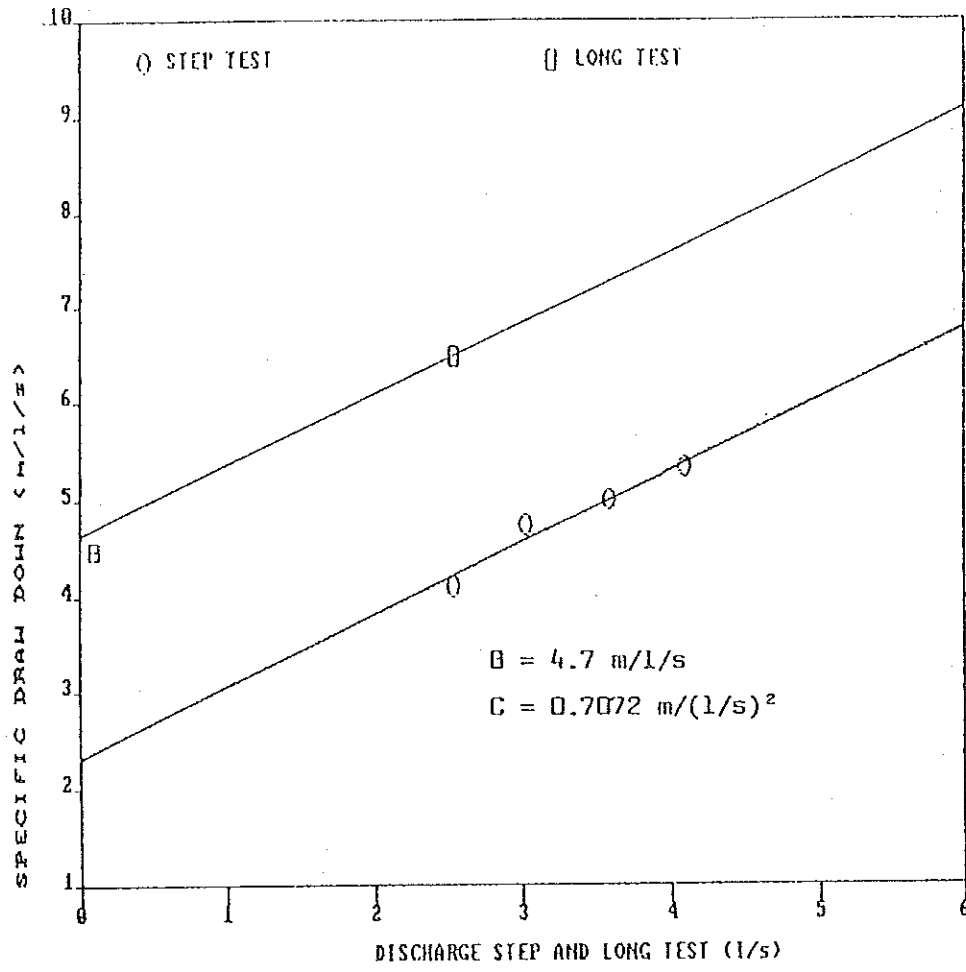
## Kembangbahu Geological Data



## Kembangbahu Test Well Detail

| Depth<br>(m) | GRAPHIC | DISCRIPTIVE  |
|--------------|---------|--|
| 0            |         | <p style="text-align: center;"><b>PILOT HOLE</b></p> <p>Date drilled : July 23, 1991<br/>           Drilling method : D.C. Mud flush<br/>           Total drilled depth: 103 m<br/>           Logs run : Resistivity &amp; S.P.</p> <p style="text-align: center;"><b>REAMING</b></p> <p>300 mm diameter : 50 m<br/>           200 mm diameter : 53 m</p> <p style="text-align: center;"><b>INSTALLATION</b></p> <p>Pump chamber casing<br/>           Type : Black steel API<br/>           Length : 42 m<br/>           I.D. : 200 mm</p> <p>Well Screen<br/>           Type : Low Carbon steel<br/>           I.D. : 200 mm<br/>           Total length : 6 m<br/>           I.D. : 100 mm<br/>           Total length : 27 m<br/>           Slot screen : 1 mm</p> <p>Lower well casing<br/>           Type : Black steel API<br/>           Length : 27 m<br/>           I.D. : 100 mm</p> <p>Gravel pack grading: 2 to 6 mm<br/>           Sanitary seal : 15 m bgl</p> <p>Development<br/>           Method : Air Jetting<br/>           Duration : 20 hours</p> <p>Date to installation: August 22, 1991</p> <p><b>TOTAL INSTALLED DEPTH : 102 m</b></p> |
| 10           |         |  |
| 20           |         |  |
| 30           |         |  |
| 40           |         |  |
| 50           |         |  |
| 60           |         |  |
| 70           |         |  |
| 80           |         |  |
| 90           |         |  |
| 100          |         |  |

KEMBANG BAHU STEP TEST ANALYSIS





LABORATORIUM TEKNIK PENYEHATAN  
 JURUSAN TEKNIK SIPIL  
 FAKULTAS TEKNIK SIPIL DAN PERENCANAAN  
 INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
 KAMPUS ITS SUKOLILO, SURABAYA 60111 TELP. (031) 596094

ITEMS OF WATER QUALITY ANALYSIS

KEMBANGBANGUN.

| NO. | Items                                    | Unit  | Indonesian Standard | Analized at Lab. |            |
|-----|--|-------|---------------------|------------------|------------|
|     |  |       |                     | 24 jam           | 48 jam     |
| 01  | Colour                                   | Pt/Co | 30                  | 30,00            | 30,00      |
| 02  | O d o r                                  | -     | None                | Tak berbau       | Tak berbau |
| 03  | Taste                                    | -     | None                | Tak berasa       | Tak berasa |
| 04  | Turbidity                                | NTU   | 25                  | 4,20             | 3,10       |
| 05  | pH                                       | -     | 6,5-9,0             | 8,00             | 8,00       |
| 06  | Total Dissolved Solid                    | mg/l  | 1500,00             | 1674,00          | 1634,00    |
| 07  | C O D                                    | mg/l  | 10,00               | 28,87            | 18,40      |
| 08  | Total Hardnes as CaCO <sub>3</sub>       | mg/l  | 500,00              | 178,57           | 178,57     |
| 09  | Calcium (Ca)                             | mg/l  | 200,00              | 96,43            | 92,86      |
| 10  | Magnesium (Mg)                           | mg/l  | 120,00              | 82,14            | 85,71      |
| 11  | Total Iron (Fe)                          | mg/l  | 1,00                | 0,50             | 0,50       |
| 12  | Manganese (Mn)                           | mg/l  | 0,50                | 0,00             | 0,00       |
| 13  | Z i n c (Zn)                             | mg/l  | 15,00               | 0,00             | 0,00       |
| 14  | Chloride (Cl <sup>-</sup> )              | mg/l  | 600,00              | 704,53           | 666,48     |
| 15  | Sulphate (SO <sub>4</sub> <sup>-</sup> ) | mg/l  | 400,00              | 35,13            | 29,95      |
| 16  | Fluoride ( F <sup>-</sup> )              | mg/l  | 1,50                | 0,00             | 0,00       |
| 17  | Nitrate (NO <sub>3</sub> <sup>-</sup> )  | mg/l  | 10,00               | 0,00             | 0,00       |
| 18  | Phenol                                   | mg/l  | 0,002               | 0,00             | 0,00       |
| 19  | Mercury (Hg)                             | mg/l  | 0,001               | 0,00             | 0,00       |
| 20  | Arsenic (As)                             | mg/l  | 0,05                | 0,00             | 0,00       |
| 21  | Cadmium (Cd)                             | mg/l  | 0,005               | 0,00             | 0,00       |
| 22  | Chromium Sexivalet                       | mg/l  | 0,05                | 0,00             | 0,00       |
| 23  | Selenium (Se)                            | mg/l  | 0,01                | 0,00             | 0,00       |
| 24  | Cyanide (Cn)                             | mg/l  | 0,1                 | 0,00             | 0,00       |
| 25  | Copper (Cu)                              | mg/l  | 1,00                | 0,00             | 0,00       |
| 26  | Lead (Pb)                                | mg/l  | 0,05                | 0,00             | 0,00       |

Surabaya, 10 September 1991

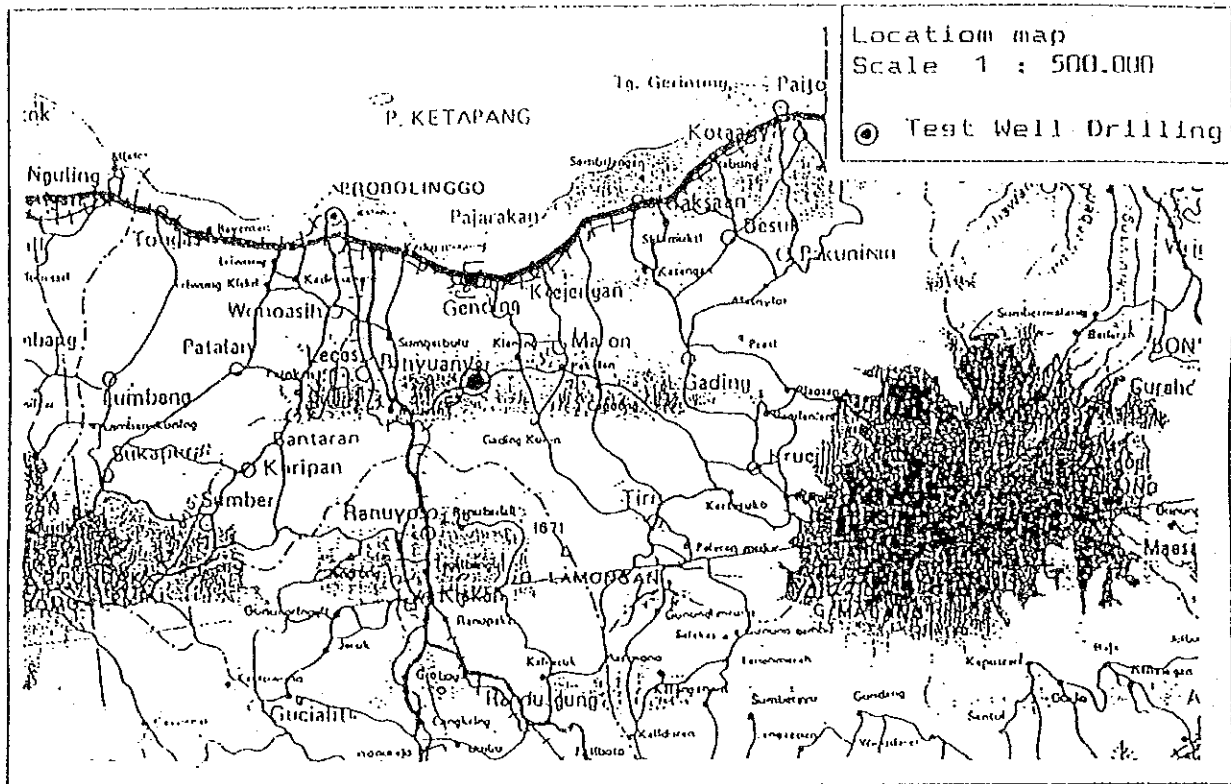
Koordinator Pengujian Masya-

rakat Lab. SIP. FISIP-ITS

*(Signature)*  
 Ir. Sonny Soenarsono S.MS.

