A - 2 PRESENT CONDITION

e. Socio-economical condition

(1) Area and Population

Area : 195,000 Km^2

Population: 9,274,000 (CPO. 1986)

The rate of population increase: 1.7 % per year (1981-1986)

The average life expectancy at birth: 45 years

(2) GND per Capita and GDP in 1984

	GNP/capita (US$)	GDP (10^6 US$)
Growth rate/year	550 5.9% (1965 - 84)	2940 8.1% (1973 - 84)

(3) GDP by Sector

	Agricultur	Industry	Serivce
GDP (10^3 US$)	705.6	617.4 (264.6)	1,646.4
Growth rate/year	1.8%	13.8% (14.2%)	9.6%

(4) Price Index : Average Inflation rate; 12.6% (1973 - 84)

Unit: %

Item \ Year	1978/79	1979/80	1980/81	1981/82
Market price in SANA'A city	21.8	10.6	7.1	5.0
GDP deflation	16.2	10.9	2.1	1.9

Note: Figures show increasing note against the previous year

(5) Growth Rate of Consumption

Individual Consumption: 5.7 %/year (1973 - 84)
National Consumption : 12.3 %/year (1973 - 84)

(6) Interenational Trade (1984)

Unit:10^6 US$

Importation	Exportation
1,401	9

(1984)

(7) Balance of International Payments

Unit: 10^6 YR

Item \ Year	1982	1983 JAN-JUN
Trade Balance	-8,764	-4,176
Invisible Trade	-169	-177
Transfer Payments	6,161	2,794
Current Balance	-2,771	-1,558
Capital Balance	972	299
Error	208	591
Total Balance	-1,592	-669

Source: Ministry of Foreign Affair and others.

(8) Financial Balance

Unit: 10^6 YR

Item \ Year	1981	1982
Current Balance	3,329	3,720
Current Expenses	3,325	4,584
Capital Balance	6	4
Capital Expenses	3,683	4,321
Financial Balance	-3,673	-5,181
Foreign Loan and Others	2,439	2,865
Local Loan	2,023	4,415
Adjustment	-787	-2,099

(9) Japanese Financial Cooperation

Project Loan (as of the end of February 1984)

Unit: 10^6 Yen

Date of Exchange Note	Date of Loan Agreement	Name of Project	Loan Amount based on the E/N
1977.6	1977.8.5	Rural water supply project	3,880
1979.7	1979.9.17	Steam-power plant project	8,200
1982.7	1982.11.2	Bodidah Harbor seventh	8,200
Total loan amount based on E/N			20,280

Source: Ministry of Foreign Affair and others.

Grant Aid Project (as of the end of February 1984)

Unit: 10^6 Yen

Date of Exchange Note	Amount of Grand Aid	Name of Project	Fiscal Year	Amount of Each Fiscal Year
1976.9.2	308	Food grant aid US1.00 Million	1976	308
1977.12.26	363.4	Food grant aid US1.18 Million	1977	363.4
1978.12.30	421.2	Food grant aid US1.80 Million	1978	421.2
1980.1.15	500	Grant aid for promotion of food production	1979	
1980.3.23	4.516	Payment of debt	1979	504.516
1981.3.16	15.511	Payment of debt	1980	15.511
1981.11.17	500	Rural water supply	1981	
1981.11.17	278	Food grant aid	1981	
1982.2.25	25.484	Payment of debt	1981	803.484
1982.6.19	500	Rural water supply	1982	
1982.10.13	500	Grant aid for promotion of food production	1982	
1982.10.13	45	Cultural grant aid for the Sanaa university	1982	
1982.12.17	116.5	Disaster grant aid (earthquake)	1982	
1983.2.7	66.341	Payment of debt	1982	1,227.841
1983.7.30	600	Rural water supply	1983	
1983.10.3	500	Grant aid for promotion of flood production	1983	-
1984.2.21	83.797	Payment of debt	1983	n.a.
Accumulate	4,827.949			

Source: Ministry of Foreign Affair and Others.

f. Completed Water Supply Projectas under the Assistance of the Government of Japan. (1/5)

1. OECF Loan Project

a) Rural Water Supply Project, Part I, Yemen Arab Republic
b) Loan Agreement :
No.YA-1 dated Aug. 5, 1977
c) Construction Period :
Aug. 26, 1980 - Aug. 25, 1983

2. Grant Project

(Grant - 1)

a) Rural Water Supply Project
b) E/N : Nov. 17, 1981
c) Project Period :
Jan., 1982 - March, 1983

(Grant - 2)

a) Rural Water Supply Project
b) E/N : June 19, 1982
c) Project Period :
July, 1982 - March, 1984

(Grant - 3)

a) Rural Water Supply Project
b) E/N : July 30, 1983
c) Project Period :
August, 1983 - March, 1985

