Chapter 3. Present Situation of Water Supply Sector

3.1 Policy of Water Supply Service

3.1.1 Official Target of Sanitary Condition

The Government of the CAR placed a high priority on improvement of water supply and sanitary services to the nation in the National Policy in 1980s. And the Government is making effort to realize this policy by introducing foreign finances from the international aid agencies and the foreign countries. The policies aimed at year 2000 in the water supply and sanitary aspects are as follows.

1) To improve the rate of water supply coverage in the urban area to 60%
2) To improve the rate of water supply coverage in the rural area to 50%
3) To improve the rate of toilet coverage in the rural area to 100%

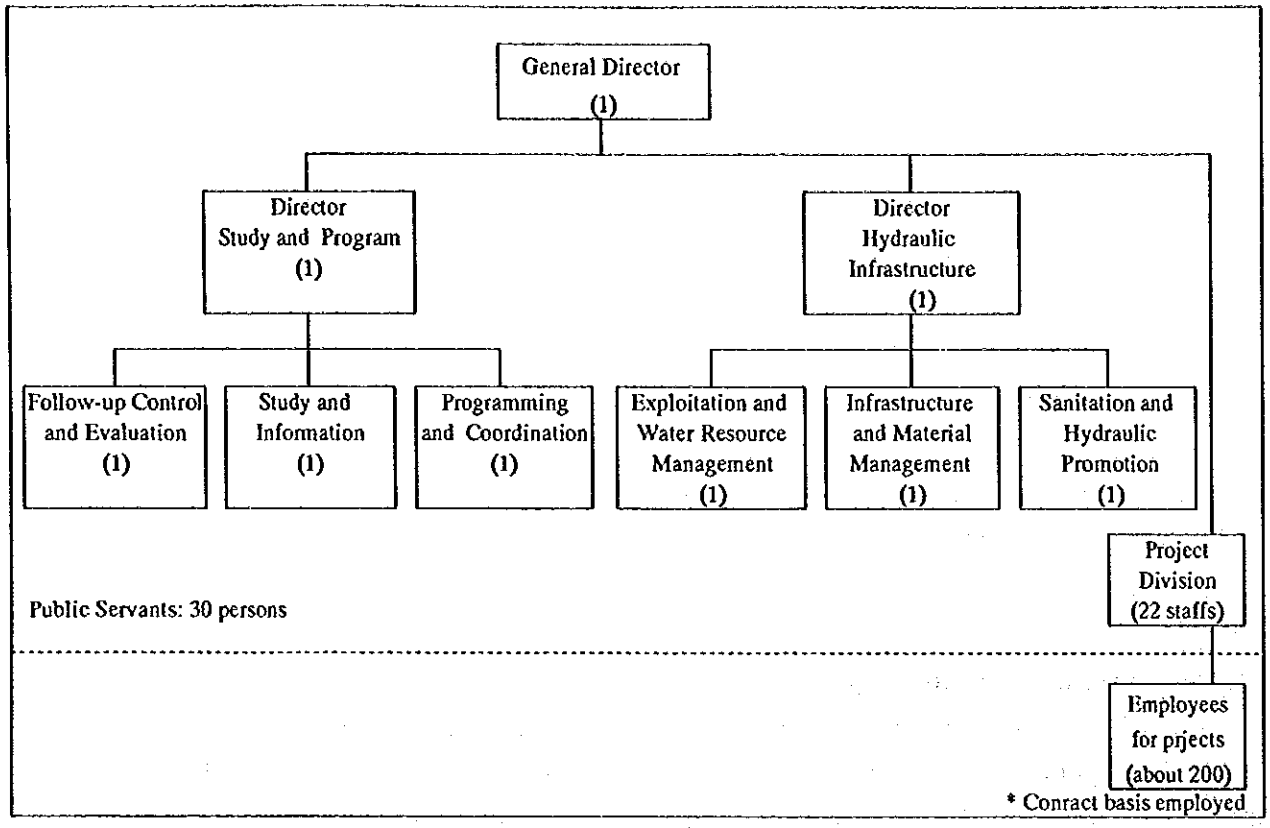
3.1.2 Organization of Water Supply Sector

The Ministry of Mines and Energy is a responsible in the Government of CAR to manage water supply policy. Under the ministry the General Department of Hydraulics (DGH), the official counterpart to JICA study team, are managing and taking various actions on development of concrete projects or studies. The DGH is the main organization which is responsible to realize the water supply policy of the Government and also in charge of development, planning, installation of water supply facilities and its maintenance in the whole Republic. The DGH has especially been dedicating to improve of sanitary condition in rural area by construction of deep wells for potable water.

Under the DGH's there was an agency named the National Water Company (Société National des Euax de Centrafrique, SNE) whose responsibility was to introduce and improve of public water system in cities with more than 10,000 water service population. Therefore the SNE had been managing the public water supply system in Bangui. However, depending on a policy of restructuring on the governmental organizations or institutions, the SNE was dissolved in May 1999 and its responsibilities and roles were supposed to be taken over by the Ministry of Mines and Energy or the DGH in near future.

Operation and maintenance works on the water supply facilities including billing work has been entrusted to the Water Distribution Company of Central Africa (Société de Distribution d'Eau en Centrafrique: SODECA) since 1992. The SODECA is in charge of Bangui City and another 6 provincial cities, which are called as Regional Centers, such as Bouar, Carnot, Berbérati, Bambari, Bossangoa, Ndele.

The present organization charts of the DGH and SODECA are shown in Figure 3.1.1 and 3.1.2, however, the DGH will be reformed in near future resulting from the dissolution of the SNE.



(Jan. 1999)

Figure 3.1.1 Organization of the DGH

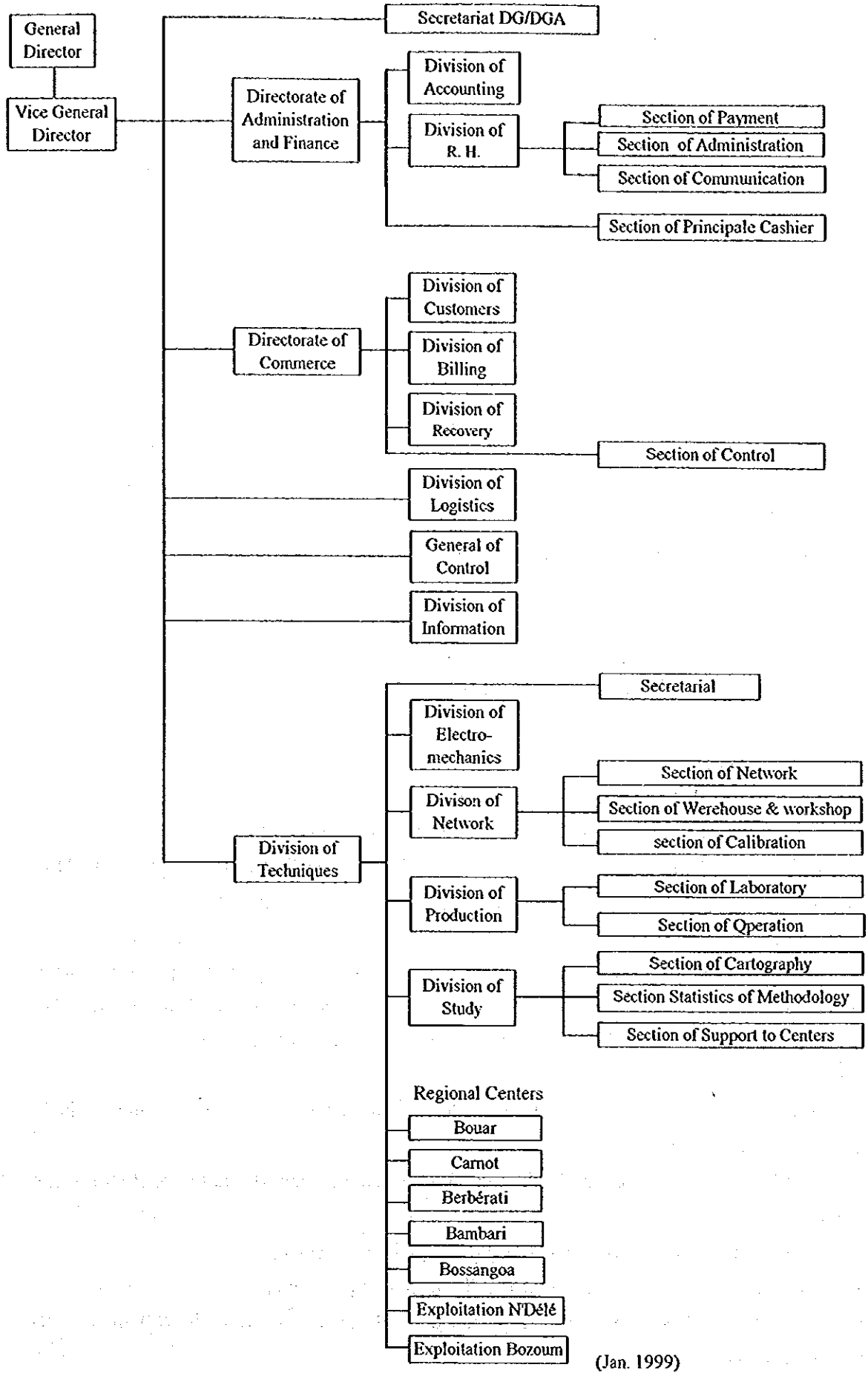


Figure 3.1.2 Organisation of the SODECA

3.2 Water Supply Condition in the Study Area

3.2.1 Existing Water Supply Facilities

1) Location of the Existing Water Supply System

People in Bangui City and some parts of Bimbo next to Bangui City owe potable water to the SODECA, which purifies through the treatment plant. People in the peripheral area, the most area of Bimbo owe to traditional dug wells or river water without proper treatment. From the sanitary point of view, the traditional dug wells and river water are not recommendable to drink directly.

The facilities of water supply system in Bangui are presently located as shown in Fig.3.2.1. The facilities of water production are stationed in the mid slope of the hill which rises closely in the east side of the down town Bangui. The public water in Bangui was begun with being supplied in the center area of the present down town where a center of business and political activities was formulated. And as the city being developed the water supply area had been expanded through the distribution system with kiosks and house connections to the west and north. There is a separated water supply area behind the hill in the east part of the Bangui City..

2) Existing Water Supply Facilities

The components of the existing facilities are as follows,

a) Intake facilities

Resource: Oubangui river

Constructed: in year 1963

Pumping equipment: Vertical axis type, 510 m^3/hr x 54m head - 5 sets.

Transmission line: 3 lines are installed from the Intake to the Water Treatment Plant Dia. 300mm (steel pipe), Dia. 400mm (ductile iron pipe), Dia. 500mm (steel Pipe)

b) Water Treatment Plant (Total capacity of the water treatment systems: 1,500 m^3/h)

There are 2 units of water treatment system with different capacity. The one with a capacity of 900 m^3/h was completed in 1963 and the other with 600 m^3/h was also constructed in 1976. The major components of the system consist of as follows.

Unit of 900 m^3/h

* Flocculation basin: 4 basins with a volume of 340 m^3 are installed. The retention time is 25 minutes per each basin.
* Sedimentation basin: 3 large size basins and 4 small size basins, the both are 2 story-type basins.

  3 large basins: L 20.0 m x W 5.0 m x H 2.07 m (height per story)

  4 small basins: L 6.5 m x W 3.11 m x H 2.56 m (height per story)

  Total volume of 5 basins is 1,600 m^3. Total area of surface of water is 760 m^2 and its retention time is 2 hours.

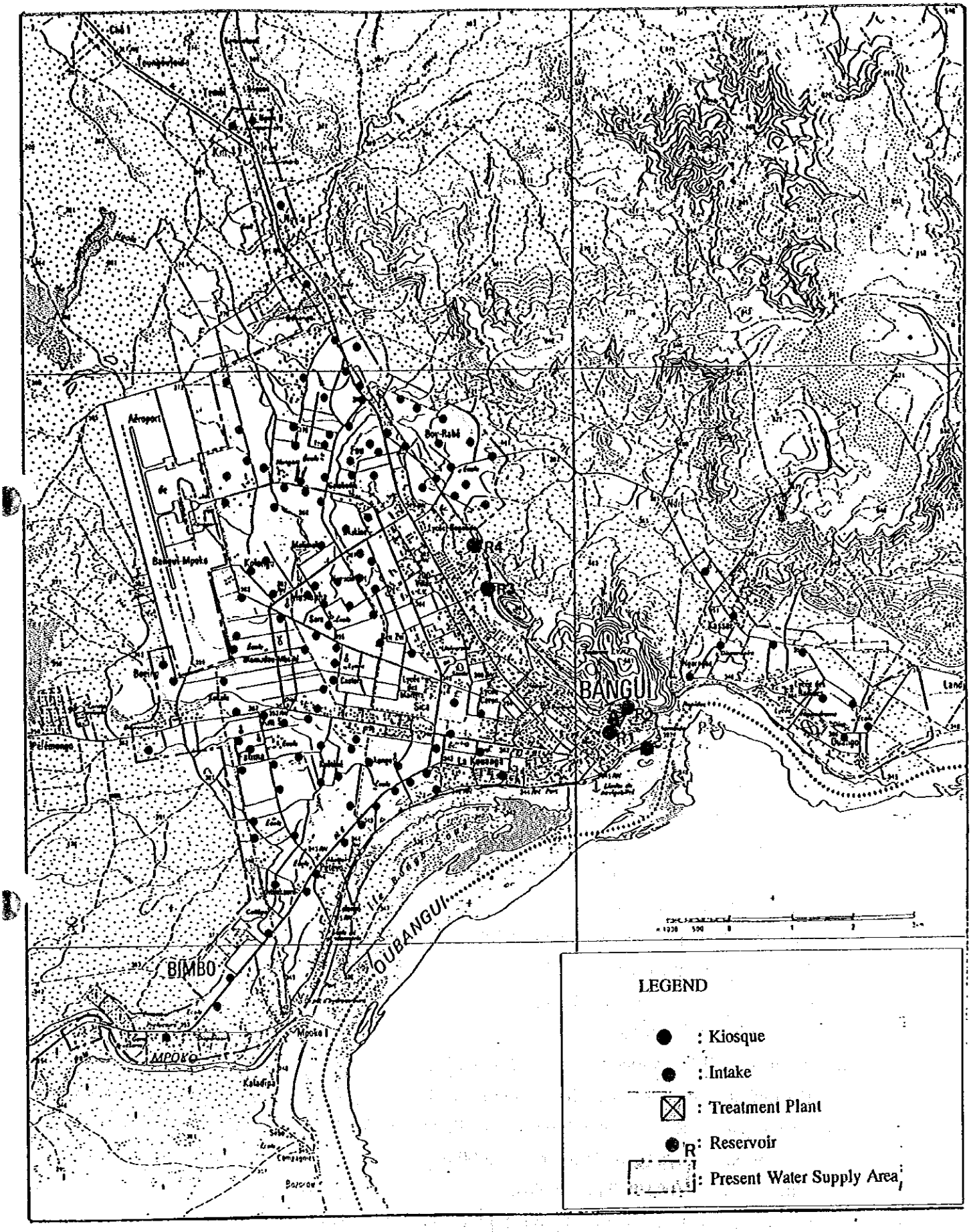


Fig. 3.2.1 Location Map of Existing Facilities of Water Supply System

* Filtration basin: 11 basins with dimensions of L 5.3 m x W 2.85 m x H 1.35 m. The area of filter is 15.1 m^2 per basin. Velocity of filtration is 5 m/ m^2/h. Water with Air Back-washing system is furnished.

Unit of 600m^3/h

* Flocculation basin: 2 basins with a volume of 225 m^3 are installed. The retention time is 22 minutes per each basin.
* Sedimentation basin: 2 basins with 2 story-type are installed.
  2 basins: L 18.8 m x W 16.0 m x H (2.05 + 2.85 +3.25)/3 m (height per story)
  Total volume of 2 basins is 1,600 m^3. The total surface area of water is 1,300 m^2 and its retention time is 2.2 hours.
* Filtration basin: 5 basins with dimensions of L 8.25 m x W 2.45 m x H 1.9 m. The total area of filters is 105 m^2.
* Velocity of filtration is 6.0 m/ m^2/h. Water with Air Back-washing system is furnished.