4.3.8 Initial Test Well in Banyuwangi

TEST WELL COMPLETION REPORT  
BANYUWANGI - PROBOLINGGO KABUPATEN



TEST WELL RESULT

Scheme Demand 2000 : 15.54 l/sec.

Estimated maximum dry season  
(Static Water Level) : - m

Nominal Maximum well capacity : - l/sec.

- m Draw down

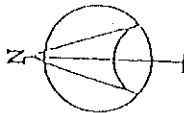
Remarks :

- Well is dry
- Additional shallow well drilling is required.



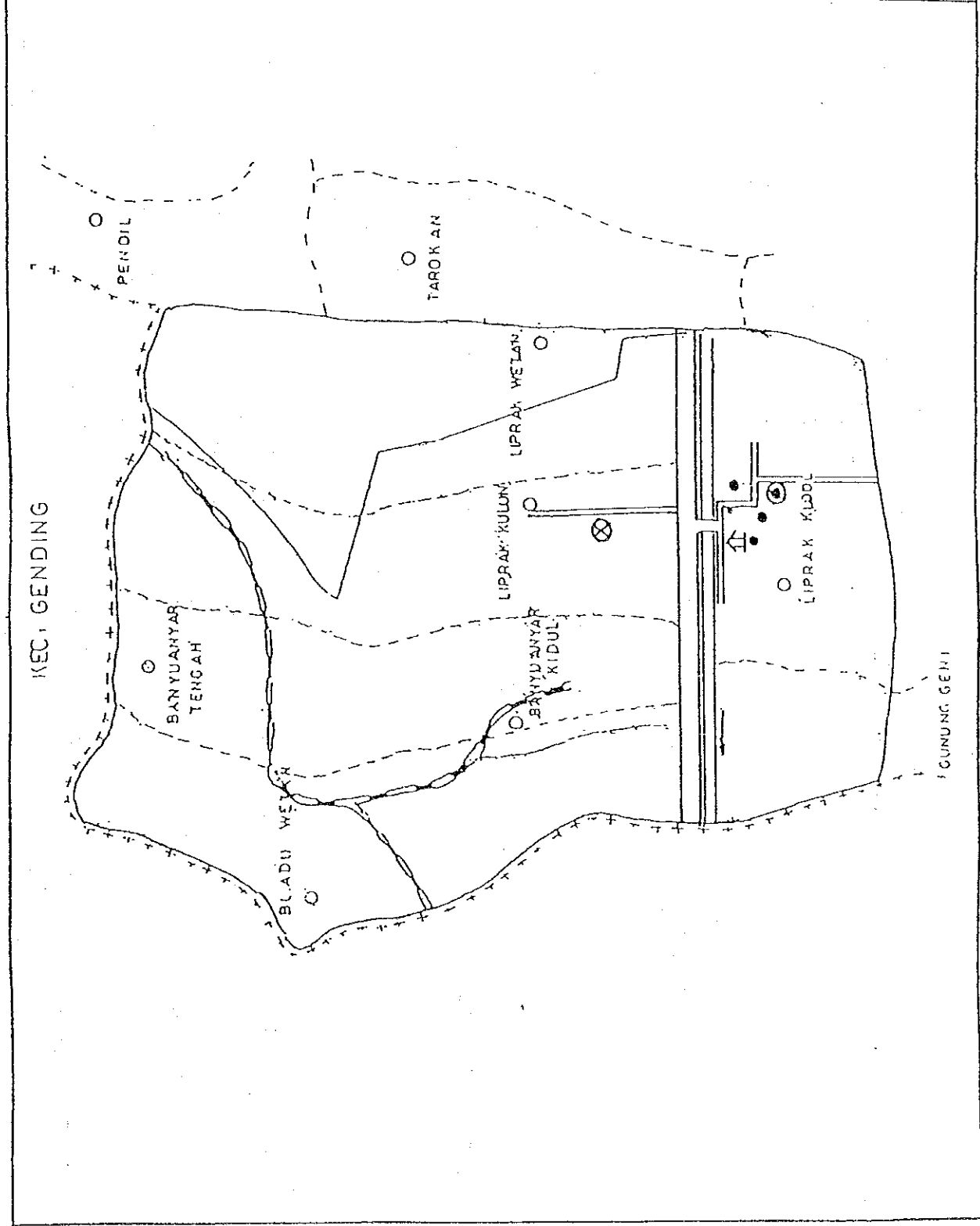
**LEGEND**

- ==== MAIN ROAD
- DESA ROAD
- - - DESA BOUNDARY
- - - - - KEC. BOUNDARY
- ⊗ RAIL WAY
- ⊃ RIVER
- DESA OFFICE
- ⊕ KEC. OFFICE
- ⊙ TEST WELL
- DUG WELL
- ⊗ PROPOSED WELL

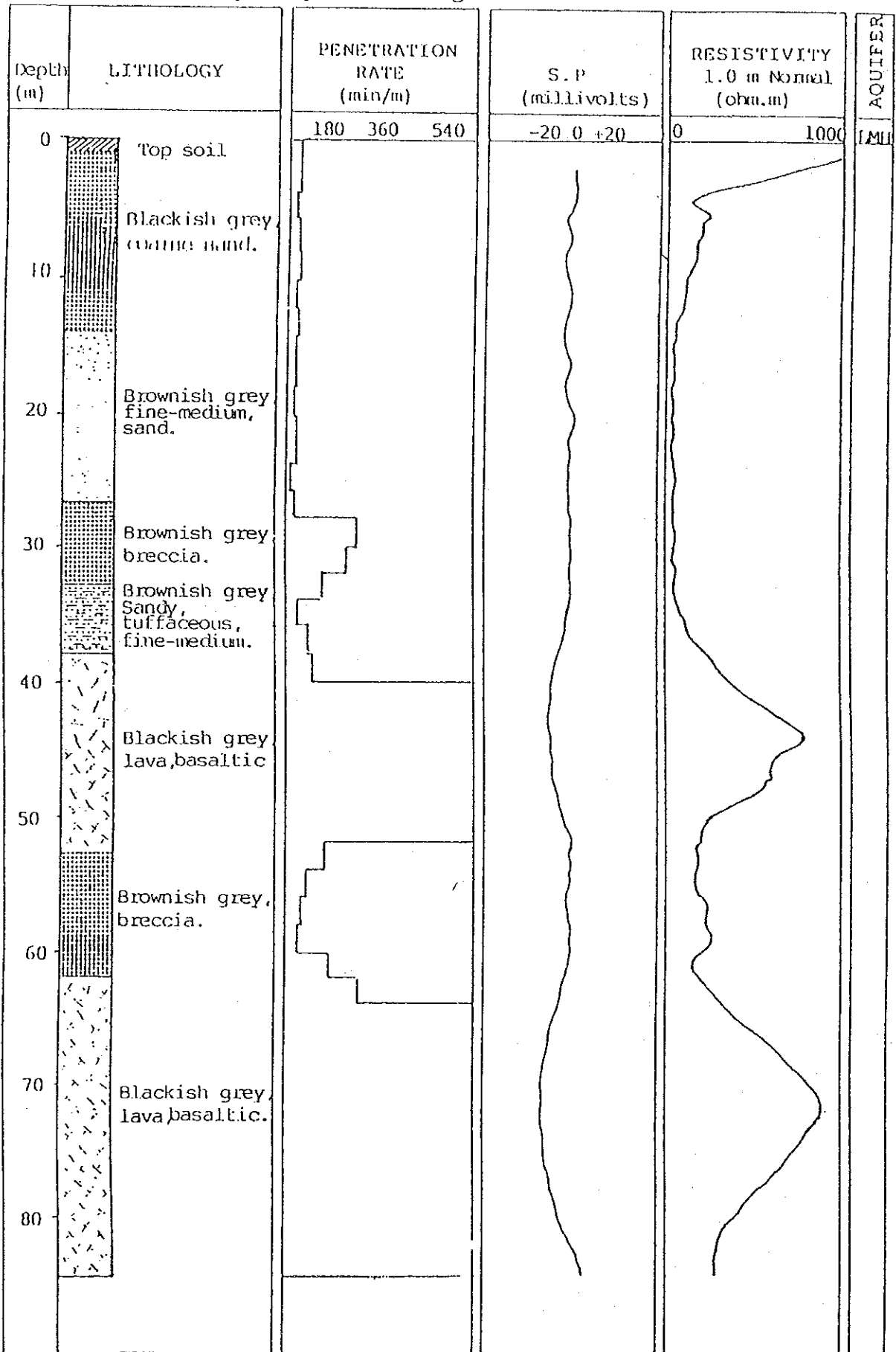
N  


SCALE: 1:30,000

**BANYUANYAR**

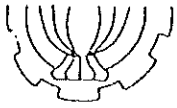


## Banyuanyar Geological Data



## Banyuanyar Test Well Detail

| Depth<br>(m)   | GRAPHIC | DISCRIPTIVE  |
|--|---------|--|
| <div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">0</div> <div style="margin-bottom: 10px;">10</div> <div style="margin-bottom: 10px;">20</div> <div style="margin-bottom: 10px;">30</div> <div style="margin-bottom: 10px;">40</div> <div style="margin-bottom: 10px;">50</div> <div style="margin-bottom: 10px;">60</div> <div style="margin-bottom: 10px;">70</div> <div style="margin-bottom: 10px;">80</div> </div> |         | <p style="text-align: center;"><b>PILOT HOLE</b></p> <p>Date drilled : June 26, 1991<br/>         Drilling method : D.C. Mud Flush<br/>         Total drilled depth : 84 m</p> <p style="text-align: center;"><b>REAMING</b></p> <p>300 mm diameter : 42,50 m<br/>         200 mm diameter : 41,50 m</p> <p style="text-align: center;"><b>INSTALLATION</b></p> <p>Pump chamber casing</p> <p style="margin-left: 20px;">Type : Black steel API<br/>         Length : 42 m<br/>         I.D : 200 mm</p> <p>Sanitary seal : 42 m bgl</p> <p>Development</p> <p style="margin-left: 20px;">Method : Air Jetting<br/>         Duration : 20 hours</p> <p>Date of installation: August 21, 1991</p> <p><b>TOTAL INSTALLED DEPTH: 84 m</b></p> |