A List of Project Sites

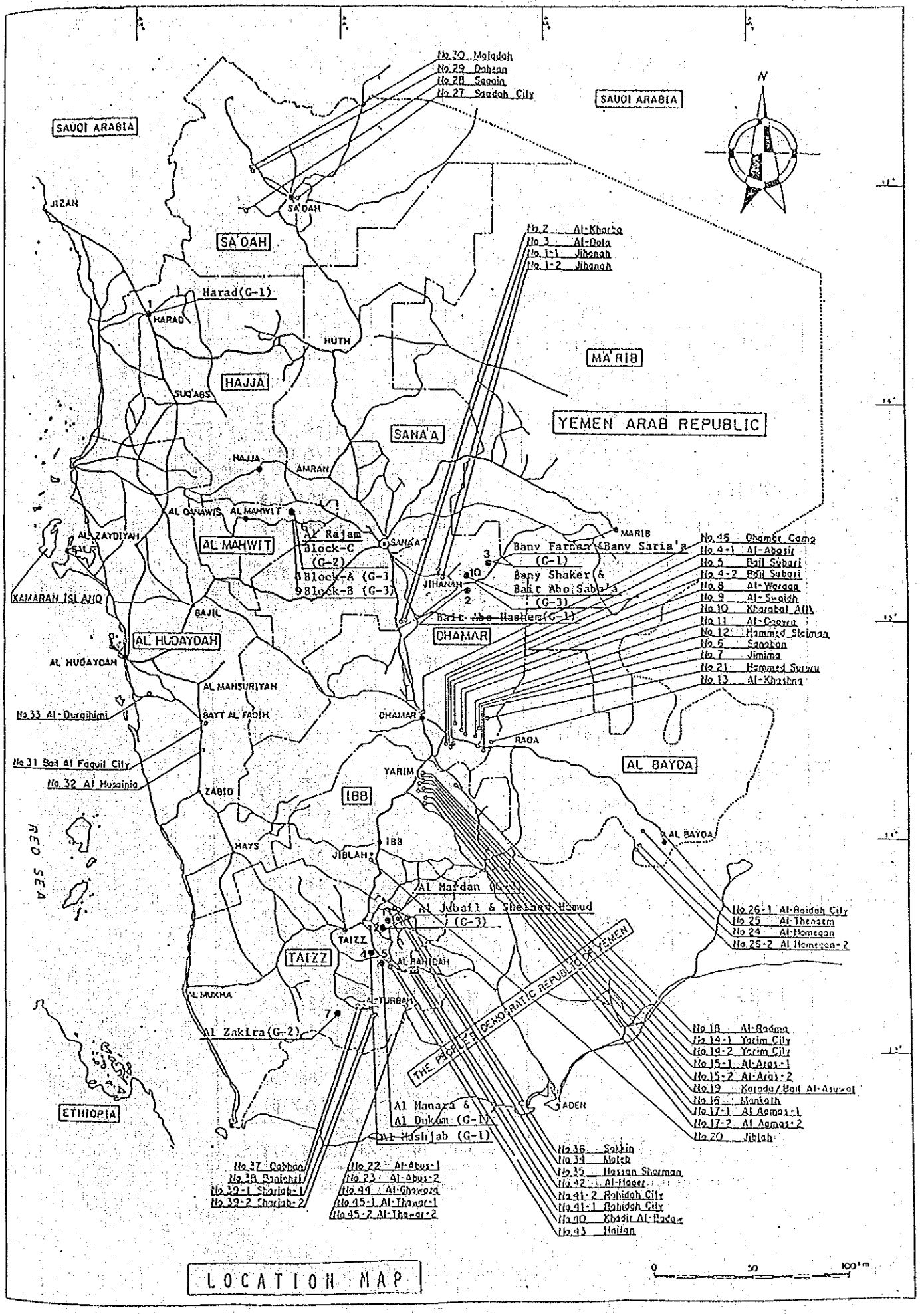
Serial No.	Site No. & Area		Governorate	
1	1-1	Jihana-1	Sanaa	◎
2	1-2	Jihana-2(Zabera)	"	◎
3	2	Al-Kharba	"	◎
4	3	Al-Dola	"	◎
5	4-1	Al-Abasir	Dhamar	◎
6	6	Sanaban	"	◎
7	7	Jimima	"	◎
8	8	Al-Waraga	"	◎
9	9	Al-Swaida	"	◎
10	10	Al-Kharabat Afik	"	◎
11	11	Al-Daayra	"	◎
12	12	Hammed Slaiman	"	◎
13	14-1	Yarim City-1	Ibb	◎
14	14-2	Yarim City-2	"	◎
15	15-1	Al-Aras-1 (Al-Kharabah)	"	◎
16	15-2	Al-Aras-2 (Al-Jardah)	"	◎
17	16	Mankath	"	◎
18	17-1	Al-Aamas-1	"	◎
19	17-2	Al-Aamas-2	"	◎
20	18	Al-Radma	"	◎
21	19	Karaba/Bait Al-Asuwal	"	◎
22	25	Al-Dhinaem	Al-Baidah	◎
23	26-1	Al-Baidah City	"	◎
24	26-2	Al-Homegan	"	◎
25	27	Saadah City	Saadah	◎
26	28	Sagain	"	◎
27	29	Dahean	"	◎
28	30	Majadh	"	◎
29	31	Bait Al-Faguit City	Hodeidah	□
30	32	Al-Husainia	"	◎
31	33	Al-Duraihimi	"	□

Serial No.	Site No. & Area		Governorate	
32	34	Moteb	Taizz	◎
33	37	Dobhan	"	◎
34	38	Banighzi	"	◎
35	39-2	Sharjab-2	"	◎
36	41-1	Ranidah City-1	"	◎
37	44	Al-Ghawaza (Mafalis)	"	◎
38	46	Dhamar Camp	Dhamar	◎
39	4-2	Bait Subari	"	◎
40	5	Bait Subari	"	◎
41	13	Al-Khashna	"	◎
42	21	Hammed Surur	"	◎
43	20	Jiblah	Ibb	◎
44	24	Al-Homegan-1	Al-Baidah	◎
45	22	Al-Abus-1	Taizz	○
46	23	Al-Abus-2	"	○
47	35	Hassan Shorman	"	◎
48	36	Sakkin	"	◎
49	39-1	Sharjab-1	"	◎
50	40	Khadir Al-Badow	"	◎
51	41-2	Rahidah City-2	"	◎
52	42	Al-Hager	"	◎
53	43	Haifan	"	○
54	45-1	Al-Thawar-1 (Mafalis)	"	◎
55	45-2	Al-Thawar-2 (Mafalis)	"	◎

Grant Project (1 - 3) Project Site

	No.	Site Name	Governorate	
	1	Harad	Hajja	◎
	2	Bait Abo Hashem	Sana'a	◎
Grant-1	3	Bany Farham & Bany Saria'a	Sana'a	○
	4	Al Mashjah	Taizz	◎
	5	Al Mancra & Al Dukum	Taizz	◎
Grant-2	6	Al Rajam (Block-C)	Al Mahweet	◎
	7	Al Zakira	Taizz	◎
	8	Al Rajam (Block-A)	Al Mahweet	□
	9	Al Rajam (Block-B)	Al Mahweet	◎
Grant-3	10	Bany Shaker&Bait Abo Saba'a	Sana'a	◎
	11	Al Maydan	Taizz	◎
	12	Al Jubail&Sheibed Hamud	Taizz	◎

Note : ○ Well and water supply facilities
□ Well
◎ Water supply facilities


No.30 Malodah
No.29 Dahean
No.28 Saggin
No.27 Saadah City
SAUDI ARABIA
SAUDI ARABIA
N
JIZAN
SA'DAH
SA'DAH
No.2 Al-Kharba
No.3 Al-Dola
No.1-1 Jihanah
No.1-2 Jihanah
Harad(G-1)
HARAD
HUTH
MA'RIB
HAJJA
SUQ'ABS
YEMEN ARAB REPUBLIC
SANA'A
NAJJA
AMRAN
AL QANAWIS
AL MAHWIT
AL ZAYDIYAH
AL MAHWIT
Rajam Block-C (G-2)
Block-A (G-3)
Block-B (G-3)
SANA'A
MARIB
Banv Farman & Banv Saria'a (G-1)
Bany Shaker & Bait Abo Saba'a (G-3)
JIHANAH
Bait Abo Hashem(G-1)
KAMARAN ISLAND
BAJIL
AL HUDAYDAH
DHAMAR
AL HUDAYDAH
AL MANSURIYAH
No.33 Al-Durgihimi
BAYT AL FAQIH
DHAMAR
No.31 Bait Al Faquil City
No.32 Al Husainia
ZABID
RADA
AL BAYDA
YARIM
188
RED SEA
HAYS
188
JIBLAH
AL BAYDA
Al Mardan (G-1)
Al Jubail & Shehara Hamud (G-3)
TAIZZ
TAIZZ
AL RAHDAH
AL MUKHA
AL TURBAH
Al Zakira(G-2)
THE PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN
ETHIOPIA
Al Manara & Al Dukam (G-1)
Al Hashjab (G-1)
ADEN
No.45 Dhamar Camp
No.4-1 Al-Abasir
No.5 Bajil Subari
No.4-2 Bajil Subari
No.8 Al-Waraga
No.9 Al-Swaidh
No.10 Kharabat Affk
No.11 Al-Qaayra
No.12 Hammed Sleiman
No.6 Sanaban
No.7 Jimima
No.21 Hammed Surour
No.13 Al-Khaibna
No.26-1 Al-Baidah City
No.25 Al-Thenaem
No.24 Al-Homegan
No.25-2 Al Homegan-2
No.18 Al-Radma
No.14-1 Yarim City
No.14-2 Yarim City
No.15-1 Al-Arga-1
No.15-2 Al-Arga-2
No.19 Karada/Bait Al-Asywal
No.16 Mankath
No.17-1 Al Aamar-1
No.17-2 Al Aamar-2
No.20 Jiblah
No.36 Sabbin
No.34 Mateb
No.35 Hassan Sharman
No.42 Al-Hageer
No.41-2 Rahidah City
No.41-1 Rahidah City
No.40 Khadir Al-Radaa
No.43 Hailan
No.37 Dahean
No.38 Saniahi
No.39-1 Sharjah-1
No.39-2 Sharjah-2
No.22 Al-Abas-1
No.23 Al-Abas-2
No.44 Al-Ghaeara
No.45-1 Al-Thaear-1
No.45-2 Al-Thaear-2
0
50
100km
LOCATION MAP