Pumping Equipment

* to R3: 466 m^3/h x 75 kw x 42 m head - 4 sets
* to R2 and zone II: 210 m^3/h x 60 m head - 3 sets
* to R4 and zone IV: 130 m^3/h x 30 kw x 48 m head- 3 sets
* to "Colline" high area: 20 m^3/h x 7.5 kw x 65 m head - 2 sets

c) Distribution Facilities

Reservoirs

There are 7 reservoirs in Bangui system. A total capacity of reservoirs is 13,880 m^3 which corresponds to 9.3 hour-capacity of the treatment system. The break downs are as follows,

* Treated water pond: Volume 321 m^3
* Reservoir No.1 (R1): A total volume is 3,000 m^3
  Circular type with 1,000 m^3 - 2 Nos.
  Rectangular type with 500 m^3 - 1 No.
  Trapezoid type with 250 m^3 - 2Nos.
* Reservoir No.2 (R2): A total volume is 2,300 m^3
  Circular type with 1,000 m^3 - 2 Nos.
  Circular type with 150 m^3 - 1 No.
  Trapezoid type with 150 m^3 - 1Nos.
* Reservoir No.3 (R3): A total volume is 2,000 m^3
  Parallel epipedigious type with 1,160 m^3 - 2 Nos.
* Reservoir No.3' (R3'): Circular type with 4,500 m^3 - 1 No.
* Reservoir No.4 (R4): A total volume is 2,000 m^3
  Circular type with 1,000 m^3 - 2 Nos.
* "Collin" reservoir: Parallel epipedigious type with 80 m^3 - 1 Nos.

Distribution network

Almost the city of Bangui except the north east hilly area is covered presently by the present water supply area. The distribution pipelines net is being extended to some parts of sub-districts of Bimbo District where are located the next to Bangui City and the population is increasing. The total length of pipeline was 170 km (in 1985), out of which an about 90 km is the pipeline with more than 100 mm diameters and the remaining about 80 km is the line less than 100 mm diameters. About 70 % of the existing pipeline is used asbestos cement pipes and the remaining is PVC pipes.

3.2.2 Present Status of Water Supply Service

1) Water Supply Service

The basic indices on water supply service done by SODECA during the last 4 years in the Capital Bangui are shown in Table 3.2.1. The mean daily consumption in the existing water supply area is estimated at 23,500 m^3/day which is delivered through 6,397 house connections and 117 kiosks, public water taps in 1998. And annual water consumption of billing to each category of subscribers are summarized in Table 3.2.2

Table 3.2.1. Status of the existing water supply system in Bangui City

Item		1995	1996	1997	1998
Annual intake volume (m^3)		7,601,000	7,321,000	7,423,000	7,997,000
Annual production volume (m^3)		7,230,000	6,837,000	7,363,000	7,912,000
Number of Public Faucets		126	-	144	144
Number of sub-scribers functioning	Private House Connections	7,376	-	6,387	6,397
	Commercials & Industries	134	-	907	848
	Administration & Public Institutions	246	-	248	254
	Public Faucets	116	-	121	117
	others	-	-	621	677
	Total	7,872	7,926	8,284	8,293
Capacity of water treatment plant		1,500m^3/hr	1,500m^3/hr	1,500m^3/hr	1,500m^3/hr
Mean daily distribution in the maximum supply month (m^3/d)		19,500	-	20,000	23,500
Billing ratio (%)		67	68	59	* 60
Recovery ratio (%)		57	56	52	* 49

Note) Numbers marked * are results in the early half-year. (Source: SODECA)

Table 3.2.2. Annual water consumption of billing to each categories of subscribers of SODECA

Subscribers \ Year		1993	1994	1995	1996	1997
Annual Volume of Billing Water (m^3)	Private House Connections	1,986,300	2,115,100	2,208,800	2,125,500	2,120,300
	Commercials & Industries	856,200	803,200	864,000	674,600	579,300
	Administration & Public Institutions	1,293,300	1,607,900	1,398,600	1,466,900	1,243,700
	Public Faucets	254,300	319,800	389,800	362,900	378,600
	Sub-total	4,390,100	4,846,000	4,861,200	4,629,900	4,321,900
Others (m^3)		2,524,800	2,145,200	2,369,000	2,207,300	3,041,000
Total Volume of Supplied Water per Annum (m^3)		6,914,900	6,991,200	7,230,200	6,837,200	7,362,900

(Source: SODECA)

In 1996, when the public order was disturbed by the mutiny, the water production was decreased 5% from the same of the year earlier. In 1997, the situation of public water supply service in Bangui can be said to have recovered to normal. The water consumption volume levels off judging from the volume of annual billed water to the each subscriber in the past 5 years. Water consumption of the public faucet shows slightly a tendency of increase, however it does not rise up the total volume of water consumption because its share to the total volume remains only about 5%.

Based on the above data the present water supply service is assumed as follows.

The SODECA is supplying water through 8,293 of subscribers including 6,397 of private house connections, and also 144 public faucets as of December 1998. The service population of the water supply system is estimated at about 204,000 persons as calculated bellow, based on the result of questionnaire survey and field reconnaissance on water consumption done by the study team.

Estimation of water service population

Population served by private house connections:

6,397 houses x 10 person/house = 64,000 persons

Population served by public faucets:

117 stations x 100 houses x 12 person/house = 140,400 persons

Total = 204,000 persons

The estimated service population corresponds to 30 % of the total population

which was estimated at 674,000 in 1998 in the water supply area (the whole Bangui City and B1, B2 and B3 of Bimbo District). From the above the present water service coverage is assumed at 30% in Bangui City. A 31% of the service population is actually received the water through private house connection and the remaining 69% is supplied by the public faucet.

Ratio of effectiveness of water supply service is equivalent to the rate of billing water in SODOECA's category. The billing rates of SODECA ware 63.5%, 69.3%, 67.2%, 67.7%, and 58.7% in the last 5 years (from 1993 to 1997). Then the average is calculated at 65.3%.

Assuming that 82% of the billing can be paid actually from the consumers, "accounted-for water as percent of total" is estimated at 53% which is almost equivalent to "ratio encaiss eau (ratio of cashing water)" of SODECA's data.

2) Water Quality Analysis on Piped Water and Stored Water in Houses

The purpose of water quality test on piped water is to grasp the present situation of water supply and to formulate some counter measures to improve the situation for especially the areas where locate in fringes of the present water supply area of Bangui. Water quality tests were carried out from late April to early May in 1996 as the first time and also from late August till early September as the second time. At the first one, two types of residual chlorine, total level and free level, and coliform were analyzed at Kiosks and house connections. And coliform tests were done for house stored water which had been taken from the Kiosk and poured into the containers in advance of the analysis. By the second time, residual free chlorine and coliform tests were carried out at the same Kiosks and the same house connections. Number of the samples for the test is also shown on Table 3.2.3. The results of the test are shown on Table 3.2. 4, 3.2.5 and 3.2.6 here under.

Table 3.2.3 WATER QUALITY TEST FOR PIPED WATER

Item of Test	1st time	2nd time
Term of execution	Late Apr. to early May	Late Aug. to early Sep.
Kiosks	20	20
House connections	20	19
Stored water in houses	30	-

Table 3.2.4 Test on Water Quality (Kiosk)

No.	Kiosk No.	Area	Location	Quality Test			Date	Remarks
				Residual chlorine (mg/lit)		Coliform		
				Total	Free			
1	9	Av. David Dacko	DAMECA	1.30	1.30	not appeared	30/04/96	
				-	0.75	not appeared	30/08/96	
2	12	- do -		1.30	1.30	not appeared	30/04/96	
				-	0.70	not appeared	30/08/96	
3	101	- do -		1.00	1.00	not appeared	30/04/96	
				-	0.65	not appeared	30/08/96	
4	80	- do -		-	1.00	not appeared	30/04/96	
				-	0.55	not appeared	30/08/96	
5	116	Route de M'Baiki	A 100m du Marche Bimbo	1.10	1.10	not appeared	30/04/96	
				-	0.55	not appeared	31/08/96	
6	97	- do -	A 800m de Barrier de PK9	1.10	1.10	not appeared	30/04/96	
				-	0.70	not appeared	30/08/96	
7	108	Av. UDEAC	1 er Kiosque en partan de Petevo	0.90	0.90	not appeared	30/04/96	
				-	0.70	not appeared	05/09/96	
8	99	Nzangoyan	Route cimitiere	0.90	0.90	not appeared	30/04/96	
				-	0.05	not appeared	30/08/96	
9	79	Av. UDEAC	200m lycee fatima	0.80	0.80	not appeared	30/04/96	
				-	0.75	not appeared	05/09/96	
10	24	Route ecole fatima garcon		0.50	0.30	not appeared	30/04/96	
				-	0.10	not appeared	30/08/96	
11	28	axe M'POKO CATIN	1 ere Kiosque cattin	0.80	0.80	not appeared	30/04/96	
				-	0.55	not appeared	30/08/96	
12	107	BOING	Derriere Aeroport	0.60	0.60	not appeared	30/04/96	
				-	0.45	not appeared	30/08/96	
13	26	Mamadou M'baiki	RUEJAGUAR	0.90	0.90	not appeared	08/05/96	
				-	0.55	not appeared	30/08/96	
14	60	Prolongement av france		0.70	0.70	not appeared	08/05/96	
				-	0.65	not appeared	04/09/96	
15	103	Route marche combattant		0.80	0.70	not appeared	08/05/96	
				-	0.28	not appeared	05/09/96	
16	105	- do -		0.90	0.90	not appeared	08/05/96	
				-	0.01	not appeared	04/09/96	
17	48	Av. Damara	En face de Englise Gobongo	0.70	0.70	not appeared	09/05/96	
				-	0.50	not appeared	05/09/96	
18	53	- do -	A 100m de Bar D10	0.80	0.80	not appeared	09/05/96	
				-	0.55	not appeared	05/09/96	
19	51	Route 37	A 100m Av. Damara	0.80	0.80	not appeared	09/05/96	
				-	0.35	not appeared	05/09/96	
20	91	Av. Damara	En face hospital Amitie	0.90	0.90	not appeared	09/05/96	
				-	0.50	not appeared	05/09/96	

Table 3.2.5 Test on Water Quality (House Connection)

No.	Family Name	Location	Quality Test			Date	Remarks
			Residual chlorine (mg/lit)		Coliform		
			Total	Free			
1	MBANGO Marie	Batalimo I (BIMBO)	0.70	0.60	not appeared	10/05/96	
			-	0.15	not appeared	30/08/96	
2	SOKAMBI Brigitte	Batalimo II (BIMBO)	0.70	0.60	not appeared	10/05/96	
			-	0.30	not appeared	30/08/96	
3	MALIZEMOKO Abe LOUNGOULA	Gbanikola I (BIMBO)	0.90	0.80	not appeared	10/05/96	change due to
			-	0.50	not appeared	30/08/96	non-identification
4	ABDOULAYE	Gbanikola II (BIMBO)	1.20	1.10	not appeared	10/05/96	
			-	0.50	not appeared	30/08/96	
5	DINGOMBE	FATIMA I	0.25	0.20	not appeared	10/05/96	
			-	0.00	not appeared	30/08/96	
6	KEMBI Henriette	FATIMA II	1.00	0.70	not appeared	10/05/96	
			-	0.15	not appeared	30/08/96	
7	LEPEUNEZE	DOLOKO I (KOKOLO)	1.20	1.10	not appeared	10/05/96	
			-	0.45	not appeared	30/08/96	
8	OBOABIVO ZOUMA	DOLOKO II (KOKOLO)	1.20	1.10	not appeared	10/05/96	
			-	0.20	1 faintly	30/08/96	
9	DOUTIFEI	Boeing I (Inspecteur de Police)	1.10	1.10	not appeared	10/05/96	
			-	0.15	not appeared	30/08/96	
10	RESTRAURANT	AMITIE (KM 5)	1.50	1.50	not appeared	10/05/96	
			-	0.45	not appeared	30/08/96	
11	MAHAMAT ADAM SOCATEL-MPOKO	Quartier FONDO (KOLONGO)	0.50	0.40	not appeared	15/05/96	change due to
			-	0.01	not appeared	04/09/96	non-identification
12	DUSMAN HAMAT	Cite ASECNA (KOLONGO)	0.05	0.03	not appeared	15/05/96	
			-	0.01	not appeared	04/09/96	
13	DJEPENO	Quatier LATIN (NGONGONON)	0.10	0.02	not appeared	15/05/96	
			-	0.01	not appeared	04/09/96	
14	BOYKOTA JOSEPH	D.G.SOCATEL (NGONGONON)	0.30	0.25	not appeared	15/05/96	
			-	0.01	appears faintly	04/09/96	
15	GONEYO REPAGO	NGONGONON 5	0.55	0.50	not appeared	15/05/96	
			-	0.01	not appeared	04/09/96	
16	BOUBA	CAPITAINE ARRIVEE(PK10)	0.40	0.35	not appeared	15/05/96	
			-	0.35	not appeared	05/09/96	
17	BAMOIDEPAUL	PK12	0.60	0.45	not appeared	15/05/96	close valve
			-	-	-	-	note passage
18	ZOUTEVALENTIN	PK12	0.40	0.30	not appeared	15/05/96	
			-	0.25	not appeared	05/09/96	
19	ICRA	PK10	0.15	0.10	not appeared	15/05/96	
			-	0.00	not appeared	05/09/96	
20	DOUSENE	PK10	0.40	0.35	not appeared	15/05/96	
			-	0.15	not appeared	05/09/96	

Table 3.2.6 Test on Water Quality (Stored water in house)

Stored Water in house		Location of the container	Type of the container		Covered condition	Instrument taking water from the container	Coliform Test	Date
No.	Area		Type	Capacity				
				Lit				
1	53	In house	Can	20	OK	Cup		9/05/96
2	53	In house	Cooking pot	25	OK	Cup	20	9/05/96
3	53	In house	Cooking pot	25	OK	Cup		9/05/96
4	48	In house	Cooking pot	20	OK	Cup		9/05/96
5	48	In house	Cooking pot	40	OK	Cup	34	9/05/96
6	48	In house	Cooking pot	40	OK	Cup	1	9/05/96
7	97	In house	Canari	25	OK	Cup		30/04/96
8	97	In house	Cooking pot	25	OK	Cup	A-6; NA-11	30/04/96
9	97	In house	Cooking pot	20	OK	Cup	A-12	30/04/96
10	24	In house	Cooking pot	25	OK	Cup	A-87	30/04/96
11	24	In house	Cooking pot	40	OK	Cup	A-1	30/04/96
12	24	In house	Cooking pot	20	OK	Cup	A-1; NA-4	30/04/96
13	26	In house	Cooking pot	40	OK	Cup	5	08/05/96
14	26	In house	Cooking pot	25	OK	Cup	>100	08/05/96
15	26	In house	Cooking pot	25	OK	Cup	26	08/05/96
16	60	In house	Can	5	OK	Cup		08/05/96
17	60	In house	Cooking pot	25	OK	Cup		08/05/96
18	60	In house	Cooking pot	25	OK	Cup		08/05/96
19	103	In house	Cooking pot	25	OK	Cup	40	08/05/96
20	103	In house	Cooking pot	25	OK	Cup	10	08/05/96
21	103	In house	Cooking pot	20	OK	Cup		08/05/96
22	99	In house	Cooking pot	30	OK	Cup		30/04/96
23	99	In house	Bowl	20	OK	Cup	A-10	30/04/96
24	99	In house	Cooking pot	20	OK	Cup	NA-4	30/04/96
25	107	In house	Cooking pot	20	OK	Cup		30/04/96
26	107	In house	Bucket	10	OK	Cup	A-67	30/04/96
27	107	In house	Cooking pot	25	OK	Cup		30/04/96
28	Gobongo	In house	Cooking pot	20	NO	Cup		09/05/96
29	Gobongo	In house	Cooking pot	20	OK	Cup		09/05/96
30	Gobongo	In house	Cooking pot	40	OK	Cup		09/05/96

There is a tendency that the level of residual chlorine is reducing as the distance is increasing from the water treatment plant. The series of tests showed that water of the kiosks are almost kept enough level of residual chlorine. However, some of the tested waters showed nearly 0 level. It deduces that deterioration of pipeline may be highly progressed. SODECA is continuing to inject high level of chlorine at the water treatment plant in order to supply safety water to the population of Bangui. However, there are also people who do not appreciate to use the piped water. Especially residents who migrated recently from the rural area prefer to use well water because of unfamiliarity of smell of chlorine in the piped water. Almost all the in-house-stored water showed affection of coliform. It is assumed that coliform may be transferred from the hands of the dwellers by touching water when they scoop with bowls. It is highly recommended that people shall use ladle with a long handle instead of bowls so as not for fingers to touch into water. And for storing water, diffusion of containers with faucet may also be effective for improve the present hygienic condition.