ITEMS OF WATER QUALITY ANALYSIS  
TEST WEL. BANYUANYAR

| No.                   | Items                                    | Unit  | Indonesian Standard | Analyzed at Laboratory |
|-----------------------|--|-------|---------------------|------------------------|
| (Physical Properties) |  |       |                     |                        |
| 1.                    | Colour                                   | Pt/Co | 50,00               | 75,00                  |
| 2.                    | Odor                                     | -     | None                | Berbau CO <sub>2</sub> |
| 3.                    | Taste                                    | -     | None                | Berrasa                |
| 4.                    | Turbidity                                | NTU   | 25,00               | 158,00                 |
| (Chemical properties) |  |       |                     |                        |
| 5.                    | pH                                       | -     | 6,50-9,00           | 7,45                   |
| 6.                    | Total Dissolved Solids                   | mg/l  | 1500,00             | 490,00                 |
| 7.                    | COD                                      | mg/l  | 10,00               | 30,00                  |
| 8.                    | Total Hardness as CaCO <sub>3</sub>      | mg/l  | 500,00              | 121,43                 |
| 9.                    | Calcium (Ca)                             | mg/l  | 200,00              | 28,57                  |
| 10.                   | Magnesium (Mg)                           | mg/l  | 120,00              | 12,00                  |
| 11.                   | Total Iron (Fe)                          | mg/l  | 1,00                | ttd                    |
| 12.                   | Manganese (Mn)                           | mg/l  | 0,50                | 0,00                   |
| 13.                   | Zinc (Zn)                                | mg/l  | 15,00               | 0,00                   |
| 14.                   | Chloride (Cl <sup>-</sup> )              | mg/l  | 600,00              | 35,03                  |
| 15.                   | Sulphate (SO <sub>4</sub> <sup>=</sup> ) | mg/l  | 400,00              | 10,78                  |
| 16.                   | Fluoride (F)                             | mg/l  | 1,50                | 0,70                   |
| 17.                   | Nitrate (NO <sub>3</sub> <sup>-</sup> N) | mg/l  | 10,00               | 0,18                   |
| 18.                   | Phenol                                   | mg/l  | 0,002               | 0,00                   |
| 19.                   | Mercury (Hg)                             | mg/l  | 0,001               | 0,00                   |
| 20.                   | Arsenic (As)                             | mg/l  | 0,05                | 0,00                   |
| 21.                   | Cadmium (Cd)                             | mg/l  | 0,005               | 0,00                   |
| 22.                   | Chromium Sexivalent (Cr <sup>+6</sup> )  | mg/l  | 0,05                | 0,00                   |
| 23.                   | Selenium (Se)                            | mg/l  | 0,01                | 0,00                   |
| 24.                   | Cyanide (CN)                             | mg/l  | 0,10                | 0,00                   |
| 25.                   | Copper (Cu)                              | mg/l  | 1,00                | 0,00                   |
| 26.                   | Lead (Pb)                                | mg/l  | 0,05                | 0,00                   |

Catatan : tak terdeteksi

B - 177

Surabaya, 30 September 1991  
Laboratorium  
Koordinator Pengabdian Masyarakat  
Lab. TP. FTSP-ITS  
FTSP-ITS  
Ir. Sonny Soenarsono S. MS



**JURUSAN TEKNIK SIPIL**  
**FAKULTAS TEKNIK SIPIL DAN PERENCANAAN**  
**INSTITUT TEKNOLOGI SEPULUH NOPEMBER**  
KAMPUS ITS SUKOLILO, SURABAYA 60111 TELP. (031) 596094

ITEMS OF WATER QUALITY ANALYSIS

BANYUANYAR

DUG WELL

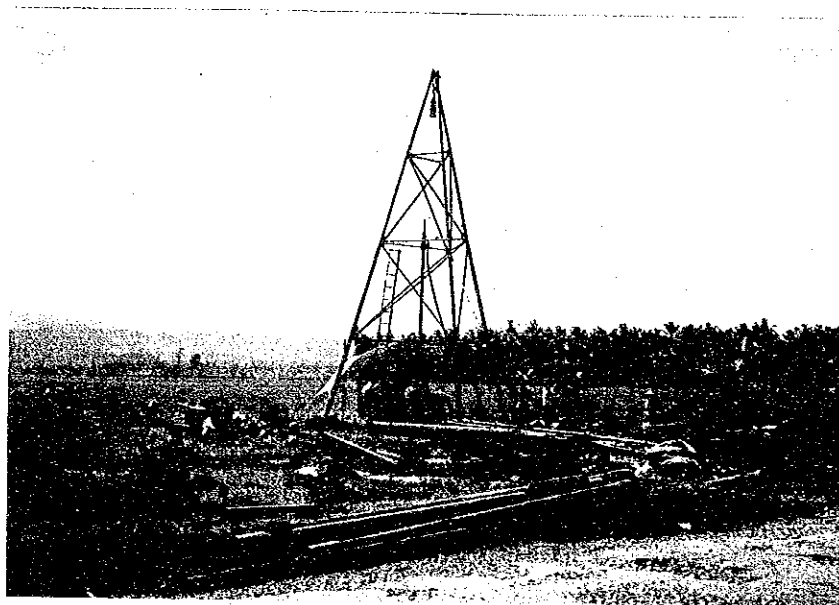
| No. | Items                 | Unit                                 | Indonesian Standard | Analyzed at Lab. |
|-----|-----------------------|--------------------------------------|---------------------|------------------|
| 1.  | Colour                | Pt/Co                                | 30,00               | 4,50             |
| 2.  | O d o r               | -                                    | None                | None             |
| 3.  | Taste                 | -                                    | None                | None             |
| 4.  | Turbidity             | NTU                                  | 25,00               | 19,60            |
| 5.  | pH                    | -                                    | 6,50-9,00           | 8,10             |
| 6.  | Total Dissolved Solid | mg/l                                 | 1500,00             | 454,00           |
| 7.  | C O D                 | mg/l                                 | 10,00               | 7,34             |
| 8.  | Total Hardness        | CaCO <sub>3</sub> mg/l               | 500,00              | 328,57           |
| 9.  | Calcium               | (Ca) mg/l                            | 200,00              | 84,00            |
| 10. | Magnesium             | (Mg) mg/l                            | 120,00              | 28,30            |
| 11. | Total Iron            | (Fe) mg/l                            | 1,00                | ttd.             |
| 12. | Manganese             | (Mn) mg/l                            | 0,50                | 0,00             |
| 13. | Z i n c               | (Zn) mg/l                            | 15,00               | 0,00             |
| 14. | Chloride              | (Cl <sup>-</sup> ) mg/l              | 600,00              | 35,04            |
| 15. | Sulphate              | (SO <sub>4</sub> <sup>=</sup> ) mg/l | 400,00              | 4,17             |
| 16. | Fluoride              | ( F ) mg/l                           | 1,50                | 0,60             |
| 17. | Nitrate               | (NO <sub>3</sub> ) mg/l              | 10,00               | 4,28             |
| 18. | Phenol                | mg/l                                 | 0,002               | 0,00             |
| 19. | Mercury               | (Hg) mg/l                            | 0,001               | 0,00             |
| 20. | Arsenic               | (As) mg/l                            | 0,05                | 0,00             |
| 21. | Cadmium               | (Cd) mg/l                            | 0,005               | 0,00             |
| 22. | Chromium Sexivalet    | mg/l                                 | 0,05                | 0,00             |
| 23. | Selenium              | (Se) mg/l                            | 0,01                | 0,00             |
| 24. | Cyanide               | (Cn) mg/l                            | 0,10                | 0,00             |
| 25. | Copper                | (Cu) mg/l                            | 1,00                | 0,00             |
| 26. | Lead                  | (Pb) mg/l                            | 0,05                | 0,00             |

Catatan : ttd = tak terdeteksi

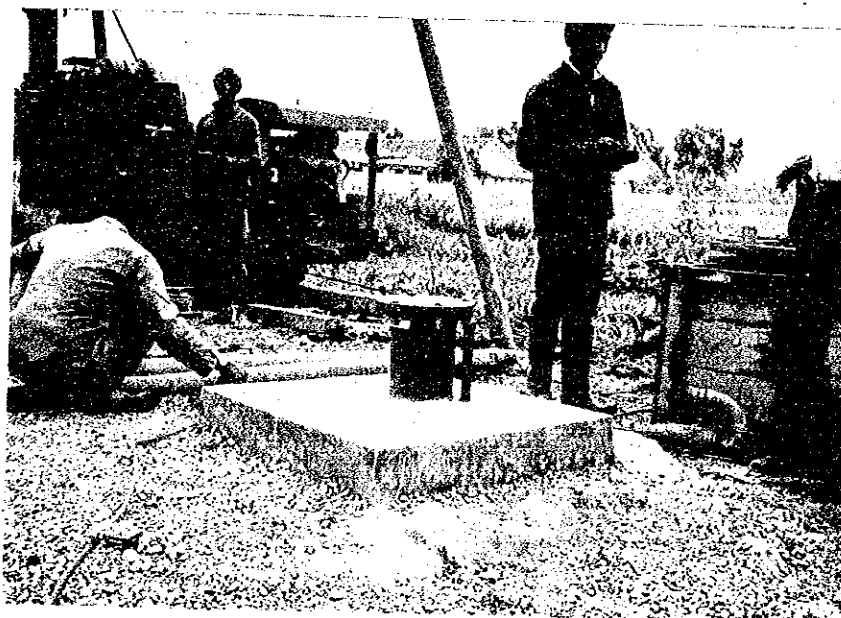
Surabaya, 24 September 1991  
Koordinator Pengabdian Masyarakat  
Lab. Mikrobiologi  
Sonny Soenarsono S, MS.



4.3.9 Photographs of Initial Test Wells



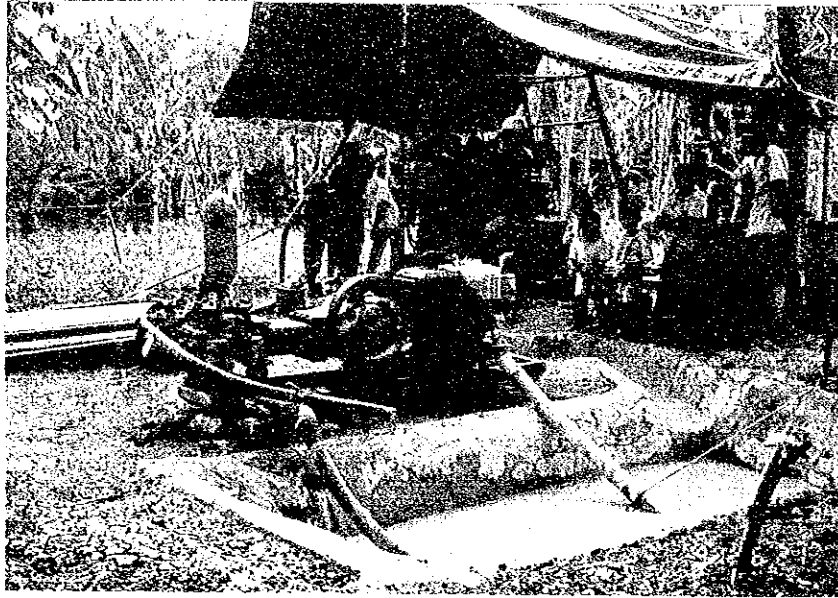
Test well drilling at Kemiri  
June, 1991