9. Population

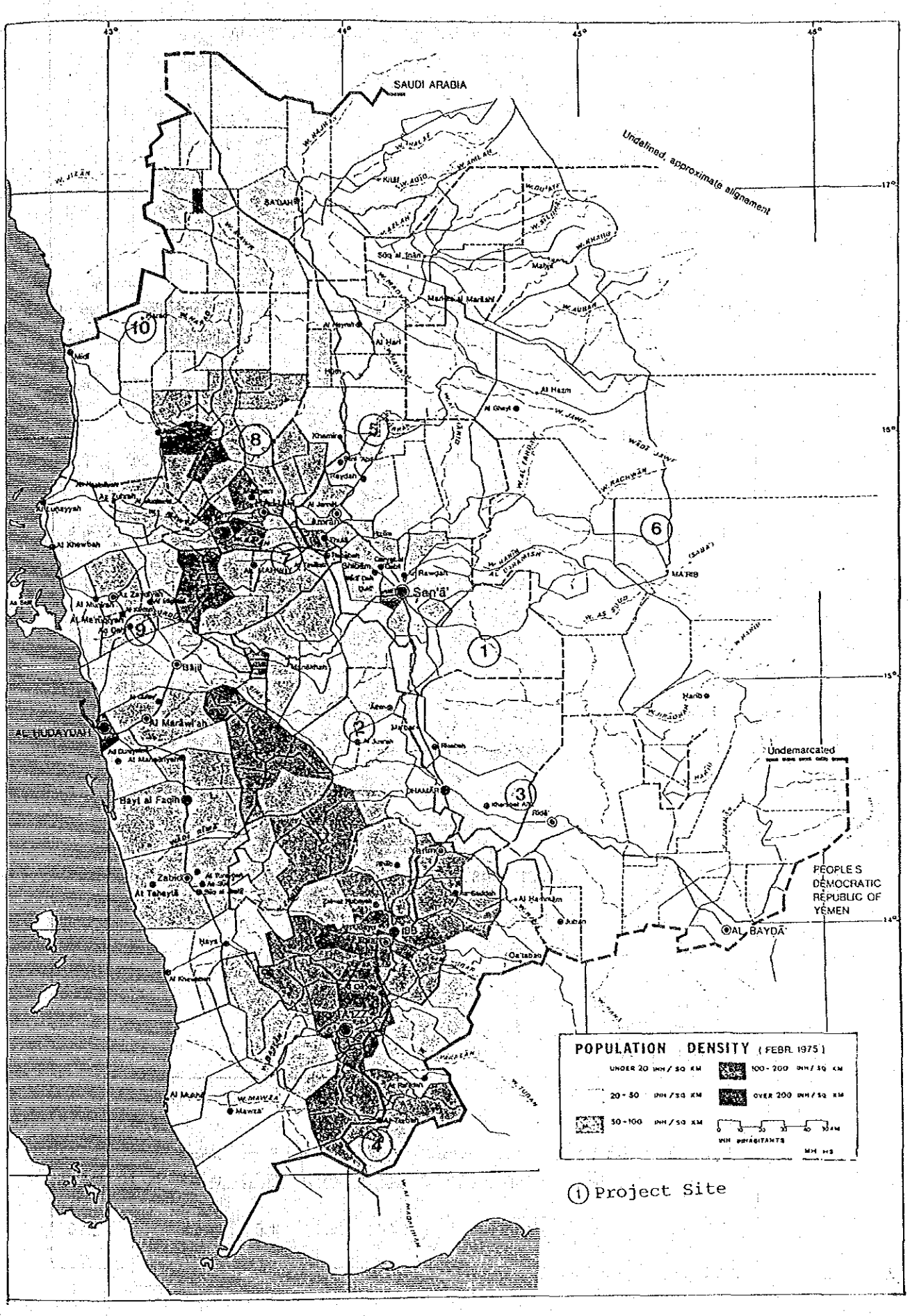
1 Population

(unit:person)

State	Year		
	1975	1981	1986
SANA'A	1,041,249 (135,625)	1,740,744 (211,150)	1,856,876 (427,185)
TAIZ	1,121,801 (79,720)	1,553,520 (87,689)	1,643,901 (178,043)
HODEIDAH	807,575 (72,895)	1,085,376 (95,873)	1,294,359 (155,110)
IBB	1,020,994 (17,494)	1,347,987 (25,888)	1,511,879 (48,806)
DHAMAR	568,186 (19,540)	787,109 (30,368)	812,981 (47,744)
HAJJAH	490,820 (5,813)	880,619 (12,891)	897,814 (15,878)
SADAH	268,840 (4,252)	332,364 (7,131)	344,152 (11,759)
MAHWIT	224,054 (2,421)	292,973 (5,503)	322,226 (5,166)
BAIDAH	229,653 (5,975)	327,539 (9,626)	381,249 (12,370)
MARIB	225,805	108,814	121,437 (1,457)
JAWF		83,074	87,299 (2,216)
Total	6,492,530	8,540,119	9,274,173

*( ):population of the capital (1986 : population report,CPO)

2 Population Density



3 Present and projected population

YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Wadi Asfan
2. Governorate : SANAA
3. No. of Villages : 6
4. Population(1986) : 695
5. Growth Rate : 1.7%
6. Water Demand : 40 ℓ/d/capt

Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Design Popu.	Design Demand (m3/d)
1. Bait Ayash	115	137	5.5	149	6.0	170	6.8	170	6.8
2. Beit Al Yamani 3. Al Garahima	171	203	8.1	221	8.8	240	9.6	240	9.6
4. Beit Emad	171	203	8.1	221	8.8	240	9.6	240	9.6
5. Beit Al Nager	213	253	10.1	275	11.0	300	12.0	300	12.0
6. Al Jaya	25	30	1.2	33	1.3	40	1.6	40	1.6
Total	695	826	33.0	899	35.9	990	39.6	990	39.6

YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Al Khashna
2. Governorate : Dhamar
3. No. of Villages : 1
4. Population(1986) : 350
5. Growth Rate : 1.7%
6. Water Demand : 40 ℓ/d/capt

Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Planned Popu.	Planned Demand (m3/d)
1. Al Khashna	350	415	16.6	451	18.0	490	19.6	490	19.6

YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Zakira
2. Governorate : TAIZZ
3. No. of Villages : 3
4. Population(1986) : 576
5. Growth Rate : 1.7%
6. Water Demand : 40ℓ/d/capt

Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Planned Popu.	Planned Demand (m3/d)
1. Al Mahazal	96	114	4.6	124	5.0	140	5.6	140	5.6
2. Safi Al Kalif	240	285	11.4	310	12.4	340	13.6	340	13.12
3. Al Ghafah	240	285	11.4	310	12.4	340	13.6	340	13.12
Total	576	684	27.4	744	29.8	820	32.8	820	32.8

YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Al Kheisen
2. Governorate : SANAA
3. No. of Villages : 5
4. Population(1986) : 824
5. Growth Rate : 1.7%
6. Water Demand : 40ℓ/d/capt

Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Planned Popu.	Planned Demand (m3/d)
1. Beit Al Eyani	120	143	5.7	155	6.2	170	6.8	170	6.8
2. Beit Obait	40	48	1.9	52	2.1	60	2.4	60	2.4
3. Beit Narshar	360	427	17.1	464	18.6	510	20.4	510	20.4
4. Beit Marwan	128	152	6.1	165	6.6	180	7.2	180	7.2
5. Al Milehe	176	209	8.4	227	9.1	250	10.0	250	10.0
Total	824	979	39.2	1,063	42.6	1,170	46.8	1,170	46.3

YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Al Rajam
2. Governorate : AL MAHWIT
3. No. of Villages : 11
4. Population(1986) : 4,055
5. Growth Rate : 2.0%
6. Water Demand : 40 ℓ/d /capt

Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Design Popu.	Design Demand (m3/d)
1. Al Mohala	105	128	5.1	142	5.7	160	6.4	320	12.8
2. Al Jamima	105	128	5.1	142	5.7	160	6.4		
3. Magbel	315	384	15.4	424	17.0	470	18.8	470	18.8
4. Ad Dubrah	506	630	25.2	695	27.8	760	30.4	760	30.4
5. Jabal Ali									
6. Al Aswat	350	427	17.1	472	18.9	520	20.8	520	20.8
7. Al Hafah	525	640	25.6	707	28.3	780	31.2	780	31.2
8. Ruhban	336	410	16.4	453	18.1	500	20.0	500	20.0
9. Beit Qitran	350	427	17.1	472	18.9	520	20.8	520	20.8
10 Beit Al Jaradi	378	461	18.4	509	20.4	570	22.8	570	22.8
11 Beit Sulayman	350	427	17.1	472	18.9	520	20.8	520	20.8
12 Al Safuf	245	299	12.0	330	13.2	370	14.8	370	14.8
13 Al Maqar	70	86	3.4	95	3.8	110	4.4	110	4.4
14 Al Hajar	420	512	20.5	566	22.6	630	25.2	630	25.2
Total	4,055	4,959	198.4	5,479	219.3	6,070	242.8	6,070	242.8

YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Shihara
2. Governorate : HAJJA
3. No. of Villages : 22
4. Population(1986) : 5,972
5. Growth Rate : 1.7%
6. Water Demand : 40 ℓ/d /capt

Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Design Popu.	Design Demand (m3/d)
1. Sihara	2,429	2,875	115.0	3,128	125.1	3,490	139.6	4,070	162.8
2. Al Najd	411	487	19.5	530	21.2	580	23.2		
3. Beit Al Goal	77	92	3.7	100	4.0	110	4.4.	110	4.4
4. Al Jamyma 5. Al Rahabah	375	444	17.8	483	19.3	530	21.2		
6. Beit Al Qazaiy	74	88	3.5	96	3.8	110	4.4	1,230	49.2
7. Al Beyadah	70	83	3.3	91	3.6	100	4.0		
8. Al Qashibah	187	222	8.9	241	9.6	270	10.8		
9. Al Qosur 10 Al Shankh	156	185	7.4	201	8.0	220	8.8		
11 Al Magrobah	192	228	9.1	248	9.9	270	10.8		
12 Beni Habshah	134	159	6.4	173	6.9	190	7.6		
13 Beni Wadan	156	185	7.4	201	8.0	220	8.8	1,590	53.6
14 Al Mahama	134	159	6.4	173	6.9	190	7.6		
15 Al Habs	338	401	16.0	436	17.4	480	19.2		
16 Mohebah	170	202	8.1	219	8.8	240	9.6		
17 Al Jehada	68	81	3.2	88	3.5	100	4.0	310	12.4
18 Al Koresh	146	173	6.9	189	7.6	210	8.4		
19 Al Qabain 20 Sug Al Qabain	489	579	23.2	630	25.2	690	27.6		
21 Al Saye	80	95	3.8	104	4.2	120	4.8	1,120	45.2
22 Al Qwashe	223	264	10.6	288	11.5	320	12.8		

YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Addahi
2. Governorate : HUDAYDAH
3. No. of Villages : 1
4. Population(1986) : 5,093
5. Growth Rate : 2.9%
6. Water Demand : 70 ℓ/d /capt

Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Design Popu.	Design Demand (m3/d)
1. Addahi	5,093	6,779	474.5	7,820	547.4	9,030	632.2	9,030	632.2

YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Harad
2. Governorate : HAJJA
3. No. of Villages : 1
4. Population(1986) : 3,905
5. Growth Rate : 2.9%
6. Water Demand : 70 ℓ/d /capt

Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Design Popu.	Design Demand (m3/d)
1. Harad	3,905	5,198	363.9	5,996	419.7	6,920	484.4	6,920	484.4

YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Dimuna
2. Governorate : DHAMAR
3. No. of Villages : 6
4. Population(1986) : 772
5. Growth Rate : 1.7%
6. Water Demand : 40 ℓ/d /capt

Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Planned Popu.	Planned Demand (m3/d)
1. Al Hafa	173	205	8.2	223	8.9	243	9.7		
2. Al Mifah	43	51	2.0	56	2.2	61	2.4		
3. Dimuna	82	98	3.9	106	4.2	115	4.6		
4. Al Salfa	128	152	6.1	165	6.6	180	7.2		
5. Qoeb Safla	346	410	16.4	446	17.8	485	19.4		
6. Qoeb Ala									
Total	772								