3.2.3 Present Water Tariff Structure

Water tariff structure should be enforced through resolution of the State Congress in the CAR. The present water tariffs, which are applied in Bangui, have been effective since April 1995. The followings are the water tariff.

Table 3.2.7 Present Water Tariff

Category	Tariff (FCFA/m^3)
1. Public faucet (Kiosk)	206.61
2. Private Connection	
0 to 5 m^3 /month	180
5 to 20 m^3 /month	200
exceeding 20 m^3 /month	436
3. Administration	
0 to 5 m^3 /month	180
5 to 20 m^3 /month	200
exceeding 20 m^3 /month	388

The tariff for Public faucet in the above table is wholesale price from the SODECA to an entrusted person with management of a kiosk. Each kiosk is obligated to sell the water to every user at prices fixed by the SODECA. The water is presently sold at the following prices at kiosks in Bangui City.

Table 3.2.8 Water Price at Kiosk

Volume	Tariff
0 to 10 litters	5 FCFA
11 to 20 litters	10 FCFA
21 to 30 litters	15 FCFA
31 to 40 litters	20 FCFA
41 to 50 litters	25 FCFA
up to 100 litters	50 FCFA
up to 200 litters	100 FCFA

3.2.4 Water Use Condition among the Population

1) Framework of the analysis

Framework of the socio-economic analysis is to identify and to define the problem among the people concerning to water usage.

There are three points in this study :

i) Characteristics of local population concerning water supply

ii) Characteristics of local population concerning water collection and management at home

iii) Characteristics of local population concerning local learning system

Data to be used are:

i) Secondary data obtained from related ministries and organisation

Especially the socio-economic statistics concerning water usage are newly collected and updated.

ii) Re-examination of interview questioner done for 200 households in1996

Additionally, there are some important data from this previous study. Together with the supplemental study done, the data of this study are re-analysed.

iii) Supplemental survey

Recently, the social change of most essential criteria on water usage and sanitation was checked.

iv) Interviews to key-persons.

2) Result of study

From the combined studies, following results have been obtained.

a) Coverage of SODECA service

37% of the population in Bangui and sub-urban area are served by SODECA .The service is divided into two types, private connection and public faucets.(locally known as Kiosque)

Farther, the recent survey by the mission shows the average payment of private connection users to SODECA is monthly around CFA 7000 (the average obtained from SODECA data, CFA 7523.4.).

b) Water consumption

Fig.3.2.2 is the finding of a study concerning the amount of domestic water consumption per day per capita. Total amount is 29.4 litre per day per capita. Traditional wells are very commonly seen. 93 % of interviewee in 1996 had well at household.

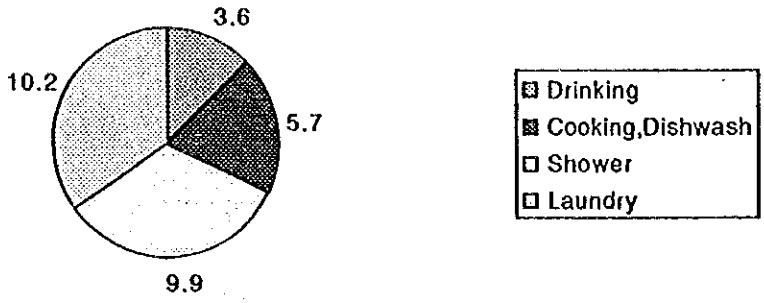


Fig. 3.2.2 Total Domestic use of water

The average amount of water bought from Kiosque is 5 to 10 liter per Capita per day. Therefore at this moment, people buy water from Kiosque only for drinking, cooking and dish-washing purpose (See Fig. 3.2.3 'the priority of water usage'). Little rest could be for other purpose. The supplemental source of water for rest of use is mainly from traditional wells.

c) Water collection

Following is the finding of the studies:

- In the studies of Kiosque users, mostly women and children are water collector.
- The average distance to kiosque is about 500m. People intend to use Kiosque only if they are within 1km of distance.
- However the time consume for water collection is much more. 66.2% of them spend more than half an hour each time to collect water.
- Among above people, 87.7% of them claim that they need to wait to get service at the Kiosque.
- More than 60 % of people go to Kiosque more than once a day, therefore majority of them need to spend about one hour every day to collect water from Kiosque.
- Most of people (83.1%) go to collect water early in the morning (before 8 o'clock)

Because of heavy load in water collection, water collector (typically women and children) have to reduce the time for productive and reproductive work or other activities. Gender difference in this aspect is significant.

Several people answered as a major problem that Kiosque were too far away for daily use. The main reason why people do not use Kiosque is distance rather than financial

d) Household water management

Sample collected from household container have been found with more contamination than direct from the water supply system. There is serious contamination during stoage of water.

Followings are the findings of the studies :

- More than 70% of people use open container for water storage.
- There are possibility that coliforms could develop easily through improper storage and handling of water. It is reportedly high risk of transfer from the hands of the dwellers by touching water.
- Most common sterilisation method is using chlorine, locally know as Javel. Sterilisation by boiling is hardly done. This is because the cost of fuel to boil water is expensive and it is time consuming. Javel is relatively cheap and easy to apply. Only people do not know the proper use.

e) Priority of water usage

People put priority clearly to drinking water. Following is the finding of the studies.

- 63.8% of people are using SODECA services to get drinking water, while for cooking 26.9 %, for dish washing 16.9% , for shower 16.2 % and for laundry 15.4%(*this is the rate obtained from the questioner in 1996 among the population whose residence situated in SODECA service area).
- If private connection users who can get most easily potable water are excluded, this rate change to 66.3% for drinking water, 22.5 % for cooking, 11.7% for dish washing, 11.7% for shower, and 10.8% for laundry.

Fig. 3.2.3 shows the priority on drinking water.

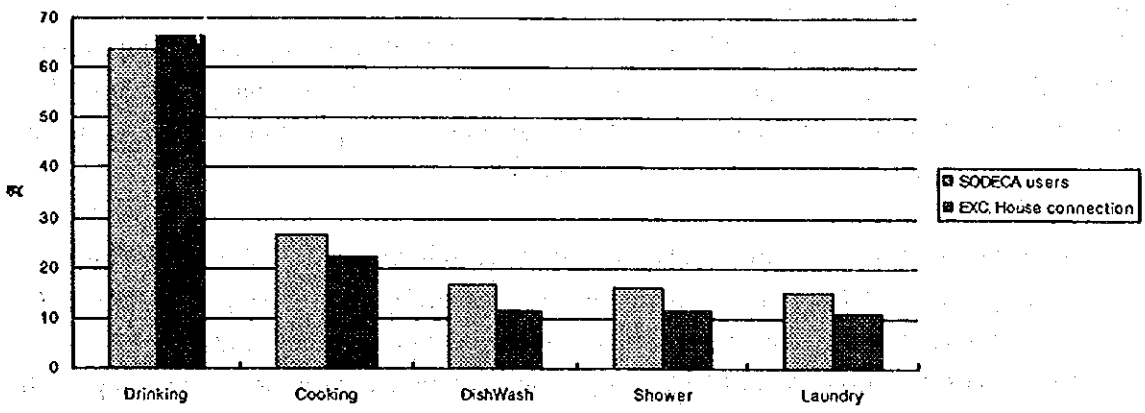


Fig.3.2.3 Water from SODECA Services

It is clear priority on potable water consumption for drinking water and followed cooking water. Especially for people who do not have private water connection, the priority is notable.

The average distance to water resources by purpose obtained in the studies supports also this finding.

- The average of the distance to water resources is , for drinking water 246.9 m, for cooking 139.7m, for dish washing 119.8 m, for shower 121.4 m and for laundry 118.8 m.

- The area where people can meet potable water supply, they go to the potable water resource between 150 m to 450 m for drinking water, but for shower and laundry about 100m. In rural area where is no potable water supply , the difference is much less.
- People go farther to get potable water for drinking and cooking than other purpose.

Fig.3.2.4 shows the average distance to water source by purpose

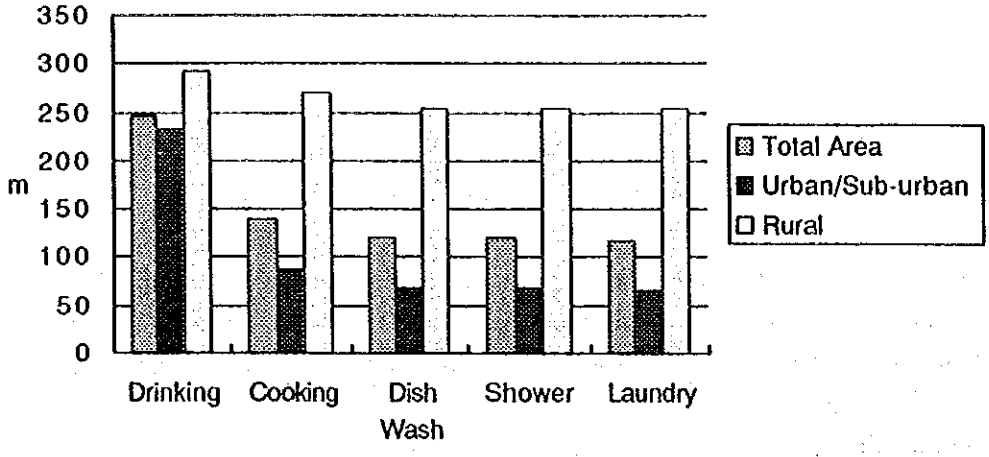


Fig.3.2.4 Average distance to Water Source

From these results, it is obvious that people are willing to pay more and consume more energy and time for primary drinking water and secondly cooking water.

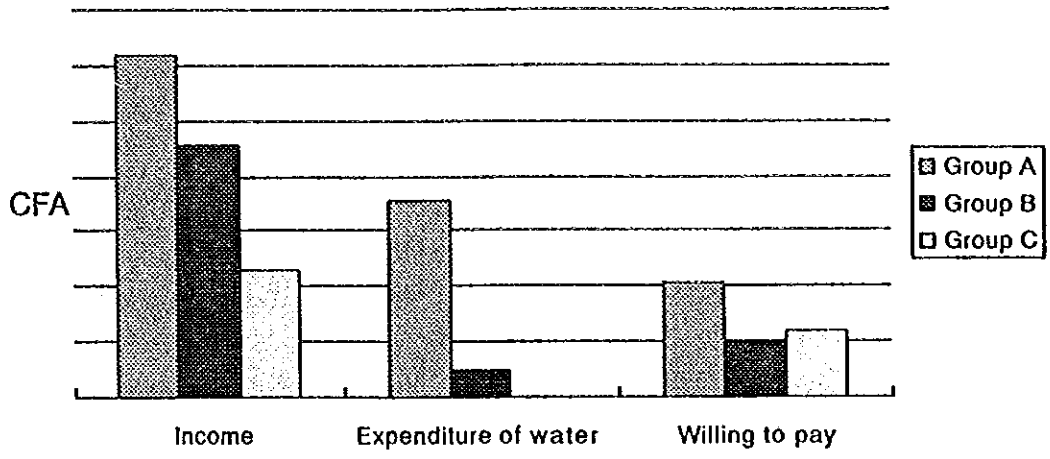
f) Different group by water source

In the analysis of the results, the households are divided into 3 groups according to the water source. The first group uses private connection (Group A), the second group uses kiosque (Group B) and the third group uses no private connection or kiosque (Group C). Difference of Socio-economic condition is notable among these groups.

- In average, Group A has the highest income , Group B follows it and Group C has lowest.
- The average sizes of the family among people are, Group A :10 people, Group B, C : 12 People. Group A people have slightly smaller families than the other group.
- About water consumption , half of Group A people are satisfied with their water supply, 30% of Group B and 23% of Group C people are satisfied with actual situation.
- The difficulties mentioned by unsatisfied people about water supply are: most of Group A people mentioned the price they pay to SODECA is too expensive, they also mentioned in dry season they have not enough water sometimes Most of Group B,C people mentioned the distance to kiosque is too long
- Particularly Group C people mentioned the quality of the water from traditional well is too bad.

Interestingly the price willing to pay for potable water of Group C people is about CFA 500 higher than its Group B, even through Group C people have lower income in general. These people live mostly too far away from Kiosque and have disparate need of potable water

therefore their willingness to pay becomes higher.



(*One unit for income is cfa20000, expenditure and willingness to pay cfa2000)

Fig.3.2.5 Income, expenditure of water and willingness to pay

The price willing to pay is exceeding the real expenditure of Group B people.

g) Awareness of potable water

About three quarter of the people are aware of the difference in water quality between potable and non-potable. This rate is lower in rural area, where they do not have a potable water supply.

h) Organisation and local learning system

It was found that there were several local organisations which support communal activities. Most of them are under the leadership of chiefs. However these activities are limited to mainly physical works like construction, maintenance, repairing and etc. Women's participation in community activities is marginal.

In every community, there are learning system by which local knowledge is adapted new information and transmitted through participation. Most often, women are the controllers and purveyors in local learning systems related to water, sanitation hygiene and health. For the local community, formal and informal information channels are evenly important source. For example waiting time (about half hour in average) by Kiosque can be used for extension of information about water ,sanitation, hygiene, health and etc.

There are traditional learning system like street theatres or dancing group in Bangui. Music is also the other media, people are very found of . However very few of these resources are used for handing out information. The result of questioner shows that most popular way to get information is organised courses, secondly through radio.

3) Conclusion

Water consumption among population in Bangui is generally still marginal level. Even for

drinking, they use only 3.6l per day per capita. Also, their consumption of clean water (SODECA) water is limited only for drinking, mainly due to the distance to Kiosque. In selecting source of drinking water, people tend to choose the nearest source of a perceived good quality water, even though this may not be nearest or cheapest of any source.

When the distance to Kiosque is shortened, there is a possibility they buy more water for extended use. The price of the SODECA water is more or less accepted, because they select water source by purpose and they can not buy water from Kiosque so much due to the long distance to Kiosque and long waiting time. So if the distance and/or waiting time to Kiosque is shortened and people started to buy more water for extended purpose, the price would be the issue in consideration. Because private connection user, who use SODECA water extendedly, complain the price most, even though their income is much higher than non private connection users.

Household water container have been found with more contamination than direct from the water supply system. Since transfer of coliforms from hands of the dwellers by touching water would be reason of contamination, it is recommended the use of ladles instead of bowls.

For well water users, use of Javel together with instruction of proper use must be more encouraged.

There are a few organisation working for community work, mostly by Chief s initiative. These activities must be more encouraged and extended to water supply projects.

Local learning system, transfer of information and communication, both informal way (like chatting) and formal way (organised course) must be encouraged. The use of waiting time at Kiosque is interesting. Traditional entertainment like theatre groups, music bands and dancers can be also good media of information .

4) General consideration for planning

To determine which source of water people use for which purpose, three type of criteria, 1. economic demands, 2. perceived water quality and 3. social relationships plays a major role. People also use these criteria for judging new sources. Knowledge of this criteria and understanding of the selection process are part of the design of new services, when programmes want to see new services not just established, but also used, maintained and paid for. It is also necessary to take it into account that people especially women, tend to prefer water sources which are reliable and from which collection requires the least time and energy because of their workload.

Where several water sources exist, management tends to be integrated, that is, the available water sources are perceived as a total package. The sources are allocated to a particular purpose, such as collection of drinking water, shower, laundry, watering animal and gardening. Sometimes water resources management is executed through regulation and social control of resource use. Maintenance and operation and hygienic control are most common regulation seen among user's community. In these practice, social condition including the gender relationship must be considered.

3.2.5 Related Project

(1) Whole Country

In the CAR various projects on groundwater development and improvement of water supply service have been implemented on loan or grant basis by some developed country or international aid organization.

From 1986 the French Development Fund (Caisse Française de Developpement : CFD), which was reformed in 1999 and named French Development Agency (Agence Française de Developpement : AFD), has been contributing for expansion or reinforcement of the existing water supply facilities and water distribution network in Bangui City by implementing of loan basis projects through the SNE. The AFD has also been conducting water supply projects in some provincial cities.

The German Development Fund, KFD, has been assisting some provincial cities through the SNE. UNDP and UNICEF have been involved in improvement of sanitary condition of rural area by management of several groundwater development projects.

Japan started assistance in water supply sector in 1986 through JICA. From the beginning Japan has been focusing at groundwater development projects which were officially managed by the DGH. Beside of implementation of the projects, Japan has also been contributing to empowerment of institutional and technical capacity of the DGH by dispatching a JICA long-term expert for more than 10 years.

Summary of the main projects, which has been implemented by the foreign countries or international aid organization, is shown in Table 3.2.9.