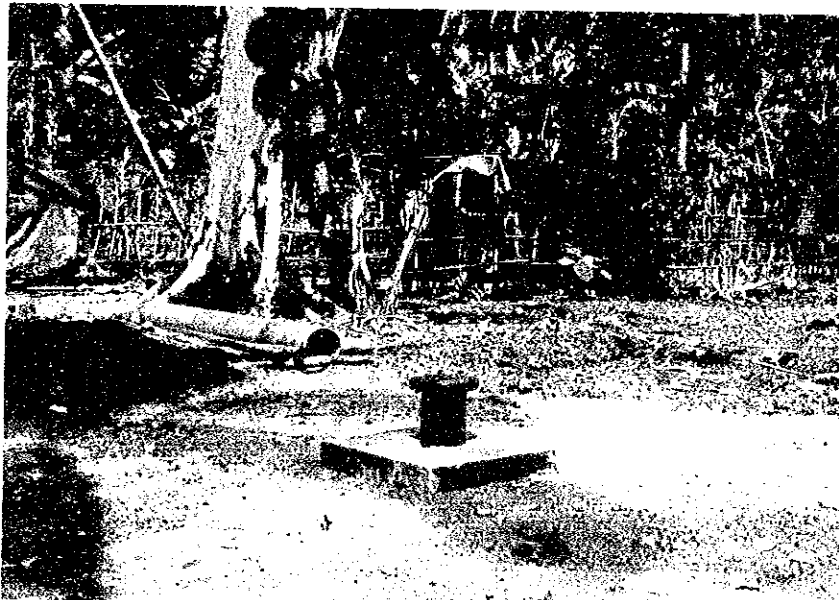
Test well head completed  
August, 1991





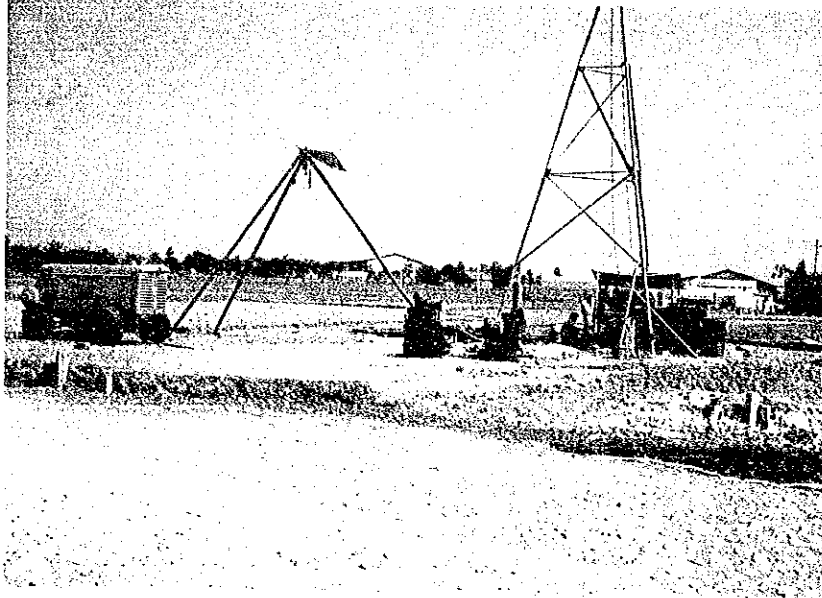


Test well drilling at Jenar  
June, 1991



Test well head completed  
August, 1991



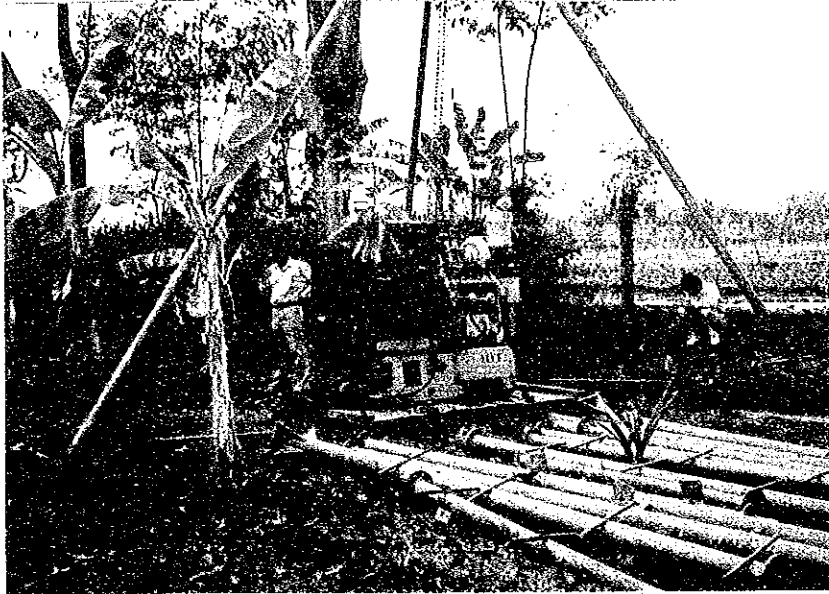


Test well drilling at Jepon  
August, 1991



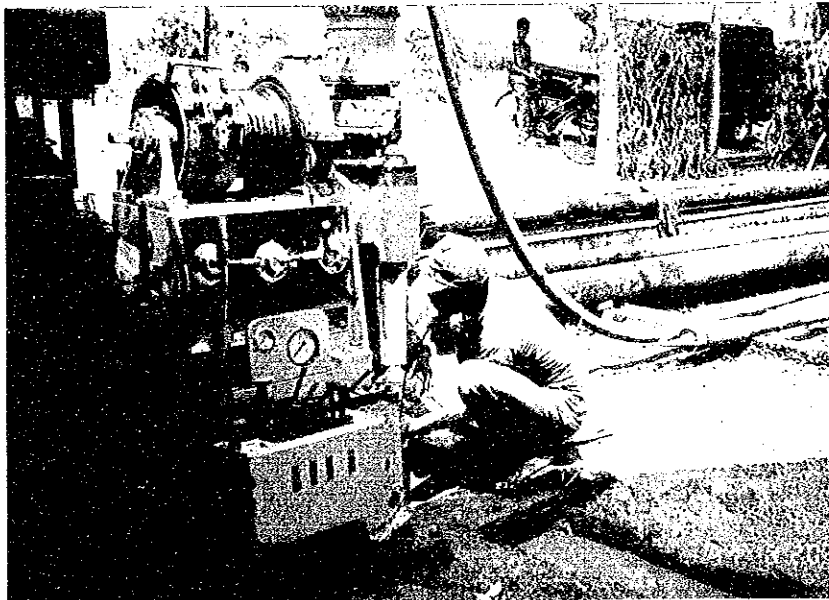
Trial pumping of test well at Jepon  
August, 1991





Drill rig mobilization, Kembangbahu

June, 1991



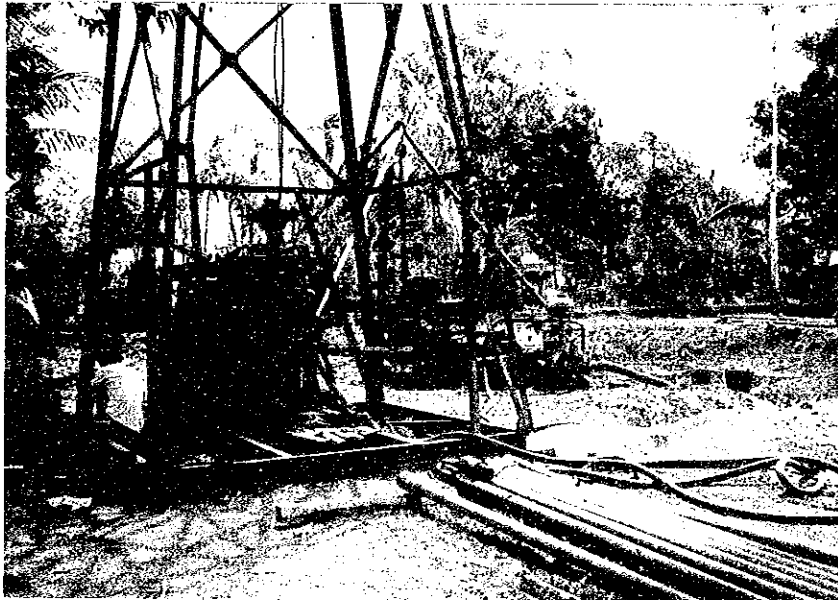
Test well drilling at Kembangbahu

August, 1991





Drill rig mobilization, Banyuanyar  
August, 1991



Test well drilling at Banyuanyar  
August, 1991





#### 4.4 Analyses of Shallow Well Pumping Tests

This section provides the following analytic data that were developed by additional pumping tests of shallow wells in Jenar and Banyuanyar.

1. Pumping Tests of Existing Shallow Wells - IKK Jenar
2. Pumping Tests of Existing Dug Wells - IKK Banyuanar

Pumping tests in Jenar were carried out using a dug well and a bored well; both are existing in Dukuh Prayunan within IKK. Pumping tests in Banyuanyar were carried out using 3 existing dug wells being around the kecamatan office.

Each document includes well condition, pumping test data (water level recovery data), calculation of the permeability of soil, and estimation of yield capacity of proposed well.

##### 4.4.1 Additional Pumping Tests of Existing Shallow Wells in Jenar

###### 1. Dug Well Test

- (1) Test method: Auger-hole method
- (2) Test date: 15 August, 1991
- (3) Test well location: Dukuh Prayunan, Desa Dawung, Kecamatan Jenar
- (4) Test well conditions: See the following sheet
- (5) Test record: Rate-of-rise data after pumping has stopped;

| Elapsed time,<br><u>t', min.</u> | Water level,<br><u>Dw, m</u> | Residual drawdown<br><u>S', m</u> |
|----------------------------------|------------------------------|-----------------------------------|
| 1                                | 5.79                         | 1.29                              |
| 2                                | 5.70                         | 1.20                              |
| 3                                | 5.67                         | 1.17                              |
| 4                                | 5.60                         | 1.10                              |
| 5                                | 5.55                         | 1.05                              |
| 6                                | 5.48                         | 0.98                              |
| 7                                | 5.42                         | 0.92                              |
| 8                                | 5.40                         | 0.90                              |
| 9                                | 5.35                         | 0.85                              |
| 10                               | 5.32                         | 0.82                              |
| 12                               | 5.28                         | 0.78                              |
| 14                               | 5.24                         | 0.74                              |
| 16                               | 5.20                         | 0.70                              |
| 18                               | 5.18                         | 0.68                              |
| 20                               | 5.13                         | 0.63                              |

A graph showing the relationship between residual drawdown and elapsed time is provided on the following page.

(6) Test result analysis

Formula: The Boast & Kirkhan equation;

$$k = Ca (ds'/dt') / 864$$

Where  $k$  = hydraulic conductivity (cm/s), and  $Ca$  = geometry factors that depend on  $Lw/rw$ ,  $s'/Lw$  and  $(H-Lw)/Lw$ .  $ds'/dt'$  in cm/s.

Values of Geometry Factor  $Ca$

| $Lw/rw$ | $s'/Lw$ | $(H-Lw)/Lw$ |     |     |     |          |
|---------|---------|-------------|-----|-----|-----|----------|
|         |         | 0.5         | 1   | 2   | 5   | $\infty$ |
| 1       | 1       | 323         | 286 | 264 | 255 | 254      |
|         | 0.75    | 360         | 324 | 303 | 292 | 291      |
|         | 0.5     | 449         | 411 | 386 | 380 | 379      |
| 2       | 1       | 134         | 123 | 118 | 116 | 115      |
|         | 0.75    | 149         | 138 | 133 | 131 | 131      |
|         | 0.5     | 138         | 175 | 169 | 167 | 167      |

In this test case,  $Lw/rw = 1.5/0.85 = 1.765$ ; say 2.0, and  $(H-Lw)/Lw = (1.64 - 1.5)/1.5 = 9.93$ ; say  $\infty$ .

- 1) When  $s' = 110$  cm,  $ds'/dt' = 0.1$  cm/s and  $s'/Lw = 1.1/1.5 = 0.73$  (say 0.75).