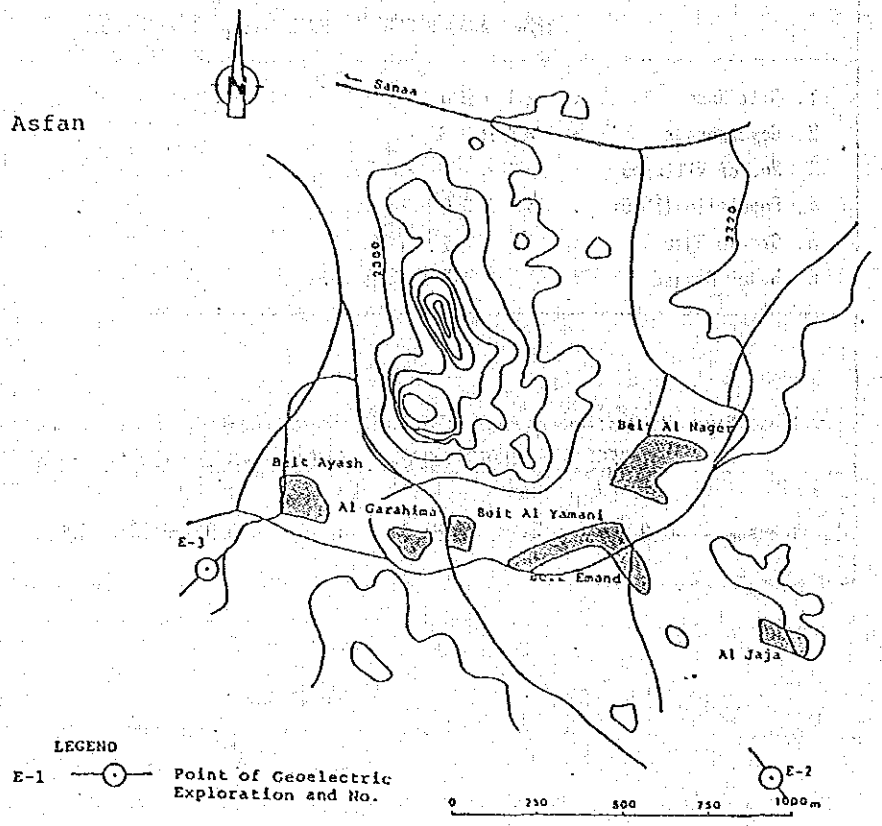
YEMEN ARAB REPUBLIC RURAL WATER SUPPLY PROJECT

1. Site Name : Al Husum
2. Governorate : MARIB
3. No. of Villages : 1
4. Population(1986) : 3,500
5. Growth Rate : 1.7%
6. Water Demand : 40 ℓ/d /capt

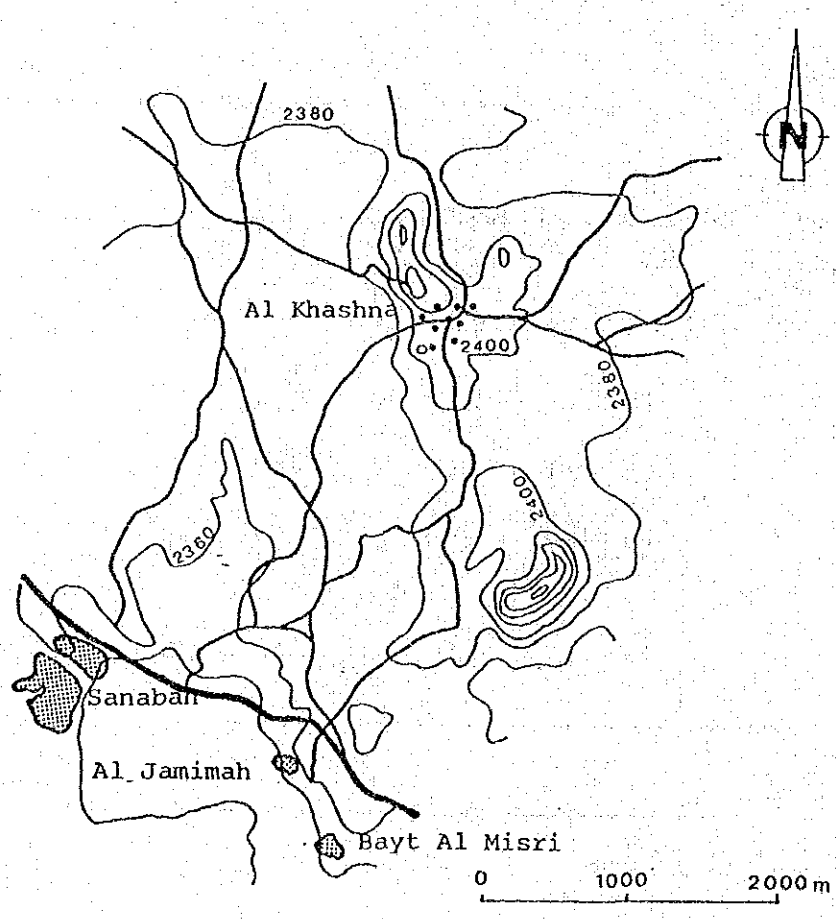
Village Name	Population (1986)	Popu. (1996)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Popu. (2001)	Demand (m3/d)	Design Popu.	Design Demand (m3/d)
1. Al Husum	3,500	4,143	165.7	4,507	180.3	4,904	196.2	4,904	196.2