Table 3.2.9 Related Projects

Title of Project	Aiding Organization	Contents/ Time/ Cost of Project
1. 3rd Project of Potable Water Supply (Bangui, and 3 provincial cities of Bouar, Bambari, Gerberati)	CFD, France	Setting up Computerized mapping system of distribution pipe network: Bangui Replacement and repairing of pipeline- 26 km : 4 cities Installation of new pipeline- 50 km: 4 cities Rehabilitation of water production facilities: 4 cities Dencification of water distribution network : Bangui Construction of kiosks: Bangui 1992 to 1997 / 56,000,000FF, loan basis
2. Study for 4th Project of Potable Water Supply (Bangui, and 3 provincial cities of Sibut, Bangassou, Kaga-Bandoro)	CFD, France	For Banui *Rehabilitation of pipeline and valves *Extension of pipe network *Construction of a reservoir with 2000m^3 capacity *Reinforcement of distribution network For other 3 cities *Installation of new water supply facilities 1995 /

3. Follow-up Study for 4th Project of Potable Water Supply (Bangui, and 2 cities of Bria and Kaga-Bandoro)	CFD, France	For Bangui City *Review on future water demand and strategy for up-grade of profitability of management *Densification and extension of the existing distribution pipe network in 5 Districts *Reinforcement of existing transmission main *Provision of connection service with lower cost For other 2 cities *Improvement of management of water resource *Investment plan for installation of the water supply facilities 1996 / 170,000,000 FCFA
4. Project of Potable Water Supply in Bozoum City	KFD, German	Introduction and erection of water supply facilities 1995 / 1,188,000,000 FCFA, Grant aid
5. Program for Central Africa (CO3 Project) I	UNDP	Hydrogeological Investigation, Master Plan and construction of 350 deep wells in 2 Provinces of Ombella –Mpoko and Lombaye 1993 to 1996 / 41,736,000 FF
6. Program for Central Africa (CO3 Continuing Project) II	UNDP	Reviewing program after the disturbance occurred in 1996 Restoration of data base of hydrogeology destroyed by the disturbance Continue the primary project in the 2 Provinces Commencement of new deep wells project in Nanamanbere Province 1997 to 2000 / 1,500,000 US$
7. Potable Water and Sanitary Project in Rural Area	UNICEF	Improvement of sanitary condition, construction of deep wells in provincial areas from 1993 /
8. Project for Exploitation of Groundwater in Occidental Region (Phase II)	JICA, Japan	Supply of well drilling machine and supporting equipment Construction of 240 deep well in Ombella-Mpoko Province Phase II: 1994 to 1997 1,643,000,000 J-Yen / Grant aid

(2) Bangui City

Water supply system in Bangui City has been operated and maintained by the SODECA since the SNE entrusted the SODECA with management of the facilities in Bangui in 1992. The AFD has been co-operating with the SNE in grading up water service level in the capital by implementing the above mentioned projects (1st to 3rd phases). It is fairly recognized that the co-operation of the AFD is indispensable to improve the water supply service level.

In accordance with the Follow-up Study for 4th Project conducted by the AFD, the Government of CAR requested the AFD in 1998 to realise the project with a total cost of 3,385,000,000 FCFA. It was no accepted by the AFD yet as of June 1999, however, the officials concerned of the both sides were positive about it. Implementation of the project is envisaged to ameliorate the profitability of the water supply management by assuming the water consumption in the present service area would increase at a rate of 4% per year. The project also recommends to introduce the various measures, as shown in the above table, for increase the number of water subscribers in the 5 Districts in Bangui City where the population densities are higher than the other Districts and water service pipeline remains still at a insufficiently level.

3.3 Financial Situations of Water-Supply Company

Although profit and loss statements (P/L) of SODECA could not be available while the JICA study team stayed in CAR from December 1998 through January 1999, the company's critical financial situations can be observed through its recent six-year balance sheets (B/S) shown as Table 3.3.1 in the following page. It may be noted here that, as far as financial situations of SNE (Societe Nationale des Eau Centrafricaine) and DGH (Directeur Général del'Hydraulique), public authorities supervising SODECA, are concerned, it cannot be confirmed at present because of following two reasons: (1) detailed figures of financial indicators of SNE/DGH (budget, expenditure, earnings, etc.) are not clarified or exhibited to the public, though only the total budget of Ministére des Mines et de l'Energie, the superior authority supervising SNE/DGH, is announced as FCFA 33,700 mil. in 1998 (source: Republique Centrafricaine, *Loi de Finances Rectificative 1998*); (2) even though the budget is allocated, the problem is actual disbursement from the government to the lower authorities. In the circumstance of chronically delayed wage payment to public officials (9 months on average), it is difficult to project any public investment, even maintenance, plans. Therefore, how to manage the financial restriction of SNE/DGH should be precisely discussed at the stage of the feasibility studies before implementation of the development project in the year 2005.

3.3.1 Liabilities Exceeding the Assets

SODECA has been in a "liabilities-exceeding" situation since 1994. That is, the figure of "Net Capital Stock" has been negative. It is a definitely dangerous sign for a commercial enterprise, because once the company was liquidated, not only shareholders cannot withdraw their investment at all, but also any credits, such as bank loans, are not guaranteed to be fully paid back. Even in developed economies, such as Japan for example, even once a commercial enterprise listed on the Tokyo Stock-Exchange Market (TSE) fell into the "liabilities-exceeding" situation, the company must be de-listed from TSE immediately.

Especially the balance of negative "Retained Earnings" (= loss) in 1994 was huge and, as a result, SODECA increased the amount of "Capital Stock" twice (in 1995 and 1996) to compensate the loss. However, figures of "Net Capital Stock" on the balance sheet have not shown favorable effects yet. The increase of the capital stock balance can be supposed as just or mainly a result of the devaluation of the CFA franc in relation to the French franc in January 1994 (= SODECA's capital stock was mainly composed of France franc value).

Table 3.3.1: Balance Sheet of SODECA

(Unit: mil. FCFA)

Assets						
Accounts / Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Intangible Fixed Assets	153	153	153	153	153	153
Tangible Fixed Assets	269	429	471	681	766	799
Granted Assets	14	14	14	14	15	16
Gross Fixed Assets	**436**	**596**	**638**	**848**	**934**	**968**
Amortization of Intangible Fixed Assets	-33	-64	-94	-125	-153	-153
Depreciation of Tangible Fixed Assets	-37	-96	-168	-316	-398	-454
Total Amortization/ Depreciation of F/A	**-70**	**-160**	**-262**	**-441**	**-551**	**-607**
Net Fixed Assets	**366**	**436**	**376**	**407**	**383**	**361**
Material Inventory	140	267	307	333	360	339
Works in Process	44	18	27	35	0	0
Total Inventory	**184**	**285**	**334**	**368**	**360**	**339**
Account Receivable	668	904	1,522	1,418	1,749	2,205
Allowance for Bad Debts	-84	-154	-173	-171	-176	-264
Net A/R	**584**	**750**	**1,349**	**1,247**	**1,573**	**1,941**
National Bond	0	0	8	40	153	88
Securities	76	103	188	302	306	338
Total Securities	**76**	**103**	**196**	**342**	**459**	**426**
Other Credits	42	15	37	25	106	237
Total Credit Assets	**702**	**868**	**1,582**	**1,614**	**2,138**	**2,604**
Total Current Assets	**886**	**1,153**	**1,916**	**1,982**	**2,498**	**2,943**
Bank Deposit	10	55	50	8	30	163
Cash	4	5	12	13	35	17
Total Deposit / Cash	**14**	**60**	**62**	**21**	**65**	**180**
Total Assets	**1,266**	**1,649**	**2,354**	**2,410**	**2,946**	**3,484**

Liabilities						
Accounts / Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Capital Stock	200	200	200	390	500	500
Discrepancy of Stock Appraisal	0	0	0	115	5	5
Deferred Liabilities	0	-193	-187	-764	-608	-603
Retained Earnings	-193	6	-577	156	5	-122
Net Stock Capital	**7**	**13**	**-564**	**-103**	**-98**	**-220**
Allowance for Risks and Taxes	0	0	242	80	120	152
Capital-Related Allowance	**0**	**0**	**242**	**80**	**120**	**152**
Total Equity	**7**	**13**	**-322**	**-23**	**22**	**-68**
Mortgage Received	37	256	271	286	291	305
Long-Term Loan	260	207	125	27	800	767
Account Payable	593	692	1,616	1,439	921	1,244
Total Long-Term Debts	**890**	**1,155**	**2,012**	**1,752**	**2,012**	**2,316**
Total Long-Term Liabilities	**897**	**1,168**	**1,690**	**1,729**	**2,034**	**2,248**
Wages Payable	58	45	179	218	219	270
Taxes Payable	39	28	20	99	206	203
Other Expenses Payable	259	370	465	363	401	552
Total Debts without Interest Expense	**356**	**443**	**664**	**680**	**826**	**1,025**
Bank Overdrafts	0	0	0	1	15	0
Other Debts	12	38	0	0	71	211
Total Short-Term Liabilities	**12**	**38**	**0**	**1**	**86**	**211**
Total Liabilities	**1,265**	**1,649**	**2,354**	**2,410**	**2,946**	**3,484**

Source: Documents from SODECA

But more investigation for confirmation is needed to prove this assumption.

3.3.2 Growing Fixed Assets and Non-Recovering Deficit

According to the B/S, the amount of "Tangible Fixed Assets" rapidly increased from FCFA 471 mil. in 1994 to 799 mil. in 1997 (growth by 1.7 times). In general increasing tangible fixed assets is a sign of (1) growth of production and (2) prospective operating profits. In the case of SODECA, however, (i) water distribution to customers did not increase not so much as the tangible fixed assets was drastically augmenting (see Table 3.3.2); (ii) the account of "Retained Earnings" shows that the company's loss has been accumulated rather than cleared.

Table 3.3.2: Total Distribution of Safe Water by SODECA
in Bangui Metropolitan Areas

(Unit: m³)

1992	1993	1994	1995	1996	1997
8,820,331	7,688,814	7,862,342	8,105,824	7,700,000	8,300,000

(Source: Statistics of SODECA)

Reasons why the reality was so dissociated from the theory are supposed as follows:

(a) improperly controlled sales price,

(b) low productivity, and/or

(c) failure of bill collection.

As for (a), pricing systems for the public water supply have not been basically changed since April 1995 (ref. *Portant Reglementation du Tarif d'Eau Potable en Republique Centrafricaine, ARRETE No. 006*). Even though the raising of the water rates is expected, the living standard of Bangui residents in these days does not allow any raise of public utility charges.[1] This restricted situation of consumers, especially of the supposedly poorest class who will be the target group of the urgent development program in the year 2005, should be taken into careful consideration when the final rates for the

[1] Many relevant CAR authorities the JICA study team interviewed during the research trip December 1998 through January 1999, such as the president of SNE, repeatedly stated that Bangui residents cannot afford even current charge of water and never admit any raise of the price.

water supply will be determined at the stage of feasibility studies.

In order to make a proper judgment on the issue (b), more technical analyses of details, such as survey of water-leaking situations, input-output analysis concerning usage of chemicals, evaluation of maintenance systems and skills, etc., are needed.

The problem (c), huge amount of delinquent account receivable of SODECA, is definitely critical for the management of the enterprise. It is more precisely investigated in the following column.

3.3.3 Accumulating Account Receivable

The balance sheet shows the amount of account receivable expanded more than 4 times larger in the year 1997 than in 1992, while the balance of gross assets just doubled during the same period. Also the total amount of accumulated A/R as of the end of 1996: FCFA 1,749 mil. was equal to approximately 8 month sales amount of the year.[2]

The main cause of the result mentioned above is addressed to be the delay of customers' payment; the public sector's delinquency (collection ratio vis-à-vis total A/R balance: 11.09% in 1997. See Table 3.3.3) is much more serious than other customers' default (collection ratio of private-connection customers: 59.95%, kiosk customers: 80.62%).[3] And the sector's total delinquent payable reaches 53.53% of SODECA's total bad debts to customers.[4]

On the other hand, it is probable for SODECA to restore its financial situations if the Government punctually paid for the bill. It is indispensable for the project of water-resource development to take the Government's delay of payment that seriously affected SODECA's critical financial situation as one of the first-priority problems to be resolved, at the stage of reorganization to maintain sound and stable water-supply systems in Bangui metropolitan areas.

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[2] SODECA's total sales amount of safe water in 1996 was FCFA 2,732 mil. (est.).

[3] Based upon SODECA statistics.

[4] In 1997 (- do -).

Table 3.3.3: SODECA's Collection of Account Receivable from Government (1997)

(Unit: m³)

Month	Billed Quantity	Withdrawal	Collection Ratio	Delinquency
February	87,622,593	50,050,757	57.12%	10 months
April	79,156,178	8,279,079	10.46%	08 months
June	77,118,382	325,838	0.42%	06 months
August	98,543,040	171,821	0.17%	04 months
October	90,424,891	0	0.00%	02 months
December	97,486,984	0	0.00%	00 months
1997 Total	530,352,068	58,827,495	11.09%	(N/A)

(Source: SODECA statistics)

3.4 Initial Environmental Examination (IEE)

Initial Environment Examination (IEE) aims at foreseeing various impacts caused by implementation of the project and to adopt the necessary measures to minimize its negative impacts. In general the groundwater development project largely contributes to reduce infection of water born diseases and to improve conditions of health and hygiene in the project area. However, it may occur unexpectedly that some small-scaled environmental impacts through construction works of planed facilities and increase of the amount of waste and drainage water as the amount of supplied water will be increased.

At the stage on which the IEE was done, no exploration well was constructed yet, then potential of groundwater for development in the project area was not evaluated and component and scales etc. of facilities which might be introduced by the project were not designed either. Therefore, the assessment was carried out under the assumption described in Table 3.4.1 below.

Table 3.4.1 Assumption of the Facilities to be Introduced by the Project

Items	Facilities	No.	Location
Source of water supply	Groundwater		
Facilities to be designed	Deep wells	10 sets	Not in the resident area
	Reservoirs	3 units	do
	Transmission main		under the existing road
	Distribution pipeline		do
	Kiosks		on the existing road side
	Electric cables		do
Others	Access road to a exploration well W-3.5m	3.5 km	Manioc field and bush area

Currently, there are no particular laws or regulations which stipulate to conduct assessment on environmental impact prior to implementation of any projects in the Central African Republic.

During the 1st stage of this study, the IEE has been conducted by means of the "Guideline of Environmental Consideration for Groundwater Development" prepared by JICA. The IEE is a preliminary assessment in terms of social environment, natural environment and environmental pollution. Results of the IEE are as shown in Table 3.4.2. All the items of environmental impact in the scoping format are evaluated into 4 categories as mentioned in the table.

Table 3.4.2 Initial Environmental Examination

Items impact			Eval.	Background / Remarks
Social Environment	1	Resettlements	D	No resident in the site of wells and facilities planed.
	2	Economic activity	B	Rout of the new access road crosses some manioc fields. Compensation shall be considered to the farmers.
	3	Infrastructure	D	〃
	4	Disturbance of community area	D	〃
	5	Historical spots and cultural property	D	No particular historical and cultural property in the project site.
	6	Water right and vested rights	D	No particular rights exist.
	7	Health and sanitation	D	Improvement can evidently be expected by the implementation of the project.
	8	Waste Disposal	D	During construction works, a little amount of soil and construction debris shall be released from the site.
	9	Disaster (risk)	D	Small scale of Construction can not be a threat to disasters.
Natural Environment	10	Topography and geology	D	No important topographical and geological features exist.
	11	Land erosion	B	Some parts of the access road situate in a gentle slop of the hill. A proper rain drainage arrangement shall be designed.
	12	Groundwater, spring and perched water	C	The impact of the project on the existing dug wells and springs in surrounding areas should be taken into consideration.
	13	Swamp, Lake, river	C	Impact from the sewage increase should be considered.
	14	Beach, sea area	D	No beach and sea exist in the project area.
	15	Animals and plants	D	No precious animals and plants exist.
	16	Meteorology	D	Small scale of Construction can not be a threat to meteorology.
	17	Landscape	D	Small scale of Construction can not be a threat to landscape.
Environment Pollution	18	Air pollution	D	No air pollutant will be emitted.
	19	Water pollution	D	Mud water for drilling work is used in a closed circulatory plant.
	20	Soil pollution	D	Same as item (19).
	21	Noise/lands vibration	D	To be considered during drilling works.
	22	Land subsidence	C	The project sites are not composed of alluvial deposits with thick clay beds.
	23	Offensive odor	D	No substance of offensive odor will be evolved.