Hence  $Ca = 131$ , thus

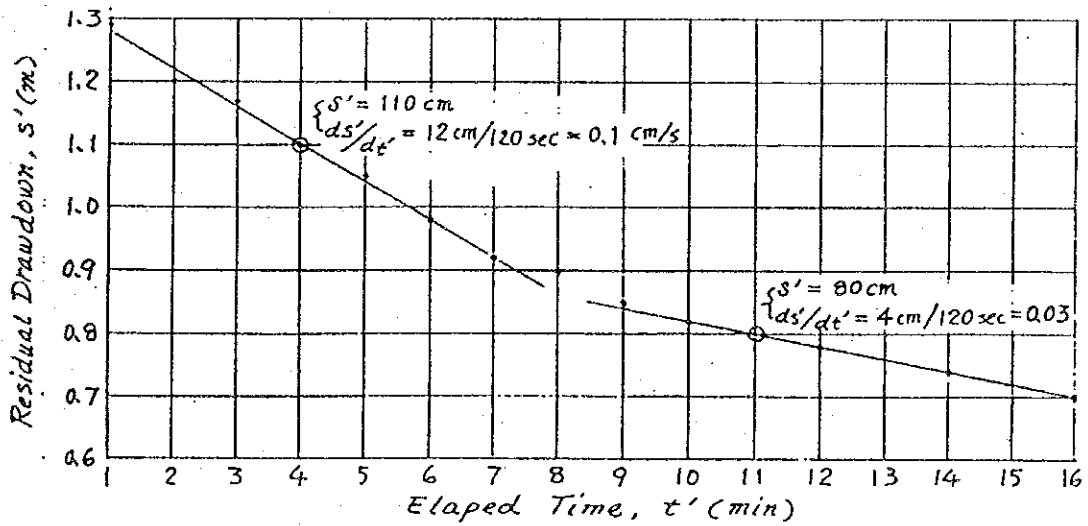
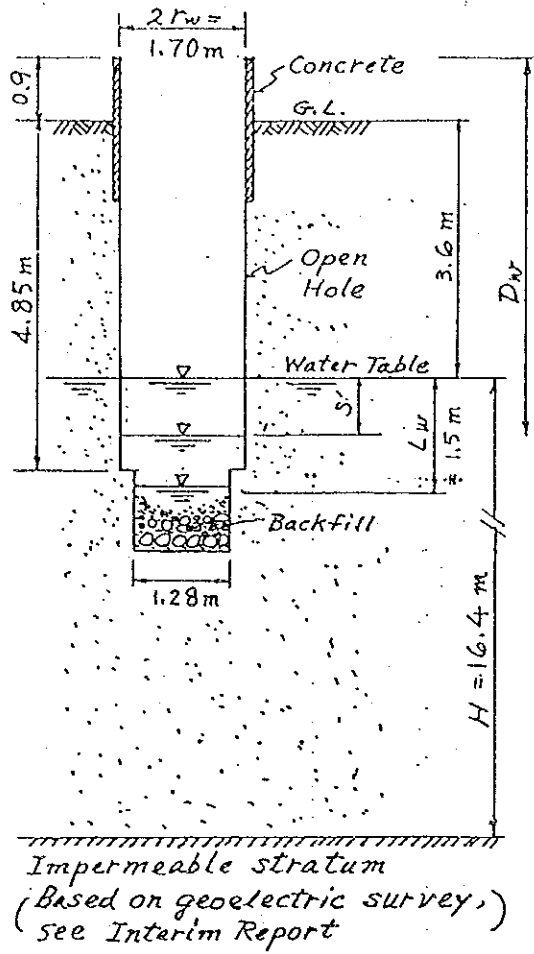
$$k = 131 (0.1) / 864 = 0.015 \text{ cm/s}$$

- 2) When  $s' = 80$  cm,  $ds'/dt' = 0.03$  cm/s and  $s'/Lw = 0.8/1.5 = 0.53$  (say 0.5).

$Ca = 167$ , then

$$k = 167 (0.03) / 864 = 0.006 \text{ cm/s}$$

- 3) Average value of  $k$  is;  $k = (0.015 + 0.006) / 2 = 0.011 \text{ cm/s}$



(7) Application to a fully penetrated well

1) Design condition

Type of aquifer: unconfined

Bottom depth of aquifer: GL-20 m

Lowest water level in the dry season: GL-4m

Hydraulic conductivity (permeability) of aquifer:  $k = 8.64\text{m/d}$

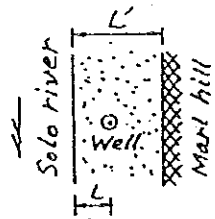
Well diameter: 15cm

Flow condition: Steady flow

Well yield formula: Dupit's formula shown below;

$$Q = \pi k(H^2 - h^2) / \ln(R/r)$$

Radius of influence: Solo river flows on the south and marl hills on the north. For a long time steady flow;



$$R = (4L/\pi) \tan(\pi L/2L)$$

Actually,  $L = 100\text{m}$ , and

$L = 800\text{m}$ , so

$R$  is estimated to be 203 m

2) Well yield estimation

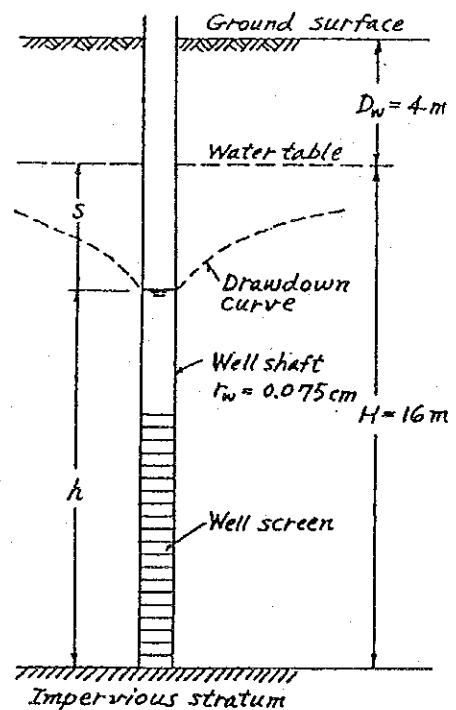
$K = 8.64\text{m/d}$ ,  $H = 16\text{ m}$ ,  $R = 203\text{m}$ , and  $r = 0.075\text{m}$ . Therefore

$$Q = \pi(8.64) (H^2 - h^2) / \ln(203/0.075)$$

$$= 3.4344 (H^2 - h^2) = 3.4344 (H+h)s$$

Hence, the following relation is obtained.

| $h$ (m) | $s$ (m) | $Q$ (m <sup>3</sup> /d) | $Q$ (l/s) |
|---------|---------|-------------------------|-----------|
| 14      | 2       | 206.1                   | 2.38      |
| 12      | 4       | 384.6                   | 4.45      |
| 10      | 6       | 535.7                   | 6.20      |
| 8       | 8       | 659.4                   | 7.63      |
| 6       | 10      | 755.6                   | 8.74      |
| 4       | 12      | 824.3                   | 9.54      |



### 3) Well design

Required total demand for IKK Jenar is 9 l/s. Judging from the estimated well capacity, the following well diameter is satisfactory;

10 cm dia. for pump bowl

15 cm dia. for casing and screens

The drilling should be made to a depth of 30 m, and the well should be sunk to minimum depth of 20 m or to the imperious stratum. Total length of screens shall not be less than 8 m. Use  $Q = 5$  l/s/well for design purpose. Consequently, two wells of similar size shall be installed.

### 2. Bored Well Test

- (1) Test method: Constant rate pumping
- (2) Test well location: 105 m from the tested dug well, Dukuh Prayunan
- (3) Size of well: 2" dia. PVC pipe; Depth is 12 m (partially penetrated)
- (4) Static water level: 2.30 m
- (5) Discharge rate: 4 l/s (constant)
- (6) Pumping duration: 10hrs
- (7) Result: Pumping for more than 10 hours could not be carried out because the owner did not allow it, but the drawdown was only 2.70 m. This result indicates that the well capacity is comparatively high

#### 4.4.2 Additional Pumping tests of Existing Shallow Wells in Banyuanyar

##### 1. Introduction

In IKK Banyuanar, pumping tests were conducted using 3 existing dug wells that are present near the deep test well. They locate within Desa Liprak Kidul, a center part of IKK. The depth of these dug wells is in the range of 21.76 m to 27.14 m, and the water depth in the wells was only 0.31 m to 0.53 m. The pumping test was carried out on 13 September, 1991. Basic information about these dug wells are summarized below.

| <u>Dug Well No.</u> | <u>Well Depth</u> | <u>S.W.L.</u> | <u>Water Depth</u> | <u>Distance from T.W.</u> |
|---------------------|-------------------|---------------|--------------------|---------------------------|
| DW-1                | 27.14m            | 26.67m        | 0.47m              | 80m                       |
| DW-2                | 25.08m            | 24.77m        | 0.31m              | 180m                      |
| DW-4                | 21.76m            | 21.23m        | 0.53m              | 80m                       |

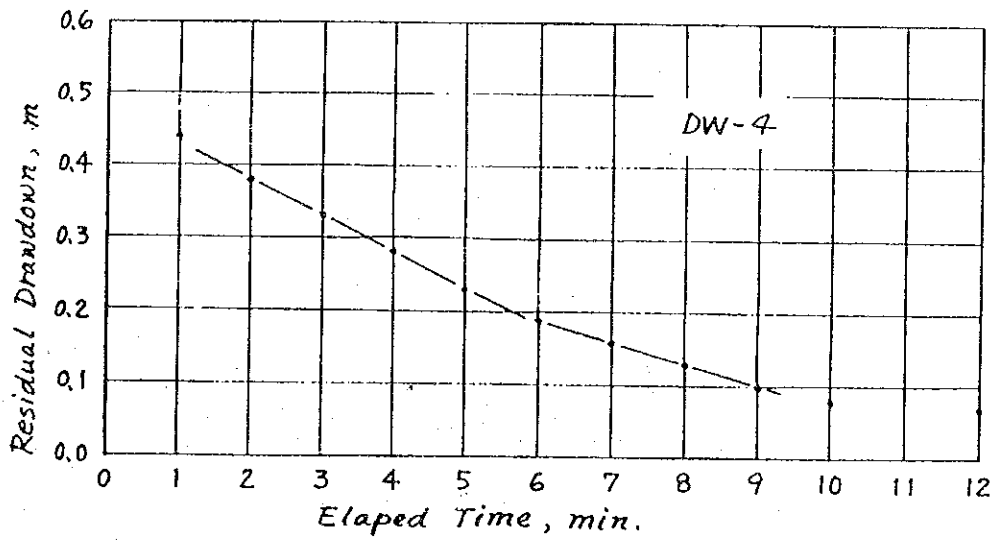
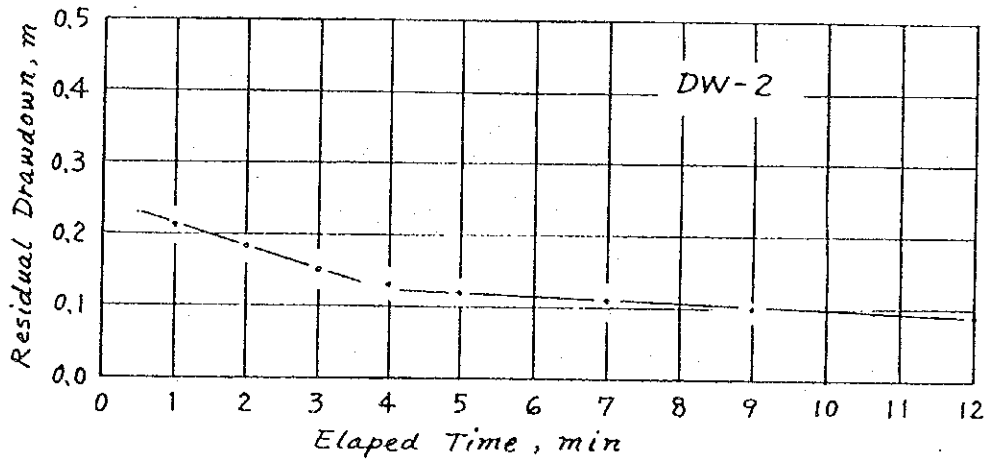
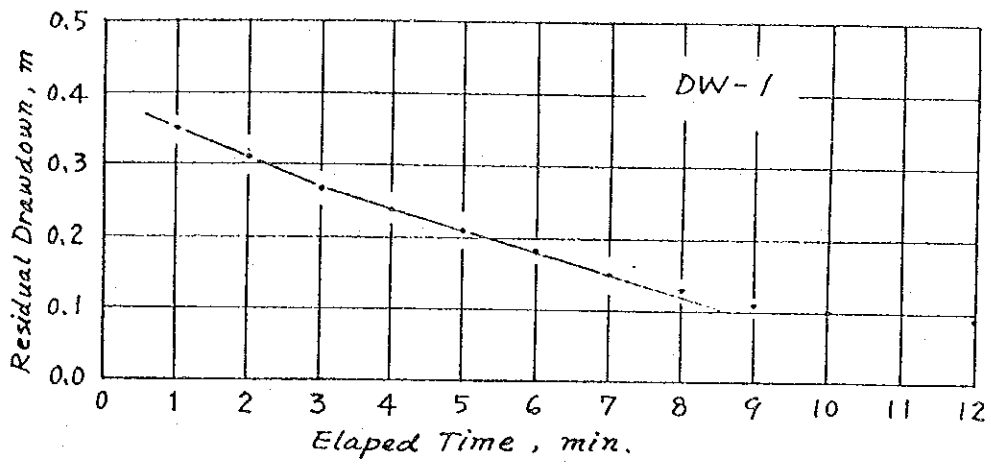
Diameter of the dug wells was about 2m.