h. Site Map

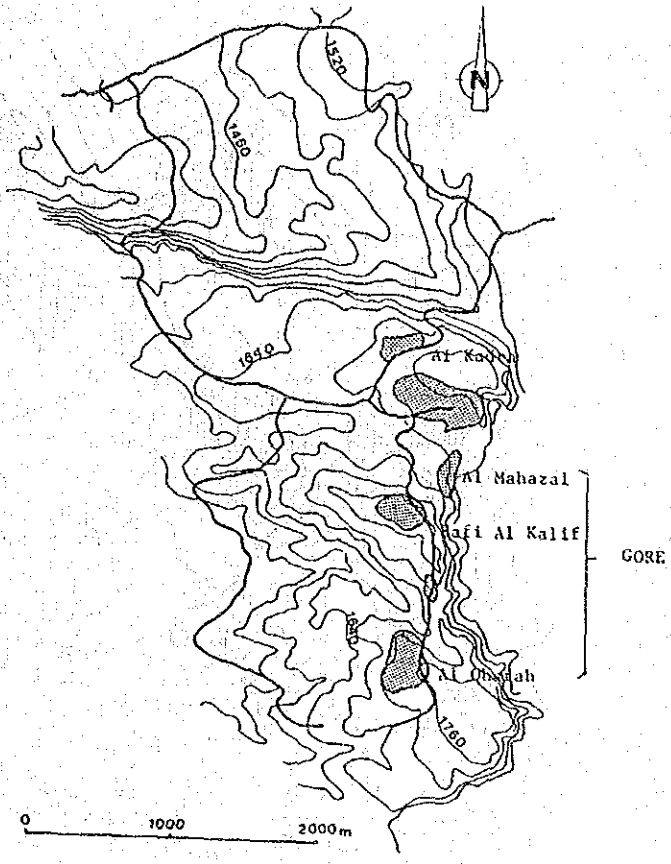
1 Wadi Asfan



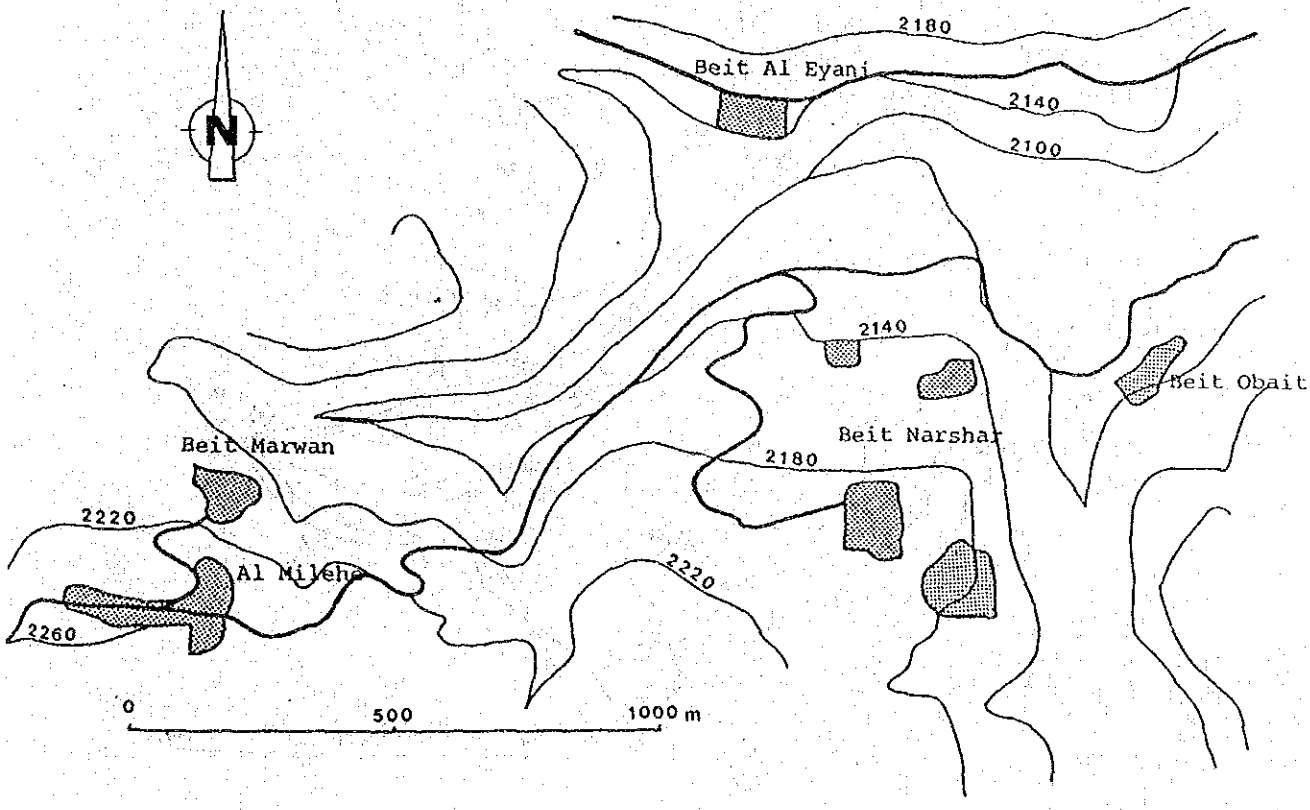
2 AL KHASHNA



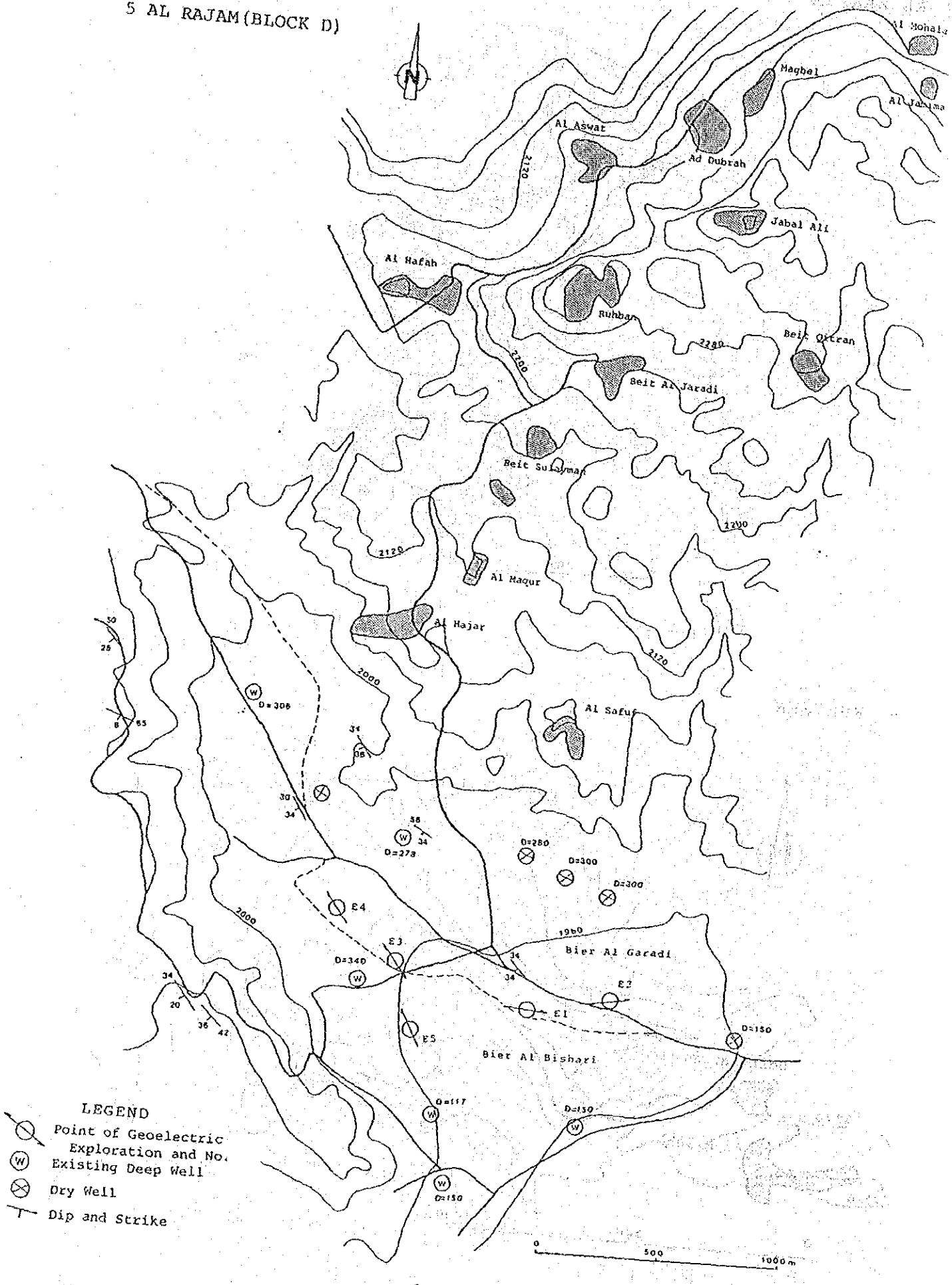
3 AL ZAKIRA

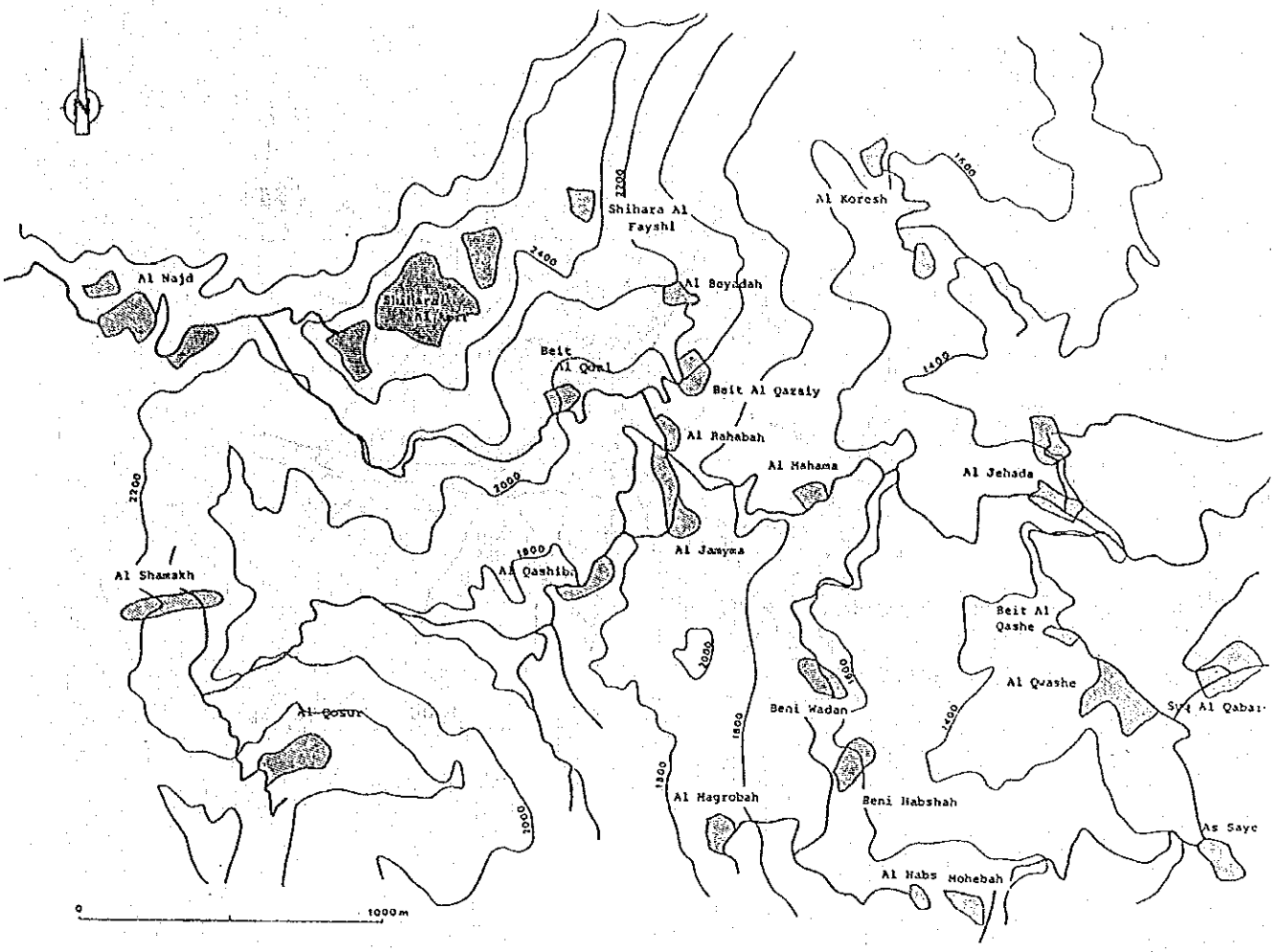


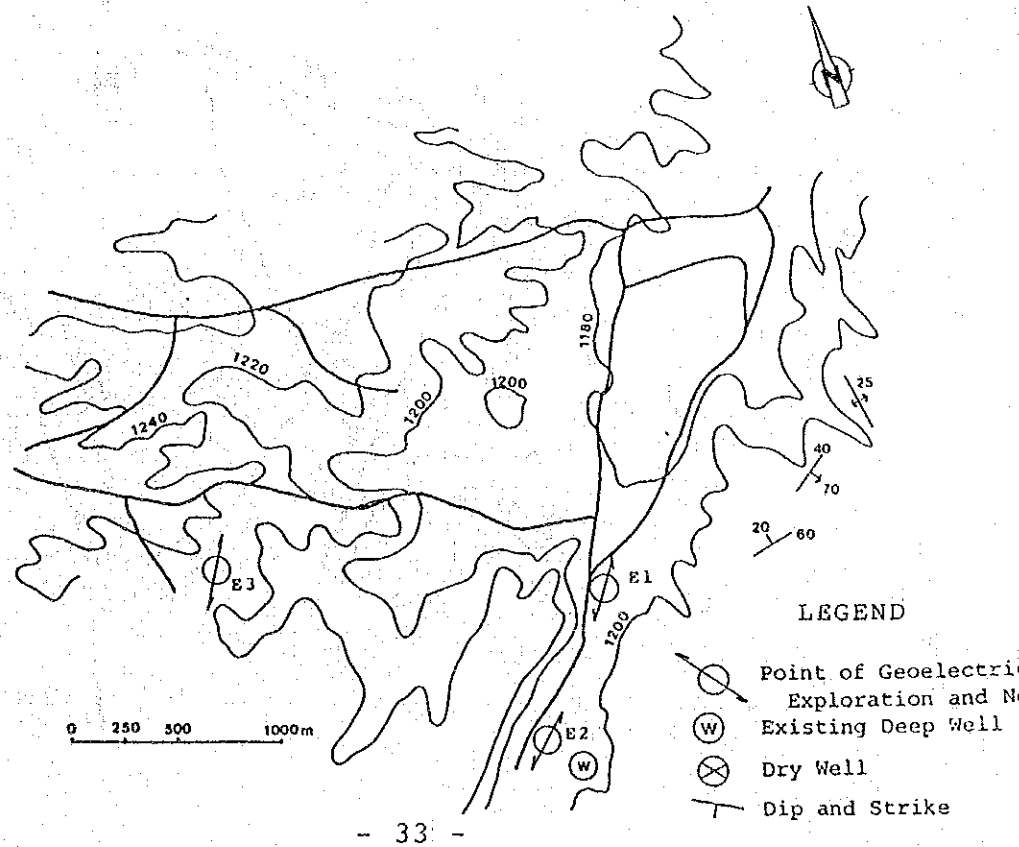
4 AL KHEISEN