Evaluation:

A: Big/serious impacts can be considered
B: Some impact can be considered
C: Not evident, considerations are necessary
D: No environmental impact

As no large-scaled facilities are expected in this project, no big or serious impacts classified as "A" exist. But some are categorized in "B" and "C" which shall call attention to conduct environmental impact assessment (EIA) in the next stage of the study. Table 3.4.3 shows subjects and recommendations for the next study.

Table 3.4.3 Subjects and Recommendations for the Second Stage Study

Items impact	Eval.	Measures to be taken in the next study	Reference
Economic Activities	B	Manioc fields on pipeling routes near Bimbo Hill shall be counted. A compensation system for the farmers shall be formulated by the CAR side if neccessary.	
Land erosion	B	As excavation and bank works for the access road shall be minimized, no erosion is expected.	
Groundwater	C	Depending on results of various hydrogeology survey and tests to be done on exploration wells, a proper pumping rate shall be designed.	
.River	C	Water contamination is anticipated from the newly developed water supply area by increasing of volume of supplied water. Proper contermeasure shall be recommended.	
Land subsidence	C	Depending on results of various hydrogeology survey and tests to be done on exploration wells, a proper pumping rate shall be designed.	

The expert for the EIA has to carry out EIA with cooperation of the counterpart in the field survey of the 2nd stage study in order to evaluate every component to be designed for the feasibility study form the environment impact point of view.

Chapter 4. Exploratory Well Drilling

4.1 Drilling Work

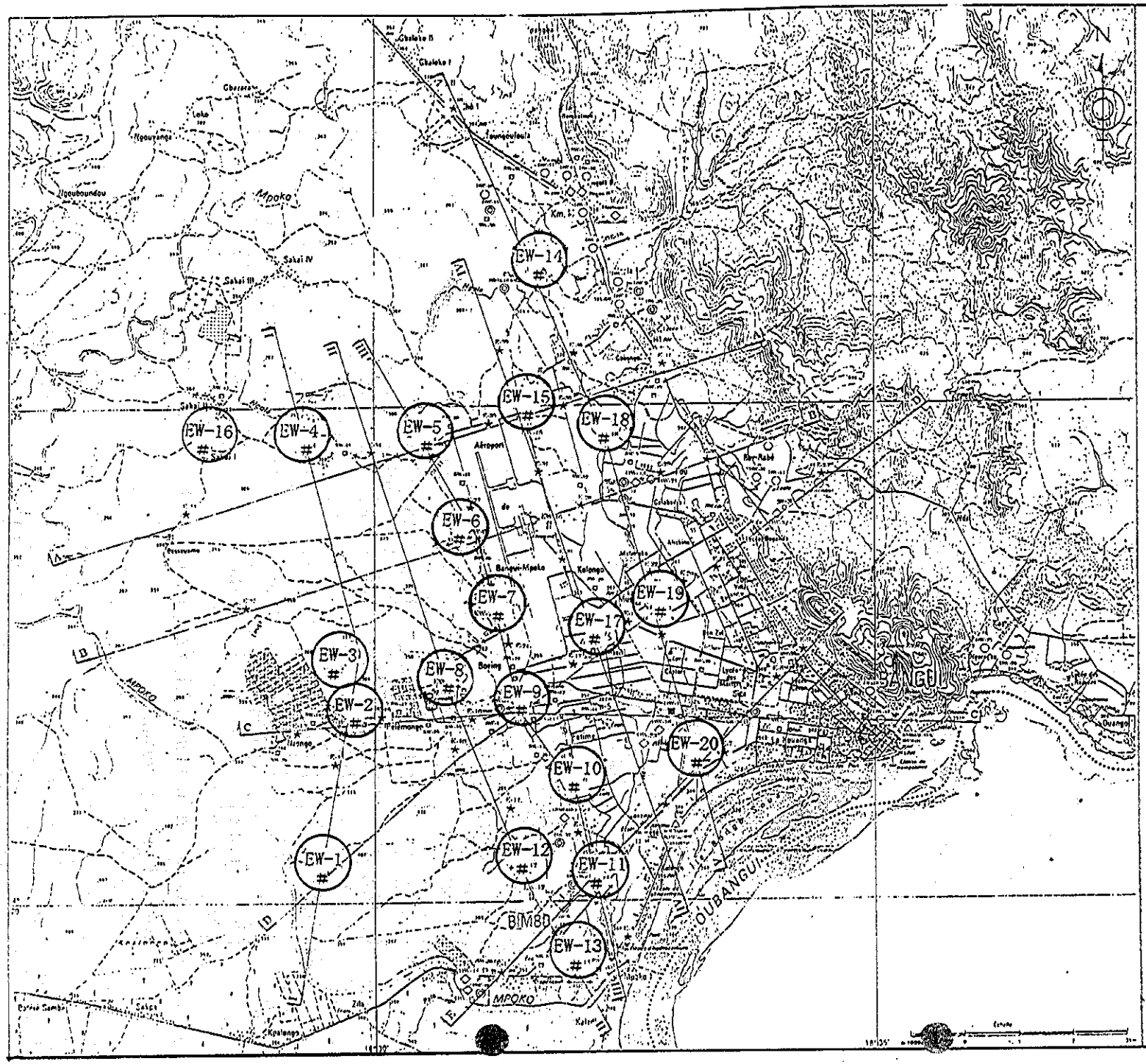
(1) Quantity and Location of the Drilling Work

The exploratory well drilling is scheduled based on the results of the aerialphoto interpretation, existing well survey and field reconnaissance in order to grasp the comprehensive hydrogeological features of the Study Area. the drilling work started from the beginning of September 1998 and completed at the end of Jannuary,1999. The number and drilling depth of the exploratory wells are shown in Table 4.1.1 and their locations are shown in Fig.4.1.1.

Table 4.1.1 Drilling Depth of the Exploratory Wells

Well Number	Main Geology	Drilling Depth (m)	Depth to Bedrock (m)	Remarks
EW-1	Lateritic clay	85.0	Not reached	Backfilled
EW-2	Lateritic clay	100.0	Not reached	Backfilled
EW-3	lateritic clay, Sandstone	70.0	52.0	Cased
EW-4	lateritic clay, Sandstone	43.0	22.0	Cased
EW-5	Lateritic clay	85.8	Not reached	Backfilled
EW-6	lateritic clay, Limestone	77.3	22.0	Cased
EW-7	lateritic clay, Limestone	51.5	24.5	Cased
EW-8	lateritic clay, Sandstone	37.0	20.0	Backfilled because of low discharge
EW-9	lateritic clay, Limestone	53.2	29.5	Cased
EW-10	lateritic clay, Limestone	92.0	56.0	Cased
EW-11	lateritic clay, Loose sand	89.0	Not reached	Backfilled
EW-12	lateritic clay, Limestone	80.0	32.8	Cased
EW-13	lateritic clay, Limestone	44.3	14.5	Cased
EW-14	Lateritic clay	95.4	Not reached	Backfilled
EW-15	lateritic clay, Sandstone	98.4	85.0	Backfilled because of low discharge
EW-16	Lateritic clay	128.0	Not reached	Backfilled
EW-17	Lateritic clay	123.5	Not reached	Backfilled
EW-18	Lateritic clay	125.0	Not reached	Backfilled
EW-19	lateritic clay, Limestone	56.0	49.0	Cased
EW-20	lateritic clay, Limestone	25.0	19.7	Backfilled because of collapsing
EW-20A	lateritic clay, Limestone	40.0	20.5	Cased, Re-drilled hole for EW-20
Total 21holes	--	1,599.4m	--	10 holes cased, 11holes backfilled

As shown in Table 4.1.1, total number of the drilled wells is 21 holes and total drilled depth is 1,599.4m.



LEGEND

EW-11 # : Exploratory Well

Fig. 4.1.1
Location Map of the Exploratory wells

(2) Casing Program

Casing and screen were installed in the productive 10 wells which reached the bedrock aquifer. The wells which were not reached bedrock aquifer and unproductive wells even tapped bedrock aquifer were backfield.

The schematic casing program of the exploratory wells is shown in Fig.4.1.2.

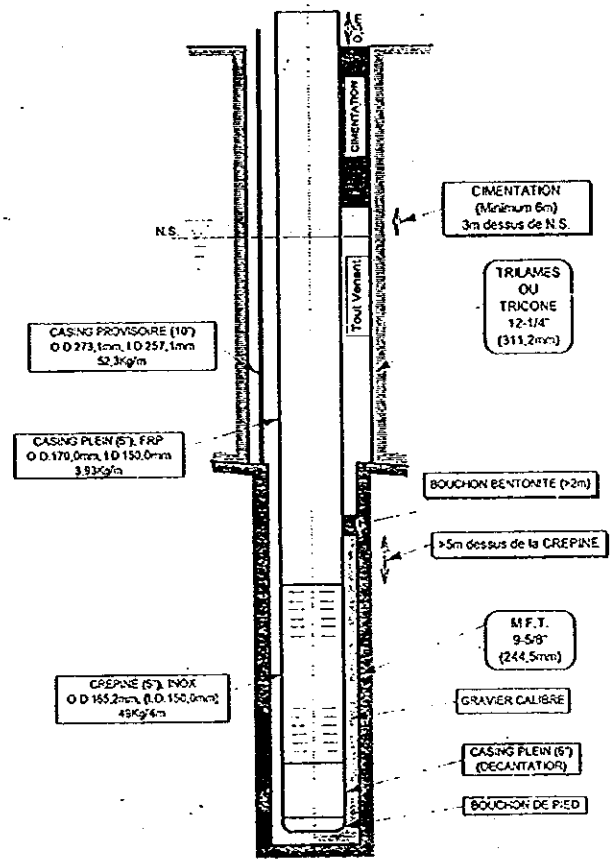


Fig.4.1.2 Schematic Casing Program of the Exploratory Wells

As shown in Fig.4.1.2, 12-1/4" hole was made in the lateritic overburden (Tertiary layers) with 10" temporary steel casing and 9-5/8" hole was drilled in the bedrock. After the completion of the hole, ID 150mm FRP pipe and ID 150mm INOX screen were installed and then the temporary steel casing was pulled out.

After the installation of casing, gravel packing, clay sealing and cementation were conducted as shown in Fig.4.1.2 and well development and pumping test were carried out subsequently.

(3) Lithology of the Exploratory Wells

The geological logs of the completed exploration wells are shown in Fig.4.1.3(1) and Fig.4.1.3(2). The Tertiary System is mainly clayey layers occasionally intercalating sandy and gravelly layers and they almost turned to reddish brown lateritic layers. The bedrock consists of limestone and sandstone.

It is inferred that the depth to the bedrock is shallower in the Northeastern area and abruptly got deeper in the area around the airport.

It is also inferred that the distribution area of the limestone shows relatively limited and its extends from the airport to the Oubangui River.

The detailed discussion on the hydrogeological structure will be described in chapter 5.

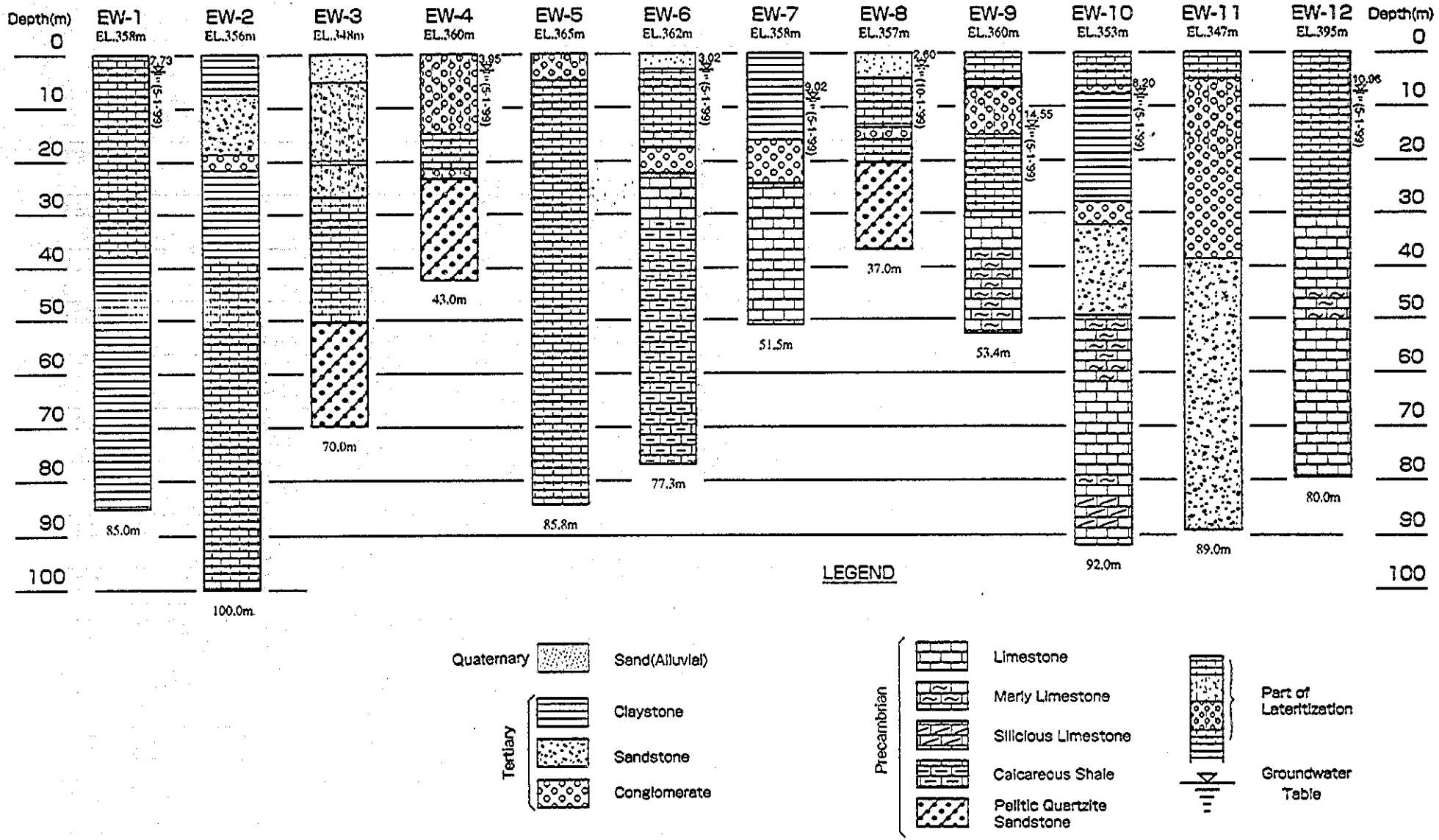


Fig.4.1.3(1) Geological Logs of the Exploratory Wells

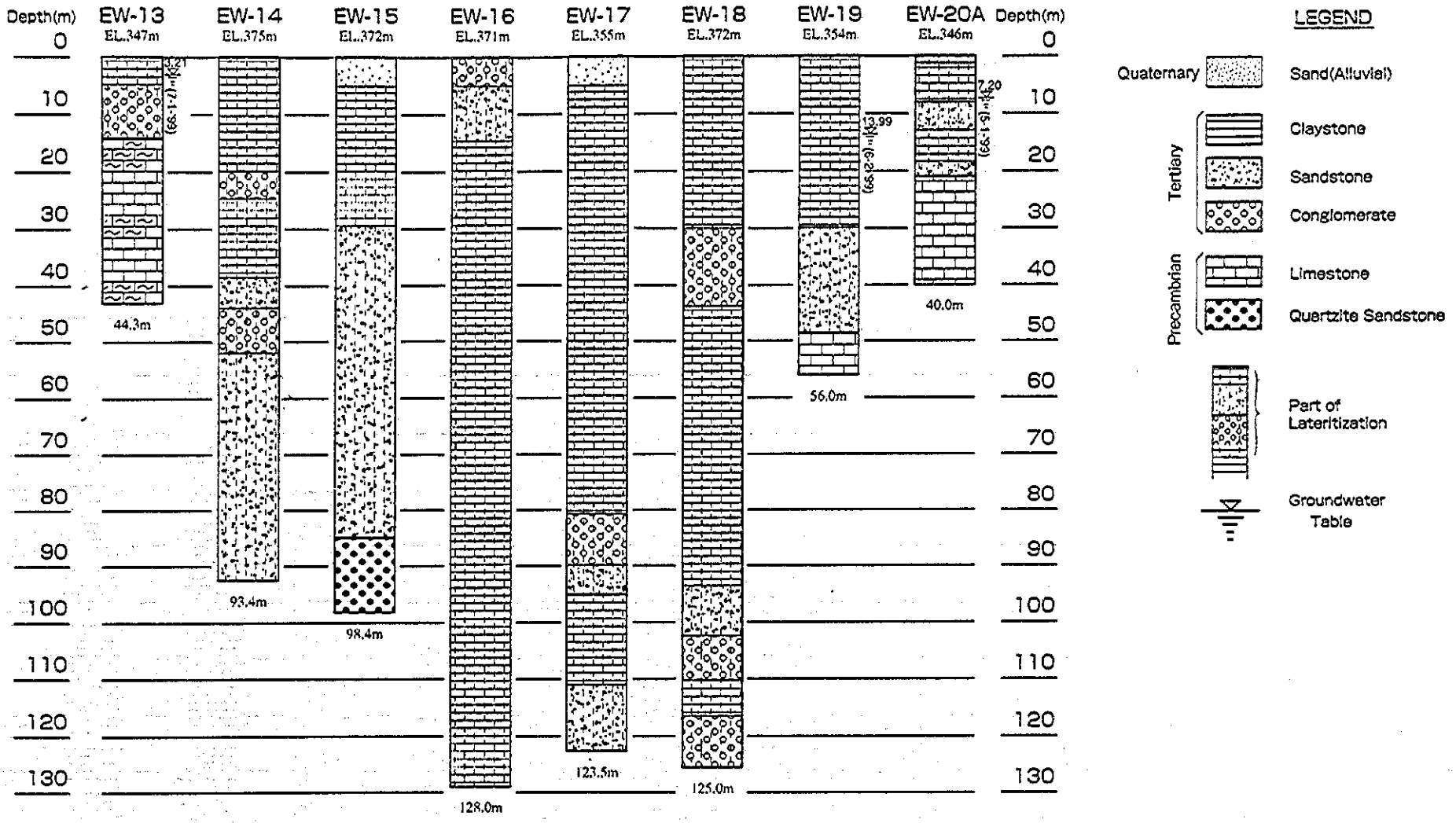


Fig.4.1.3(2) Geological Logs of the Exploratory Wells

4.2 Well Logging

The resistivity, spontaneous potential (SP) and natural gamma ray logging were conducted in four wells which are EW-1, EW-6, EW-12 and EW-14. Although the well logging was scheduled to be done in every exploratory wells, it could not be conducted in other wells due to the well collapsing.