##### 2. Recovery Data

After pumping at a constant rate of 0.46 l/s, water level recovery was observed at each well. The data are summarized below.

| <u>Elapsed Time after<br/>Pumping stops (min)</u> | <u>DW-1</u>   |           | <u>DW-2</u>   |           | <u>DW-4</u>   |           |
|---|---------------|-----------|---------------|-----------|---------------|-----------|
|   | <u>D.W.L.</u> | <u>s'</u> | <u>D.W.L.</u> | <u>s'</u> | <u>D.W.L.</u> | <u>s'</u> |
| 1   | 27.02m        | 0.35m     | 24.98m        | 0.21m     | 21.67m        | 0.44m     |
| 2   | 26.98m        | 0.31m     | 24.95m        | 0.16m     | 21.61m        | 0.38m     |
| 3   | 26.94m        | 0.27m     | 24.92m        | 0.15m     | 21.56m        | 0.33m     |
| 4   | 26.91m        | 0.24m     | 24.90m        | 0.13m     | 21.51m        | 0.28m     |
| 5   | 26.82m        | 0.21m     | 24.89m        | 0.12m     | 21.46m        | 0.23m     |
| 6   | 26.85m        | 0.18m     | 24.885        | 0.115     | 21.42m        | 0.19m     |
| 7   | 26.82m        | 0.15m     | 24.88m        | 0.11m     | 21.39m        | 0.16m     |
| 8   | 26.80m        | 0.13m     | 24.875        | 0.105     | 21.36m        | 0.13m     |
| 9   | 26.78m        | 0.11m     | 24.87m        | 0.10m     | 21.33m        | 0.10m     |
| 10  | 26.77m        | 0.10m     | 24.865        | 0.095     | 21.31m        | 0.08m     |
| 12  | 26.76m        | 0.09m     | 24.86m        | 0.09m     | 21.30m        | 0.07m     |
| 14  | 26.75m        | 0.08m     | 24.85m        | 0.08m     | 21.29m        | 0.06m     |

The following graph shows a relation between time and residual drawdown.



3. Calculation of Permeability of Subsoil

(1) Formula: The following equation for auger hole is used in this case.

$$K = \frac{r}{16DS} \times \frac{h_1 - h_2}{t_2 - t_1}$$

In which S is a factor. In this case of the dug wells S = 0.5 may be used.

(2) Calculation of k

1) For DW-1: D = 47 cm

Case - 1;  $t_1 = 2\text{min.}, t_2 = 3\text{min.}, h_1 = 31\text{ cm}, h_2 = 27\text{ cm}$

$$k = \{100/16(47)(0.5)\} (4/60) = 0.018\text{ cm/s}$$

Case - 2;  $t_1 = 4\text{min.}, t_2 = 5\text{min.}, h_1 = 24\text{ cm}, h_2 = 21\text{ cm.}$

$$k = \{100/16(47)(0.5)\} (3/60) = 0.013\text{ cm/s}$$

2) For DW - 2: D = 31 cm

Case - 1;  $t_1 = 2\text{min.}, t_2 = 3\text{min.}, h_1 = 18\text{ cm}, h_2 = 15\text{ cm}$

$$k = \{100/16(31)(0.5)\} (3/60) = 0.02\text{ cm/s}$$

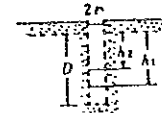
3) For DW - 4: D = 53cm

Case - 1;  $t_1 = 3\text{min.}, t_2 = 4\text{min.}, h_1 = 33\text{cm}, h_2 = 28\text{ cm}$

$$k = \{100/16(53)(0.5)\} (3/60) = 0.012\text{ cm/s}$$

Case - 2;  $t_1 = 7\text{min.}, t_2 = 8\text{min.}, h_1 = 16\text{ cm}, h_2 = 13\text{ cm.}$

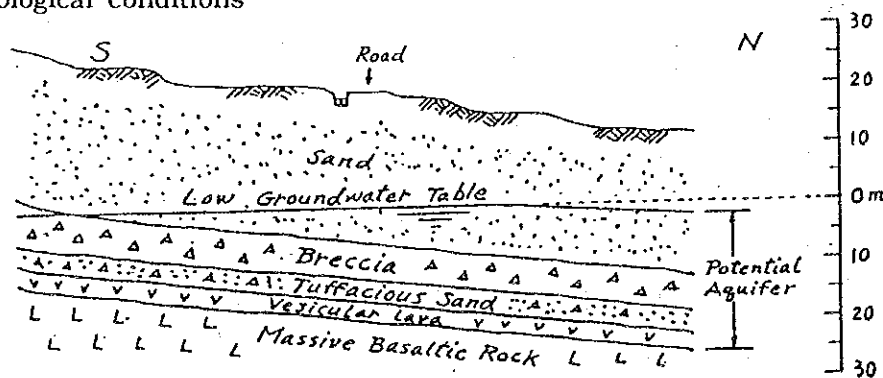
$$k = \{100/16(53)(0.5)\} (3/60) = 0.012\text{ cm/s}$$



The results show that the coefficient of permeability of subsoil is more than 0.012 cm/s, which implies that the subsoil below groundwater but above the basaltic lava is a good aquifer.

4. Estimation of Yield Capacity of a Medium Depth Well

(1) Lithological conditions



A Schematic Diagram showing Subsurface Conditions



From a lithological profile of the test well of 84m depth, topography and water level in existing dug wells (G.W.L. in dug wells is almost flat in elevation). It is estimated that a typical hydrogeological profile in IKK Banyuanyar is as shown in the preceding sheet. Note that aquifer thickness increases as going north.

(2) Design condition

- 1) Aquifer type: Unconfined aquifer
- 2) Well location : About 250m north of the town main road
- 3) Well size: Depth = 40m, well casing = 20cm diameter
- 4) Average aquifer thickness:  $H = 18.5\text{m}$
- 5) Radius of influence:  $R = 300\text{m}$
- 6) Permeability of aquifer materials:  $k = 8.64\text{m/d}$  on the safe side
- 7) Equation:  $Q = \pi k (H_2 - h_2) / \ln (R/r)$

(3) Calculation results

- 1) When the drawdown in 6m;  $Q = 630.6\text{m}^3/\text{d} = 7.3 \text{ l/s}$
- 2) When the drawdown is 8m;  $Q = 786.5\text{m}^3/\text{d} = 9.1 \text{ l/s}$
- 3) When the drawdown is 10m;  $Q = 915.4 \text{ m}^3/\text{d} = 10.6 \text{ l/s}$

(4) Proposal

Water demand for IKK Banyuanyar is 20 l/s, so provide 3 wells of  $Q = 7-8 \text{ l/s}$  capacity and the depth = 40 - 50m, each.

## 5. Water Quality Analyses

### 5.1 Items of Water Quality Analyses

Table B.5.1 shows the items of water quality analyses conducted together with the Indonesian Standard for Clean Water and its threshold values. Photographs of the analyses using the portable test kit at some sites are attached.

### 5.2 Results of Water Quality Analyses

Table B.5.2 summarizes the results of the analyses on samples collected from 9 (nine) springs, 1 (one) river water and 5 (five) groundwater of testwells. As for COD on samples collected from Tranbawulan Spring, Tlogomili Spring and Umbul Spring were rechecked at laboratory in Yogyakarta.

Name of laboratories are given in bottom marginal note.

Table-B.5.1

## Items of Water Quality Analysis

| No | Items                                     | Unit        | Indonesian Standard<br>(Clean Water) | Analized at Site | Analized at Laboratory |
|----|---|-------------|--------------------------------------|------------------|------------------------|
|    | (Physical Properties)                     |             |                                      |                  |                        |
| 1  | Colour                                    | Pt/Co       | 50                                   | —                | ○                      |
| 2  | Odor                                      | —           | None                                 | —                | ○                      |
| 3  | Taste                                     | —           | None                                 | —                | ○                      |
| 4  | Turbidity                                 | NTU         | 25                                   | ○                | ○                      |
|    | (Chemical Properties)                     |             |                                      |                  |                        |
| 5  | pH  | —           | 6.5-9.0                              | ○                | ○                      |
| 6  | Total Dissolved Solids                    | mg/l        | 1500                                 | ○                | ○                      |
| 7  | C O D                                     | mg/l        | 10                                   | —                | ○                      |
| 8  | Total Hardness as (CaCO <sub>3</sub> )    | mg/l        | 500                                  | ○                | ○                      |
| 9  | Calcium (Ca)                              | mg/l        | 200                                  | ○                | ○                      |
| 10 | Magnesium (Mg)                            | mg/l        | 120                                  | ○                | ○                      |
| 11 | Total Iron (Fe)                           | mg/l        | 1.0                                  | ○                | ○                      |
| 12 | Manganese (Mn)                            | mg/l        | 0.5                                  | ○                | ○                      |
| 13 | Zinc (Zn)                                 | mg/l        | 15                                   | —                | ○                      |
| 14 | Chloride (Cl <sup>-</sup> )               | mg/l        | 600                                  | ○                | ○                      |
| 15 | Sulphate (SO <sub>4</sub> <sup>2-</sup> ) | mg/l        | 400                                  | ○                | ○                      |
| 16 | Fluoride (F)                              | mg/l        | 1.5                                  | ○                | ○                      |
| 17 | Nitrate (NO <sub>3</sub> -N)              | mg/l        | 10                                   | ○                | ○                      |
| 18 | Phenol                                    | mg/l        | 0.002                                | —                | ○                      |
| 19 | Mercury (Hg)                              | mg/l        | 0.001                                | —                | ○                      |
| 20 | Arsenic (As)                              | mg/l        | 0.05                                 | —                | ○                      |
| 21 | Cadmium (Cd)                              | mg/l        | 0.005                                | —                | ○                      |
| 22 | Chromium Sexivalent (Cr6+)                | mg/l        | 0.05                                 | ○                | ○                      |
| 23 | Selenium (Se)                             | mg/l        | 0.01                                 | —                | ○                      |
| 24 | Cyanide (CN <sup>-</sup> )                | mg/l        | 0.1                                  | —                | ○                      |
| 25 | Copper (Cu)                               | mg/l        | 1.0                                  | ○                | ○                      |
| 26 | Lead (Pb)                                 | mg/l        | 0.05                                 | —                | ○                      |
|    | (Bacterial Test)                          |             |                                      |                  |                        |
|    | Total Coliform                            | group/100ml | 10                                   | ○                | —                      |
|    | Bacteria                                  | pcs./ml     | not given                            | ○                | —                      |