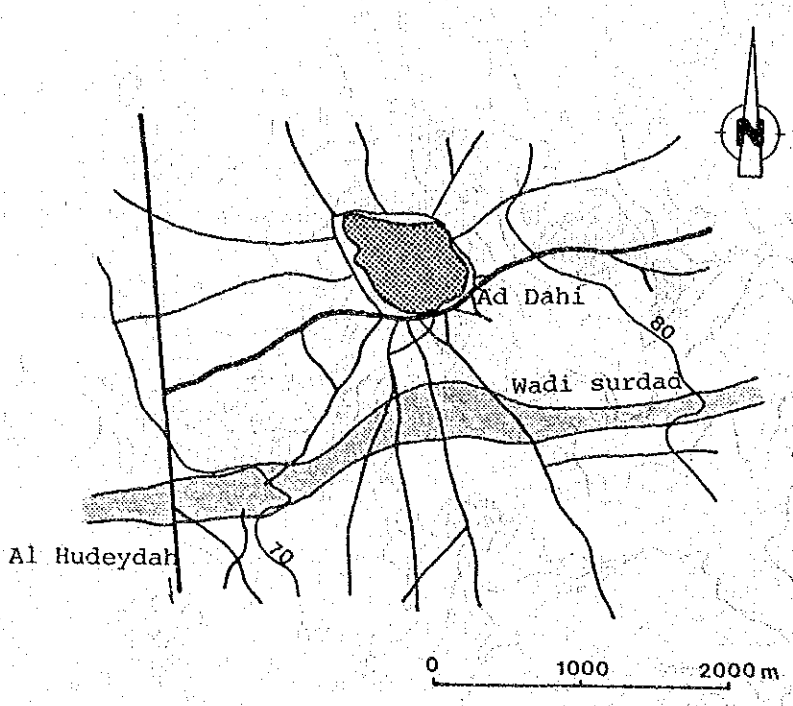
5 AL RAJAM (BLOCK D)



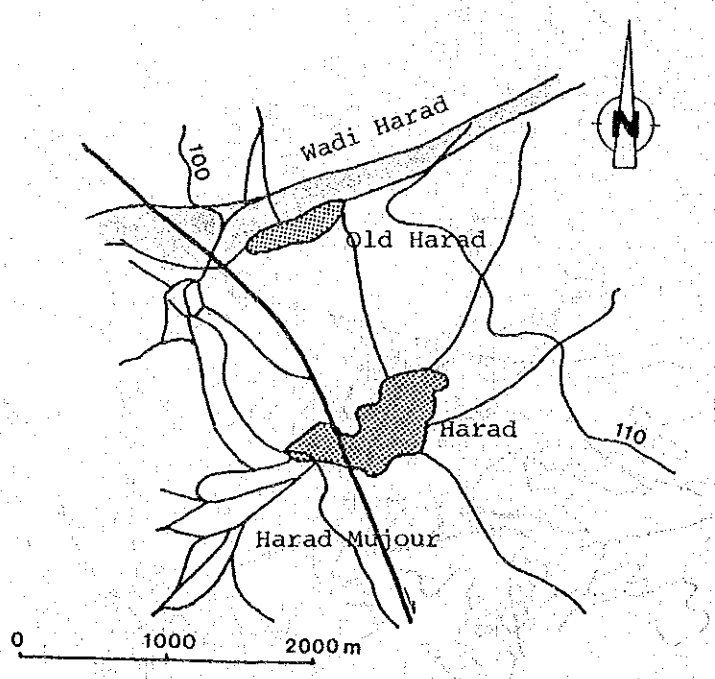

Al Najd
Shihara Al Fayshi
Al Koresh
Al Beyadah
Beit Al Qazaly
Al Rahabah
Al Mahama
Al Jehada
Al Shamakh
Al Qashib
Al Jamyma
Beit Al Qashe
Al Qashe
Beni Wadan
Al Qosur
Al Hagrobah
Beni Habshah