The general tendency of the reisitivity of each strata is summarized as follows:

Layers	Resistivity (Ohm-m)
-Lateritic clay	100-500
-Lateritic sandy or gravely clay	500-1,000
-Bedrock (limestone)	1,000-2,000

4.3 Pumping Test

The pumping test was done only in the productive wells which were cased and capped. The results of the pumping test is summarized in Table 4.3.1.

Table 4.3.1 Results of the Pumping Test

Well No.	Aquifer	Transmissibility (m^2/day)	Permeability (m/day)	Max. Discharge Amount (m^3/h)
EW-3	Pelitic Quartzite Sandstone	1.9	$3.5x10^{-2}$	approx.1.0
EW-4	Pelitic Quartzite Sandstone	2.2	$1.6x10^{-1}$	approx.1.0
EW-6	Limestone, Calcareous Shale	1.0	$1.5x10^{-2}$	approx.1.0
EW-7	Limestone	9.8	$1.8x10^{-1}$	approx.1.5
EW-9	Marly Limestone	147	5.9	approx. 12
EW-10	Limestone, Marly Limestone	0.2	$9.1x10^{-3}$	<1.0
EW-12	Limestone	0.3	$1.5x10^{-2}$	<1.0
EW-13	Limestone	314	8.1	approx. 100
EW-19	Limestone	1,385	198	>100
EW-20	Limestone	810	25.3	>100

It is inferred that the transmissibility and permeability are not necessarily larger in the limestone. It seems that the transmissibility and permeability get higher along the two fault zones. One of the fault zones is running from the airport to Mpoko I through Fatima area. Another fault zone is assumed to extend from the former office of the hydraulic department to UCATEX in N-S direction. Detailed hydrogeological analysis will be discussed in chapter 5.

4.4 Water Quality Analysis

Water quality analysis was conducted on the productive exploration wells. Groundwater was sampled at the end of the continuous pumping test. The items of the water quality analysis are determined based on the water quality standards for potable use of WHO.

The results of the water quality analysis are shown in Table 4.4.1.

Table 4.4.1 Results of Water Quality Analysis

Item	EW-3	EW-4	EW-6	EW-7	EW-9	EW-10	EW-12	EW-13	EW-19	EW-20
pH	5.78	5.69	7.15	8.22	7.02	7.12	8.48	7.20	7.02	7.91
Temp.(℃)	27	28	28	28	24	27	22	28	28	26
TDS (mg/l)	67	19	224	171	207	243	559	256	280	217
Hard.($CaCO^3$ mg/l)	38	20	259	197	283	273	291	335	294	280
NO_3 (mg/l)	10.3	1.3	9.5	10.6	22.5	7.5	8.7	7.5	1.2	9.3
NH_4 (mg/l)	0.58	0.38	0.43	0.41	0.73	0.37	0.28	0.34	0.3	0.40
SO_4 (mg/l)	5	6	8	6	13	6	7	4	8	6
Mn (mg/l)	1.9	0	0.8	0.9	2.0	0.6	0.8	0.4	0.3	0.4
Fe (mg/l)	10	0.49	0.24	0.9	0.91	0.37	0.35	0.18	0.06	0.08
Cl (mg/l)	2.9	5.2	2.6	trace	11.5	3.4	4.9	7.9	8.2	3.3
Ca (mg/l)	12	5.6	85.2	54	105	101.2	78	87.6	62.8	62.4
Mg (mg/l)	1.9	1.4	11.2	15.1	5.0	4.8	23.4	28.3	33.4	30.2
HCO_3 (mg/l)	31.1	13.3	193	139	220	204	227	224	200	206
T. Coli. (/100ml)	10	2	>200	0	$>2x10^5$	>200	>100	20	2	>200
Coliforms (/100ml)	3	>200	>200	>200	$>2x10^5$	>200	>200	20	10	>200
Str. Fec. (/100ml)	0	0	0	0	0	0	0	0	0	0
C. Sul-red. (/100ml)	>200	>200	>200	0	0	>200	>200	0	0	>200
T. Bc. Ar. (/100ml)	0	>20,000	>20,000	10^5	$1.7x10^6$	20,000	>20,000	40,000	0	>20,000

T. Coli.: Thermotolerant Coliform, Str. Fec.: Streptocoques Fecaux, C. Sul-red.: Clostridies Sulfito-reductrices, Staphylo.: Staphylocoques, T. Bc. Ar.: Total Aerobic Bacteria, 400: Out of WHO Standard

As shown above table, coliforms were detected in every wells and the Fe and Mn concentration exceeds the WHO standards in almost all the exploratory wells.

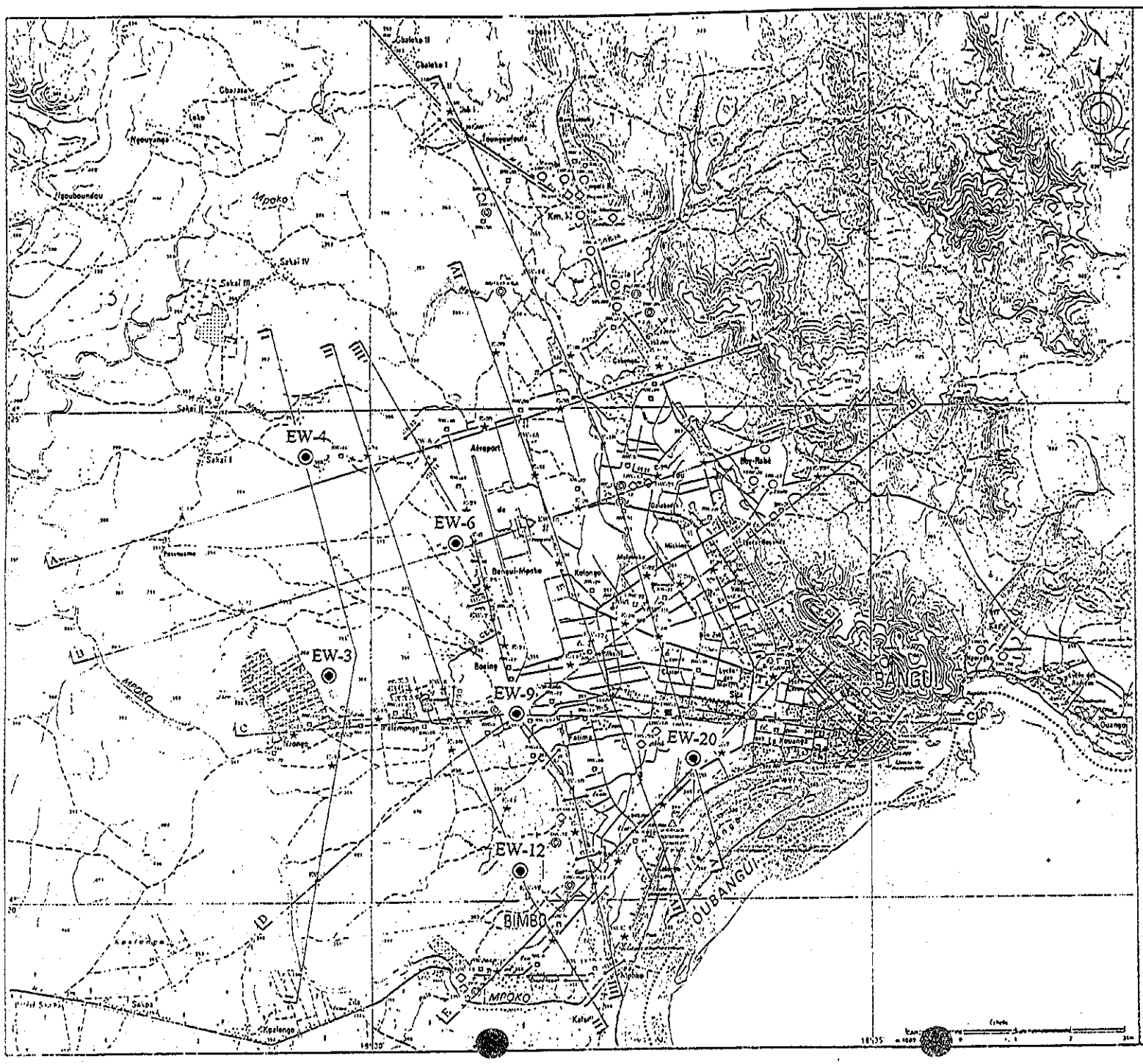
It is unusual that the coliforms and ammonia were found in the deep aquifers which are more than 30m in depth. It is preliminary inferred as the reason that the bedrock aquifer connected with the shallow aquifer and shallow groundwater rapidly seeps into the deep bedrock aquifer.

4.5 Groundwater Level Observation

Automatic groundwater level recorders have been installed at the following exploration wells. The location of the exploration wells equipped with the recorders is shown in Fig.4.5.1.

EW-3
EW-4
EW-6
EW-9
EW-12
EW-20

As shown in Fig.4.5.1, the location of the automatic groundwater level recorders were selected covering the western part of the Study Area in order to monitor the groundwater fluctuation in the proposed well fields. These observation wells should be utilized and maintained to monitor the groundwater draw-down to be caused by the groundwater development in future.



LEGEND

◉ : Groundwater level Observation Well Equipped with Automatic Recorder

Fig.4.5.1
Location of the Well Equipped with the Automatic Groundwater Level Recorders

Chapter 5. Hydrogeology

Hydrogeological map of the Study Area is shown in Fig.5.1.1 and hydrogeological cross sections are shown in Fig.5.1.2 and Fig.5.1.3.

5.1 Aquifer of the Study Area

The main aquifers in the Study Area are considered to be formed with next layers and rocks:

- Laterite Layers (mother rock : Tertiary sedimentary layers)
- Bedrock (surface weathered part of the Precambrian bedrock)

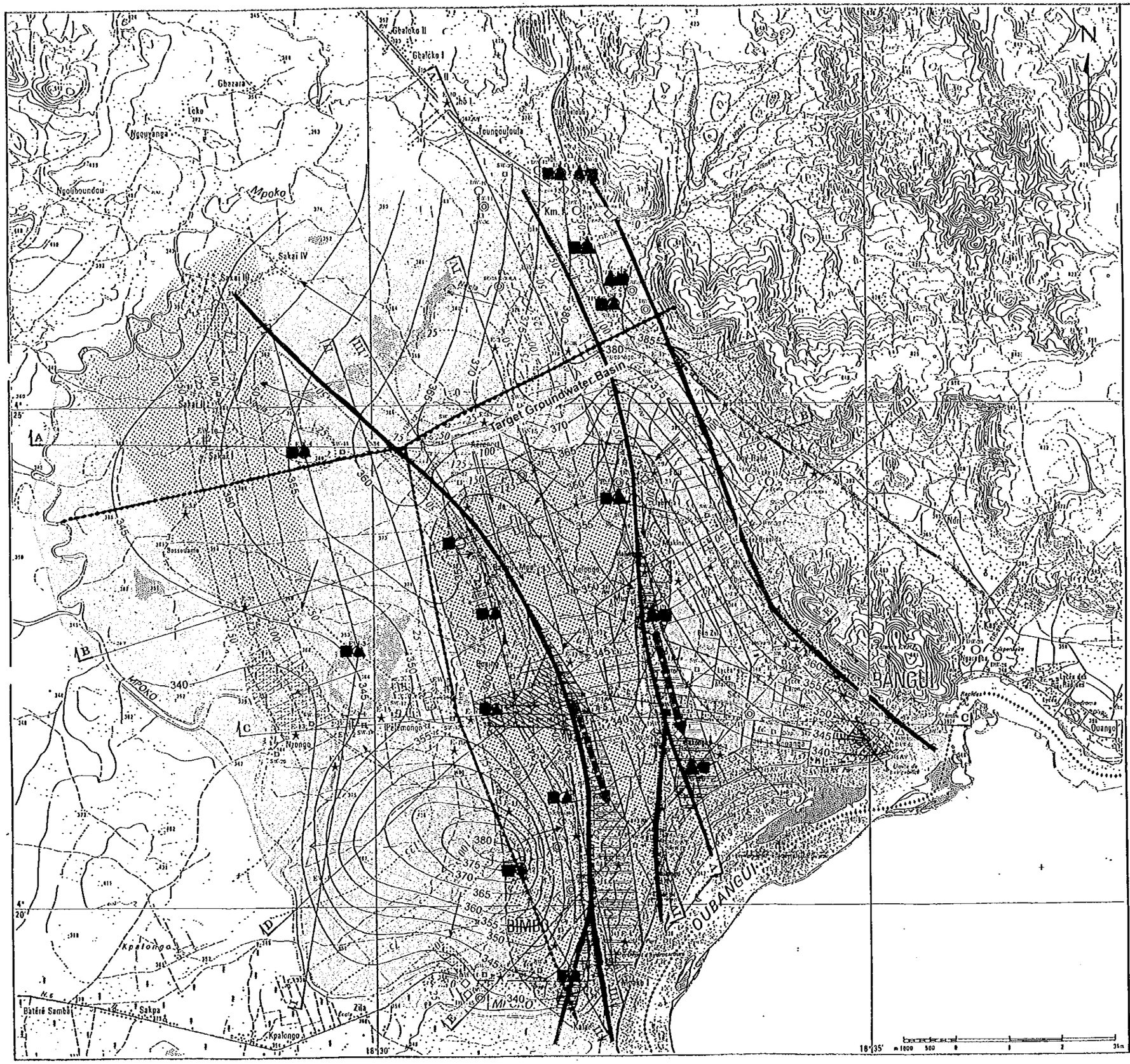
The laterite layers are underlain with the Precambrian bedrock.

(1) Laterite Aquifer

As described in "2.1.1 Geomorphological and Geological Aspects of the Study Area", the mother rock of the laterite layers is the Tertiary system which is composed of yellow claystone intercalated with sandstone and conglomerate and it covers all of the Study Area. The Tertiary system turned into lateritic clay, lateritic clayey sand and lateritic clayey gravel because of severe weathering action under the tropical condition. The thickness of the laterite aquifer is around 50m in average and more than175m around the airport.

(2) Bedrock Aquifer

The bedrock consists of quartzite sandstone, quartz schist and limestone. In general case, the aquifer is formed in the surface weathered part of the bedrock which is fractured by the weathering action. The thickness of this part is around 30m according to the results of the exploratory well drilling. Another type of the aquifer is formed along the fault in the bedrock which is highly fractured. The productivity of the latter aquifer is much greater than the former one.