Table B.5.2 Summary of Water Quality Data

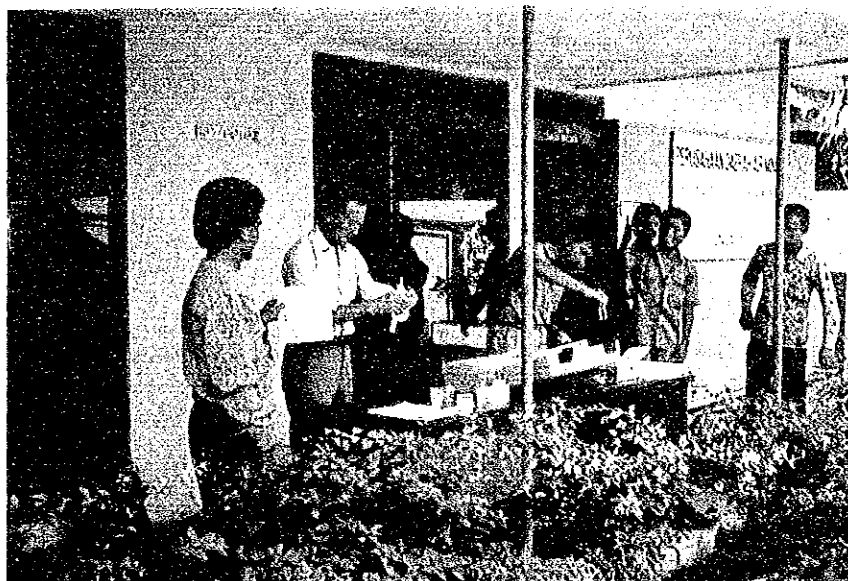
| Name Code          |   | 3           |                                   | 4            |                        | 5                 |           | 8                |          | 9         |          | 10                         |                       | 12             |           | 13            |                       | 14               |          | 19                                     |          | 24                 |          | 25          |          | 27                 |          | 29             |          | 30                  |          |         |       |
|--------------------|---|-------------|-----------------------------------|--------------|------------------------|-------------------|-----------|------------------|----------|-----------|----------|----------------------------|-----------------------|----------------|-----------|---------------|-----------------------|------------------|----------|--|----------|--------------------|----------|-------------|----------|--------------------|----------|----------------|----------|---------------------|----------|---------|-------|
| Kabupaten          |   | PURWOREJO   |                                   | BANJARNEGARA |                        | BANJARNEGARA      |           | KENDAL           |          | BLORA     |          | PATI                       |                       | SRAGEN         |           | WONOGIRI      |                       | SEMARANG         |          | LAMONGAN                               |          | LUMAJANG           |          | PROBOLINGO  |          | GIANJAR            |          | KARANGASEM     |          | KARANGASEM          |          |         |       |
| Kecamatan          |   | KEMIRI      |                                   | MADUKARA     |                        | PUNGCELAN         |           | SUKOREJO         |          | JEPON     |          | BATANGAN                   |                       | JENAR          |           | GIRIWOYO      |                       | HARJOSARI        |          | KEMBANGBAHU                            |          | TEMPURSARI         |          | BANYUANYAR  |          | TAPPAKSIRING       |          | RENDANG        |          | BEBANDEM            |          |         |       |
| I K K              |   | KEMIRI      |                                   | MADUKARA     |                        | PUNGCELAN         |           | SUKOREJO         |          | JEPON     |          | BATANGAN                   |                       | JENAR          |           | GIRIWOYO      |                       | BAWEN            |          | KEMBANGBAHU                            |          | TEMPURSARI         |          | BANYUANYAR  |          | TAPPAKSIRING       |          | MENANGA        |          | SIBETAN             |          |         |       |
| Type of Source     |   | SW          |                                   | SPR          |                        | SPR               |           | SPR              |          | DW        |          | Surface Water              |                       | SW             |           | SPR           |                       | SPR              |          | DW                                     |          | SPR                |          | SW          |          | SPR                |          | SPR            |          | SPR                 |          |         |       |
| Source Name        |   |             |                                   | Mudal Spring |                        | Trebawulan Spring |           | Tlogomili Spring |          |           |          | Sani river Genbong Dam     |                       |                |           | Kakap Spring  |                       | Umbul Spring     |          |  |          | Umbulsari I Spring |          |             |          | Titra Empul Spring |          | Gerubug Spring |          | Dukuh Mading Spring |          |         |       |
| Source Location    |   | Desa Kerep  |                                   | Banjarmangu  |                        | Desa Petugulan    |           | Desa Tlogopoyo   |          | Desa Soko |          | Desa Karangudowo Kec. Pali |                       | Dusun Prayunan |           | Desa Giriwoyo |                       | Desa Keban Dalem |          | Desa Manu Kujajar, Desa Kedung Megarih |          | Tempursari         |          | Desa Liprak |          | Titra Empul Spring |          | Desa Mananga   |          | Banjar Dukuh        |          |         |       |
| No                 | Items of Water Quality Analysis           | Unit        | Indonesian Standard (Clean Water) | at site      | at labo.               | at site           | at labo.  | at site          | at labo. | at site   | at labo. | at site                    | at labo.              | at site        | at labo.  | at site       | at labo.              | at site          | at labo. | at site                                | at labo. | at site            | at labo. | at site     | at labo. | at site            | at labo. | at site        | at labo. | at site             | at labo. |         |       |
| 1                  | (Physical Properties) Color               | Pt/Co       | 50                                | -            | 12                     | -                 | 5         | -                | 5        | -         | 5        | -                          | 3                     | -              | 5         | -             | 2                     | -                | 12       | -                                      | 5        | -                  | 30       | -           | 5        | -                  | 4.5      | -              | 0.0      | -                   | 0.0      | -       | 0.0   |
| 2                  | Ordor                                     | -           | None                              | -            | normal                 | -                 | normal    | -                | -        | -         | -        | -                          | normal                | -              | normal    | -             | normal                | -                | normal   | -                                      | -        | -                  | -        | -           | -        | None               | -        | None           | -        | None                | -        | None    |       |
| 3                  | Taste                                     | -           | None                              | -            | normal                 | -                 | normal    | -                | -        | -         | -        | -                          | normal                | -              | normal    | -             | normal                | -                | normal   | -                                      | -        | -                  | -        | -           | -        | None               | -        | None           | -        | None                | -        | None    |       |
| 4                  | Turbidity                                 | NTU         | 25                                | -            | 10 (SiO <sub>2</sub> ) | -                 | 0.5 (FTU) | 1 (FTU)          | 5        | 0 (FTU)   | 5        | -                          | 5 (SiO <sub>2</sub> ) | -              | 1.2 (FTU) | -             | 3 (SiO <sub>2</sub> ) | 0 (FTU)          | 10       | 0 (FTU)                                | 5        | -                  | 3.1      | 0 (FTU)     | 2.1      | -                  | 19.6     | 0 (FTU)        | 0        | 0 (FTU)             | 0        | 0 (FTU) | 0     |
| 5                  | (Chemical Properties) pH                  | -           | 6.5-9.0                           | -            | 6.81                   | -                 | 7.0       | 6.99             | 6.5      | 7.00      | 7.0      | -                          | 6.76                  | -              | 6.9       | -             | 7.72                  | 6.97             | 6.90     | 6.99                                   | 6.5      | -                  | 8.0      | 7.00        | 7.2      | -                  | 8.1      | 7.00           | 7.3      | 7.00                | 7.3      | 7.00    | 7.4   |
| 6                  | Total Dissolved Solid                     | mg/L        | 1500                              | -            | 200                    | -                 | 0.04      | 56.7             | 100      | 63.8      | 100      | -                          | 508.5                 | -              | 1.16      | -             | 560.0                 | 294              | 0.4      | 111.4                                  | 180      | -                  | 1.634    | 139.3       | 214      | -                  | 454.0    | 266            | 172      | 206                 | 502      | 149.8   | 564   |
| 7                  | COD                                       | mg/L        | 10                                | -            | 3.7                    | -                 | 5.06      | -                | 0.29     | -         | 0.00     | -                          | 2.0                   | -              | 5.06      | -             | 6.7                   | -                | 3.12     | -                                      | 0.00     | -                  | 18.4     | -           | -        | -                  | 7.3      | -              | -        | -                   | -        | -       |       |
| 8                  | Total Hardness as CaCO <sub>3</sub>       | mg/L        | 500                               | -            | 140.4                  | -                 | 50.4      | 45               | 64.26    | 133       | 74.23    | -                          | 476.2                 | -              | 85.4      | -             | 109.5                 | 300              | 333      | 91                                     | 103.95   | -                  | 178.57   | 103         | 121.43   | -                  | 328.6    | 180            | 170.3    | 125                 | 146.5    | 145     | 190.1 |
| 9                  | Calcium (Ca)                              | mg/L        | 200                               | -            | -                      | -                 | 14        | 29               | -        | 42        | -        | -                          | 128.8                 | -              | 20        | -             | 25.0                  | 287              | 121      | 65                                     | -        | -                  | 92.9     | 69          | 71.43    | -                  | 84.0     | 91             | 35.7     | 76                  | 34.13    | 77      | 55.25 |
| 10                 | Magnesium (Mg)                            | mg/L        | 120                               | -            | -                      | -                 | 3.7       | -                | -        | -         | -        | -                          | 37.7                  | -              | 8.6       | -             | 11.3                  | -                | 7.4      | -                                      | -        | -                  | 85.7     | -           | 50.00    | -                  | 28.3     | -              | 20.5     | -                   | 9.79     | -       | 12.70 |
| 11                 | Total Iron (Fe)                           | mg/L        | 1.0                               | -            | 3.5                    | -                 | 0.0       | 0.03             | 0.0      | 0.01      | 0.25     | -                          | 1.4                   | -              | 0.0       | -             | 0.01                  | 0.01             | 0.0      | 0.01                                   | 0.0      | -                  | 0.5      | 0.0         | 0.0      | -                  | -        | 0.01           | 0.0      | 0.01                | 0.05     | 0.02    | 0.05  |
| 12                 | Manganese (Mn)                            | mg/L        | 0.5                               | -            | 0.61                   | -                 | 0.0       | 0.0              | 0.0      | 0.0       | 0.20     | -                          | 0.0                   | -              | 0.0       | -             | 0                     | 0.2              | 0.0      | 0.0                                    | 0.0      | -                  | 0.00     | 0.0         | 0.0      | -                  | 0.0      | 0.0            | 0.0      | 0.0                 | 0.0      | 0.0     | 0.0   |
| 13                 | Zinc (Zn)                                 | mg/L        | 15                                | -            | 0                      | -                 | 0.01      | 0.43             | 0.15     | 0.40      | 0.15     | -                          | 0.99                  | -              | 0.0       | -             | 0                     | 0.45             | 0.0      | 0.45                                   | 0.15     | -                  | 0.00     | 0.44        | 0.0      | -                  | 0.0      | 0.38           | 0.0      | 0.45                | 0.0      | 0.39    | 0.0   |
| 14                 | Chloride (Cl <sup>-</sup> )               | mg/L        | 600                               | -            | 49.5                   | -                 | 5.8       | 2.0              | 3.61     | 4.0       | 7.1      | -                          | 17.1                  | -              | 9.8       | -             | 133.9                 | 7.0              | 4.7      | 1.0                                    | 7.98     | -                  | 666.5    | 6.0         | 68.0     | -                  | 35.0     | 54             | 0.0      | 14.0                | 5.25     | 19.0    | 31.48 |
| 15                 | Sulphate (SO <sub>4</sub> <sup>-2</sup> ) | mg/L        | 400                               | -            | 0.0                    | -                 | 13.6      | 0.0              | 1.0      | 0.0       | 0.0      | -                          | 237                   | -              | 3.0       | -             | 0.0                   | 1.0              | 47.2     | 0.0                                    | 0.0      | -                  | 30.0     | 9.0         | 4.57     | -                  | 4.2      | 0.0            | 0.0      | 104                 | 166.6    | 0.0     | 93.75 |
| 16                 | Fluoride (F)                              | mg/L        | 1.5                               | -            | 0.0                    | -                 | 0.07      | 0.00             | -        | 0.07      | -        | -                          | 0.12                  | -              | 0.38      | -             | 0.0                   | 0.00             | 0.003    | 0.46                                   | -        | -                  | 0.00     | 0.5         | -        | -                  | 0.6      | 0.52           | 0.0      | 0.54                | 0.0      | 0.35    | 0.0   |
| 17                 | Nitrate (NO <sub>3</sub> -N)              | mg/L        | 10                                | -            | 0.0                    | -                 | 2.0       | 0.7              | 0.0      | 0.9       | 0.0      | -                          | 0.0                   | -              | 3.0       | -             | 0.0                   | 1.5              | 2.3      | 1.1                                    | 0.0      | -                  | 0.0      | 1.5         | 7.23     | -                  | 4.3      | 1.7            | 0.0      | 2.2                 | 0.0      | 1.7     | 0.0   |
| 18                 | Phenol                                    | mg/L        | 0.002                             | -            | -                      | -                 | 0.0       | -                | 0.0      | -         | 0.0      | -                          | -                     | -              | 0.0       | -             | -                     | -                | 0.0      | -                                      | 0.0      | -                  | 0.0      | -           | 0.0      | -                  | 0.0      | -              | 0.0      | -                   | 0.0      | -       | 0.0   |
| 19                 | Mercury (Hg)                              | mg/L        | 0.001                             | -            | 0.0                    | -                 | 0.0       | -                | 0.0      | -         | 0.0      | -                          | 0.0                   | -              | 0.0       | -             | 0.0                   | -                | 0.0      | -                                      | 0.0      | -                  | 0.0      | -           | 0.0      | -                  | 0.0      | -              | 0.0      | -                   | 0.0      | -       | 0.0   |
| 20                 | Arsenic (As)                              | mg/L        | 0.05                              | -            | 0.0                    | -                 | 0.0       | -                | 0.0      | 0.01      | 0.0      | -                          | 0.0                   | -              | 0.0       | -             | 0.0                   | -                | 0.0      | -                                      | 0.0      | -                  | 0.0      | -           | 0.0      | -                  | 0.0      | -              | 0.0      | -                   | 0.0      | -       | 0.0   |
| 21                 | Cadmium (Cd)                              | mg/L        | 0.005                             | -            | 0.0                    | -                 | 0.0       | -                | 0.0      | -         | 0.0      | -                          | 0.0                   | -              | 0.0       | -             | 0.0                   | -                | 0.0      | -                                      | 0.0      | -                  | 0.0      | -           | 0.0      | -                  | 0.0      | -              | 0.0      | -                   | 0.0      | -       | -     |
| 22                 | Chromium Sexivalent (Cr6 <sup>+</sup> )   | mg/L        | 0.05                              | -            | -                      | -                 | 0.0       | 0.01             | 0.00     | 0.00      | 0.00     | -                          | 0.00                  | -              | 0.00      | -             | -                     | 0.02             | 0.00     | 0.01                                   | 0.00     | -                  | 0.00     | 0.01        | 0.00     | -                  | 0.00     | 0.01           | 0.0      | 0.01                | 0.0      | 0.01    | 0.0   |
| 23                 | Selenium (Se)                             | mg/L        | 0.01                              | -            | 0.0                    | -                 | -         | -                | -        | -         | -        | -                          | 0.0                   | -              | -         | -             | 0.0                   | -                | -        | -                                      | -        | -                  | 0.00     | -           | -        | -                  | 0.0      | -              | 0.0      | -                   | 0.0      | -       | 0.0   |
| 24                 | Cyanide (CN <sup>-</sup> )                | mg/L        | 0.1                               | -            | 0.0                    | -                 | 0.0       | -                | 0.00     | -         | 0.00     | -                          | 0.00                  | -              | 0.00      | -             | 0.0                   | -                | 0.00     | -                                      | 0.00     | -                  | 0.00     | -           | 0.00     | -                  | 0.00     | -              | 0.0      | -                   | 0.0      | -       | 0.0   |
| 25                 | Copper (Cu)                               | mg/L        | 1.0                               | -            | 0.00                   | -                 | 0.01      | 0.03             | 0.00     | 0.04      | 0.00     | -                          | 0.08                  | -              | 0.00      | -             | 0.0                   | -                | 0.00     | 0.03                                   | 0.00     | -                  | 0.00     | 0.04        | 0.00     | -                  | 0.00     | 0.06           | 0.0      | 0.05                | 0.0      | 0.05    | 0.0   |
| 26                 | Lead (Pb)                                 | mg/L        | 0.05                              | -            | 0.0                    | -                 | 0.62      | -                | 0.00     | -         | 0.00     | -                          | 0.00                  | -              | 0.15      | -             | 0.0                   | -                | 0.066    | -                                      | 0.00     | -                  | 0.00     | -           | 0.00     | -                  | 0.0      | -              | 0.0      | -                   | 0.0      | -       | 0.0   |
| Name of Laboratory |   |             |                                   | B            |                        | Y                 |           | SE               |          | SE        |          | B                          |                       | Y              |           | B             |                       | Y                |          | SE                                     |          | SU                 |          | SU          |          | SU                 |          | 0              |          | 0                   |          | 0       |       |
| (Bacterial Test)   |   |             |                                   |              |                        |                   |           |                  |          |           |          |                            |                       |                |           |               |                       |                  |          |  |          |                    |          |             |          |                    |          |                |          |                     |          |         |       |
| Total Coliform     |   | group/100ml | 10                                | -            | -                      | -                 | -         | 100              | -        | 700       | -        | -                          | -                     | -              | -         | -             | 600                   | -                | 500      | -                                      | -        | -                  | 0        | -           | -        | -                  | 4,000    | -              | 300      | -                   | 200      | -       |       |
| Bacteria           |   | pcs./ml     | -                                 | -            | -                      | -                 | -         | 1,000            | -        | 20,000    | -        | -                          | -                     | -              | -         | -             | 17,000                | -                | 5,000    | -                                      | -        | -                  | 10,000   | -           | -        | -                  | 23,000   | -              | 2,000    | -                   | 2,000    | -       |       |