LEGEND

Geology

- Limestone
- Quartzite Sandstone and Quartz Schist
- Assumed Fault
- 75 — Contour Line of the Depth to the Bedrock Aquifer (m)

Groundwater Table

- 350 — Groundwater Table Contour Line of the Bedrock Aquifer (m, measured in Jan. 1999)
- Divide of the Groundwater Basin
- Groundwater Flow Line in the Bedrock Aquifer
- Main Groundwater Flow Line in the Bedrock Aquifer

Possible Area for Well Field

- Max. Yield of a Well:100m³/hour or more
- Max. Yield of a Well:100m³/hour or less

Note: Other areas is 1m³/hour or less

Groundwater Quality

Fe Ion Concentration
- More than 0.3mg/Lit
- Less than 0.3mg/Lit

Mn Ion Concentration
- More than 0.5mg/Lit
- Less than 0.5mg/Lit

I — II Line of the Cross Section

Fig.5.1.1 Hydrogeological Map of the Bedrock Aquifer

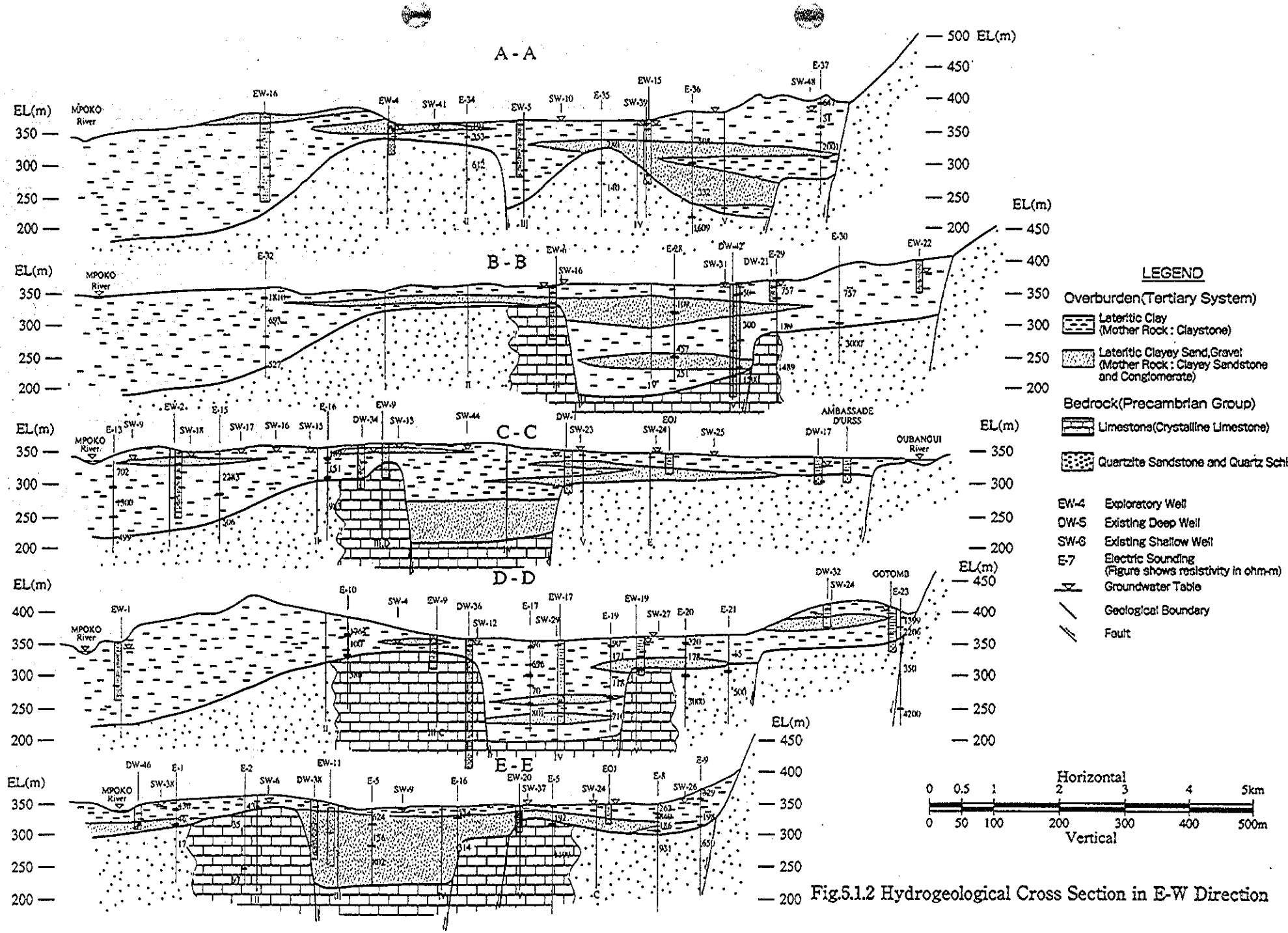


Fig.5.1.2 Hydrogeological Cross Section in E-W Direction

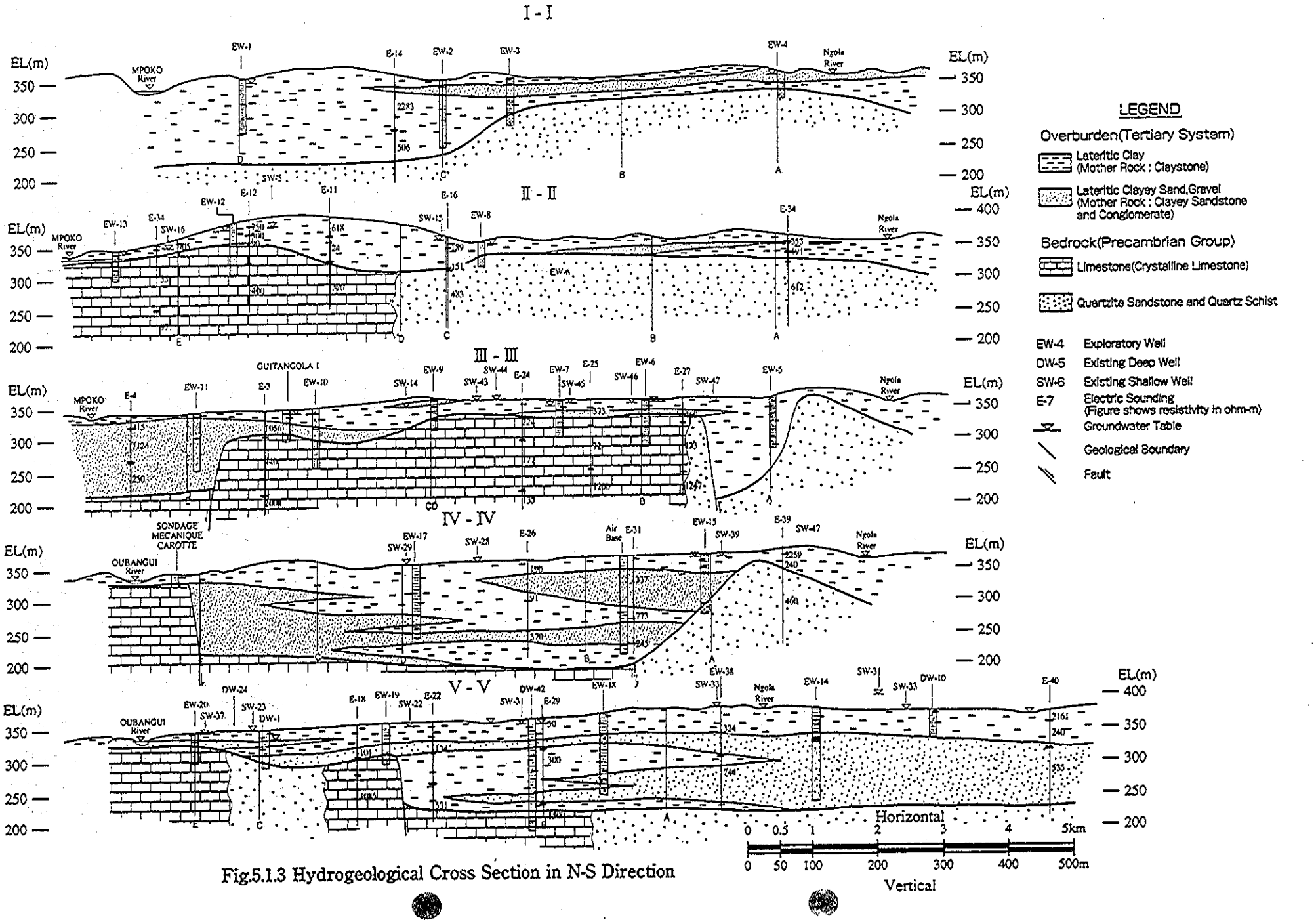


Fig.5.1.3 Hydrogeological Cross Section in N-S Direction

5.2 Permeability of the Aquifers

(1) Permeability of the Laterite Aquifer

The permeability of the laterite aquifer is generally low as it contain much clay even in the sandy and gravely layers. The specific capacity of the laterite aquifer ranges from 4.8 m^2/day to 93.6m^2/day and its permeability coefficient is assumed 0.01m/day to 0.8m/day according to the limited existing well data. The greater part of the laterite aquifer has low permeability as low as 0.1m/day because it is mainly consists of clay layer. It is inferred that the permeability of the vertical direction might be much smaller than the horizontal one because the laterite aquifer is composed of alternation of lateritic clay layers and clayey sand layers.

(2) Permeability of the Bedrock Aquifer

The distribution of the transmissibility of the bedrock aquifer is plotted in Fig.5.2.1 based on the exploratory well drilling results and existing pumping test results.

As shown in Fig.5.2.1, the transmissibility of the bedrock aquifer greatly differs from place to place and the maximum value (100m^2/day to 1,000m^2/day) is more than 100,000 times larger than the minimum value (0.1m^2 to 1m^2/day). Fig.5.2.1 also shows that the transmissibility is not necessarily larger in the limestone.

It is assumed that such heterogeneousness in the transmissibility is appeared by the existence of the high permeable zone along the faults which were presumably detected based on the hydrogeological survey results as shown in Fig 5.1.1 to Fig 5.1.3.

It seems that the high transmissibility zones extend along the assumed fault lines, one of which is running from the airport to Mpoko I through Fatima and another one is running from UCATEX to Bakongo through Mustafa as shown in the hydrogeological map.

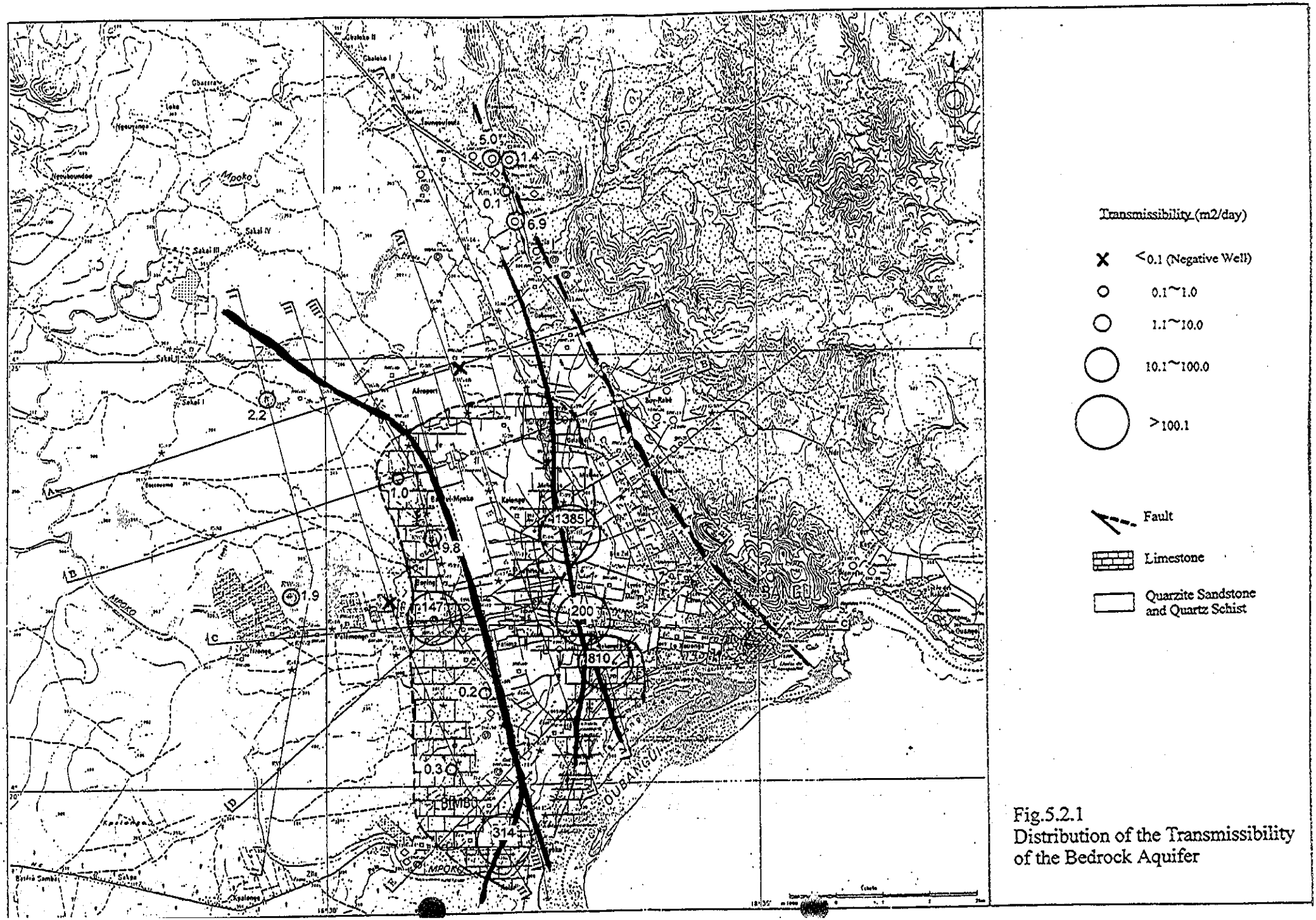


Fig.5.2.1
Distribution of the Transmissibility of the Bedrock Aquifer

5.3 Hydrogeological Structure

(1) Fault and Depression

Three major faults is inferred as shown in the hydrogeological map based on the results of the hydrogeological surveys which are geophysical prospecting and exploratory well drilling. These fault are running in NNW-SSE direction. As mentioned in Chapter 5.2, the faults form main groundwater path in the bedrock aquifer.

These faults dislocated the bedrock and formed depression which is passing through the Bangui city area. as shown in Fig.5.3.1 which shows the shape of the surface of the bedrock. The depth of the depression is 100m to 180m and its width is about 2km according to the hydrogeological cross sections of Fig.5.1.2 and Fig. 5.1.3. The depression is buried with thick lateritic layers whose mother rock is Tertiary system.

The depth to the bedrock aquifer largely changes from place to place because of the depression. The assumed contour line of the depth to the bedrock aquifer is shown in the hydrogeological map. According to this map, the depth to the bedrock aquifer deepens around the airport and gets shallower in the western area to the Bangui City.

(2) Piezometric Potential and Groundwater Basin

1) Piezometric Potential of the Laterite Aquifer

Piezometric contour line of the laterite aquifer is shown in Fig.5.3.2. This map is prepared based on the data of shallow well survey conducted in May 1996. As shown in this map, the Piezometric surface of the laterite aquifer has same configuration with topographic features, namely, piezometric potential is higher at plateau and lower at plain and valley. It is concluded that the laterite aquifer ca be classified typical unconfined aquifer which receives recharge mainly from the precipitation from the reasons mentioned above.

2) Piezometric Potential of the Bedrock Aquifer

Piezometric contour line of the bedrock aquifer measured in January 1999 is shown in the hydrogeological map (see Fig.5.1.1). Comparing the piezometric contour line of the bedrock aquifer with the contour line of the laterite aquifer (see Fig.5.3.2), it is said that the piezometric contour line of the both aquifers are almost coincident except the zones along the assumed faults. Namely, the groundwater table of the bedrock aquifer gets lower than the laterite aquifer by about 10m along the faults because the piezometric valleys are formed along the faults. It is assumed that the groundwater is mainly flowing through the fractured zones of the faults.

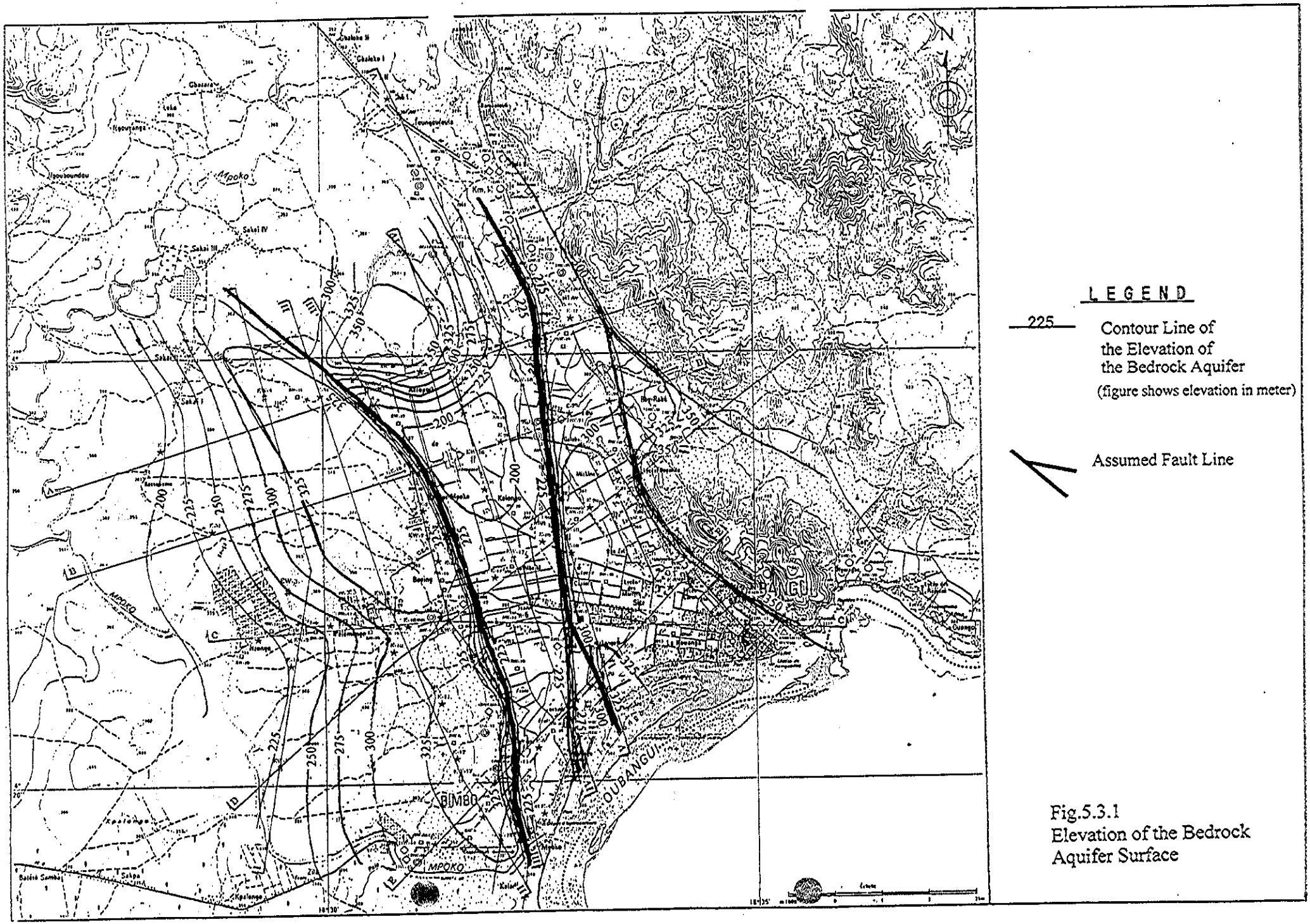


Fig.5.3.1
Elevation of the Bedrock
Aquifer Surface

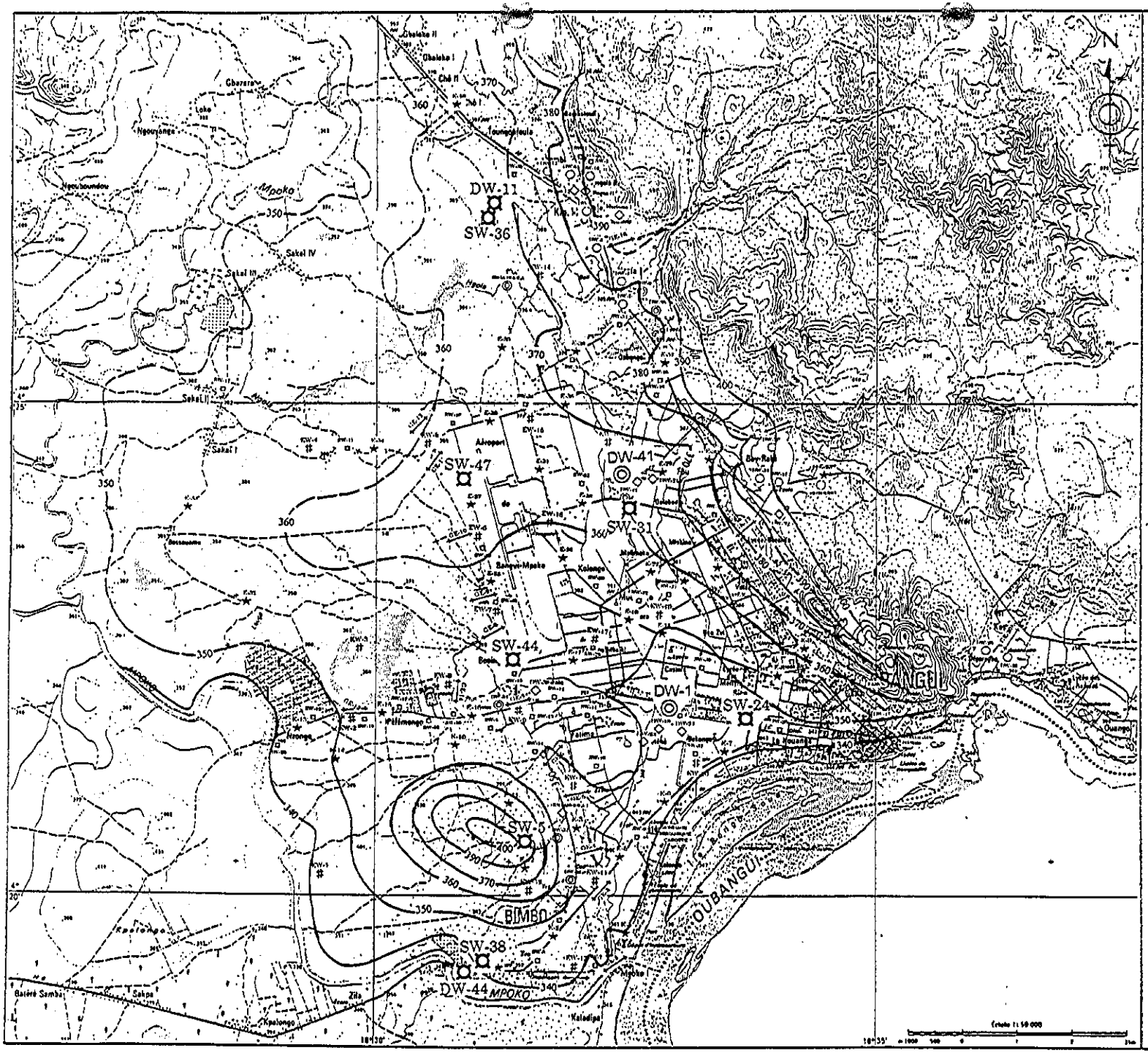


Fig.5.3.2
Piezometric Contour Line of the Laterite Aquifer

The piezometric contour line of the bedrock aquifer shows that the bedrock aquifer also solely receives recharge from the precipitation through the laterite aquifer and there is no inflow from the other groundwater basins. It means that the bedrock aquifer hydraulically connected with the overlain laterite aquifer strongly.

The bedrock aquifer can be divided into three groundwater basin as shown in the hydrogeological map. The promising groundwater basin is located in the Bangui city area where the highly permeable faults are running in NNW-SSE direction as shown in the hydrogeological map (see Fig.5.1.1). As any permeable groundwater paths could not be found in the other two ground basins, it is concluded that the groundwater potential of these two groundwater basins is too low for the urban water supply.

(3) Groundwater Level Fluctuation

The monthly groundwater level observation was conducted in ten existing wells from April to December in 1996. As it was scheduled to continue for one year, it could not be done because of the outbreak of mutinies. The continuous observation was done from 1992 to 1994 in DW-1 tapped the bedrock aquifer (chert) which is located in the former office yard of General Department of Hydraulics. The groundwater level monitoring results including DW-1 are shown in Fig.5.3.3 with the mean monthly precipitation and the location of the groundwater level observation wells is shown in Fig.5.3.2.

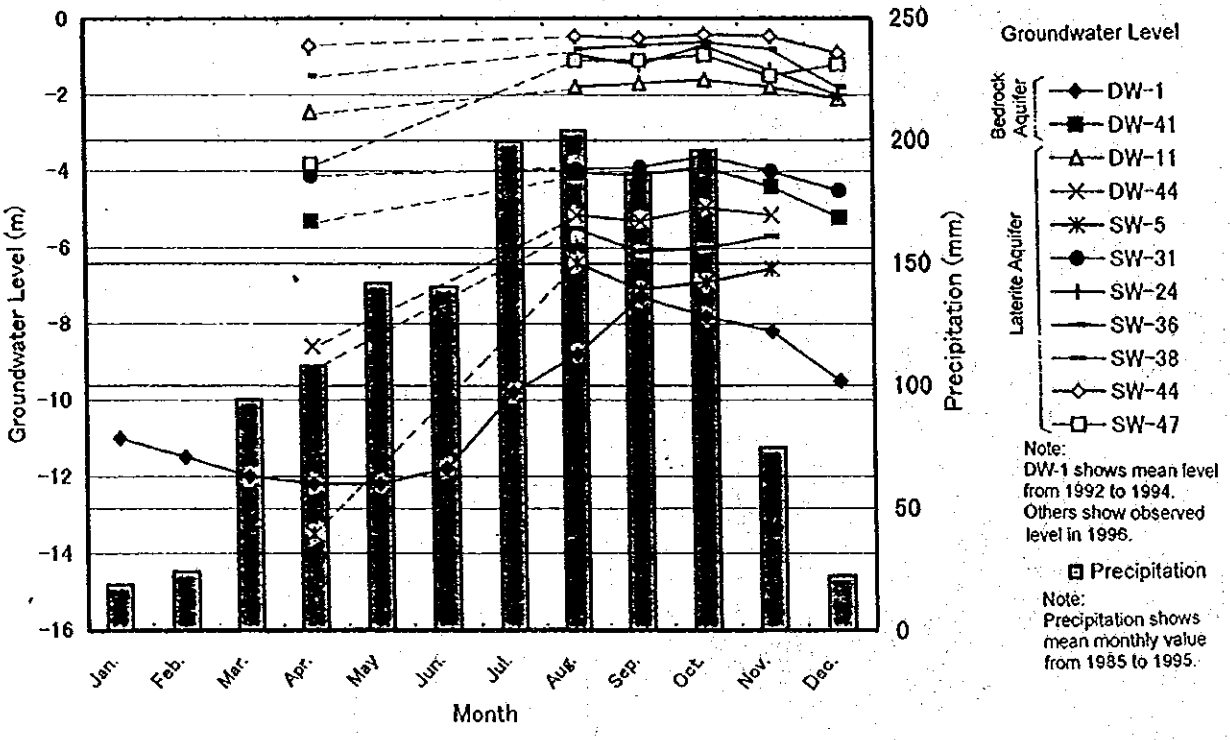


Fig. 5.3.3 Precipitation and Groundwater Fluctuation Pattern

As shown in the above figure, the groundwater fluctuation pattern is almost coincident with precipitation pattern and it also shows clear seasonal groundwater level fluctuation. It is supposed that the groundwater recharge is brought mainly from the precipitation even in the deep bedrock aquifer and it is inferred that the both aquifers hydraulically connected and could be regarded as one unconfined aquifer based on the reasons mentioned above.

The continuous groundwater level observation with automatic recorders was conducted in six exploratory wells from the beginning of February 1999 to the end of May 1999. The location of the exploratory wells is shown in Fig.4.5.1 and the groundwater level observation results are shown in Fig. 5.3.4. All of the six observation wells penetrated to the deep bedrock aquifer and upper shallow aquifer was completely sealed.

It is particular that the groundwater level of the deep bedrock aquifer quickly responds the precipitation as shown in this figure. This phenomena also shows that the deep bedrock aquifer hydraulically connected to the ground surface and quickly recharged by the precipitation.

As indicated in Chapter 4.4, even the groundwater of the deep bedrock aquifer contaminated with coliforms and ammonia. This fact also suggests that the both aquifers hydraulically connected and shallow groundwater easily seeps into the deep aquifer.

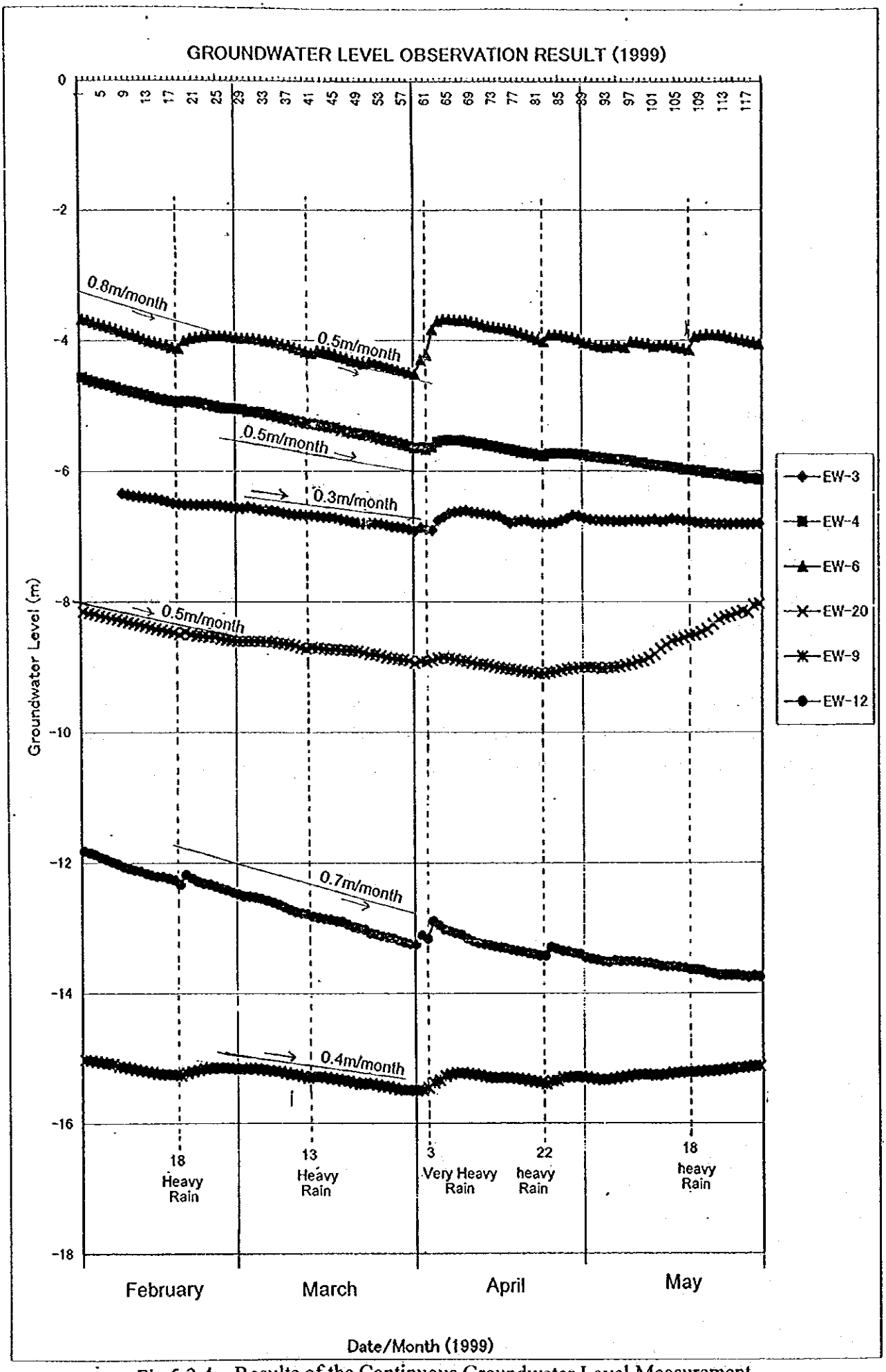


Fig.5.3.4 Results of the Continuous Groundwater Level Measurement