\* Note1 Y -- Departemen Pendidikan Dan Kebudayaan Universitas Gadjah Mada Fakultas Geografi, Yogyakarta  
 SE -- Departemen Kesehatan R. I. Direktorat Jenderal Pengawasan Obat & Makanan Balai Pemeriksaan Obat Dan Makanan, Semarang  
 SU -- Laboratorium Teknik Penyehatan Jurusan Teknik Sipil Fakultas Teknik Sipil Dan Perencanaan Institut Teknologi Sepuluh Nopember, Surabaya  
 D -- Departemen Kesehatan R. I. Balai Laboratorium Kesehatan Denpasar  
 B -- Departemen Kesehatan R. I. Balai Laboratorium Kesehatan, Bandung

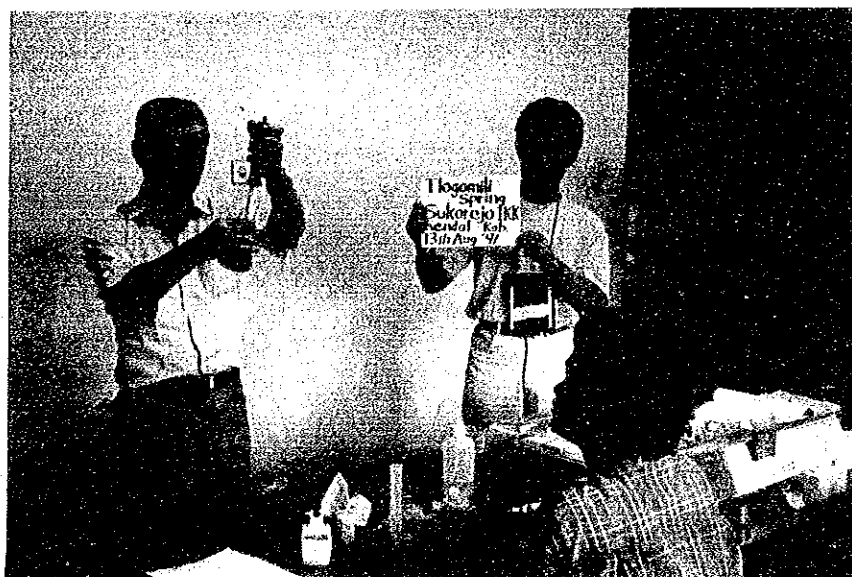
\* Note2 Mark [ - ] not analyzed



Photographs of Water Quality Analysis at Site



Umbul Spring (IKK Bawen) analyzed at PDAM office  
Aug. 1991



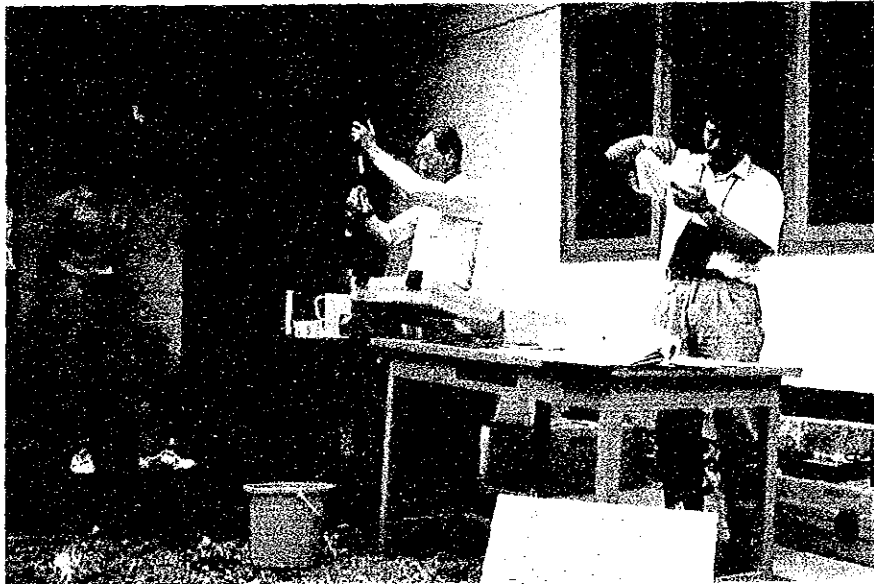
Tologomili Spring (IKK Sukorejo) analyzed at PDAM Branch office  
Aug. 1991





Umbul Spring (IKK Bawen) analyzed at Kecamatan office

Aug. 1991



Titra Empul Spring (IKK Tampak Sukorejo) analyzed at PDAM Branch office

Aug. 1991