As Sayc
Al Nabs Mohebah
2200
2400
2000
1800
1600
1400
1200
1000
0
1000m


1220
1240
1200
1180
1200
E3
E1
E2
W
25
40
70
20
60
0
250
500
1000m
LEGEND
Point of Geoelectric Exploration and No.
Existing Deep Well
Dry Well
Dip and Strike

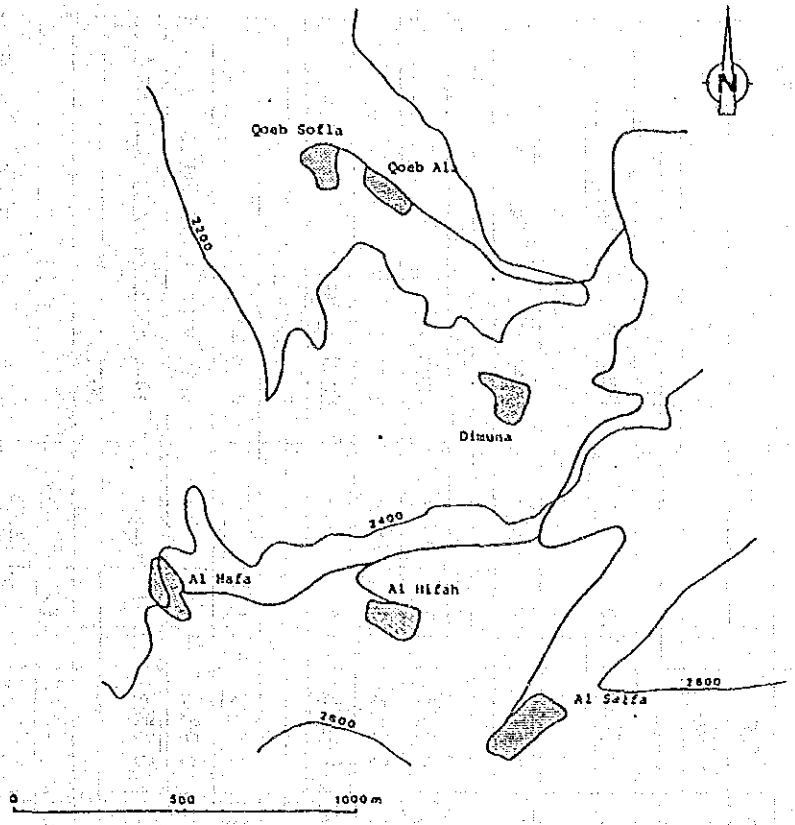
7 AD DAHI



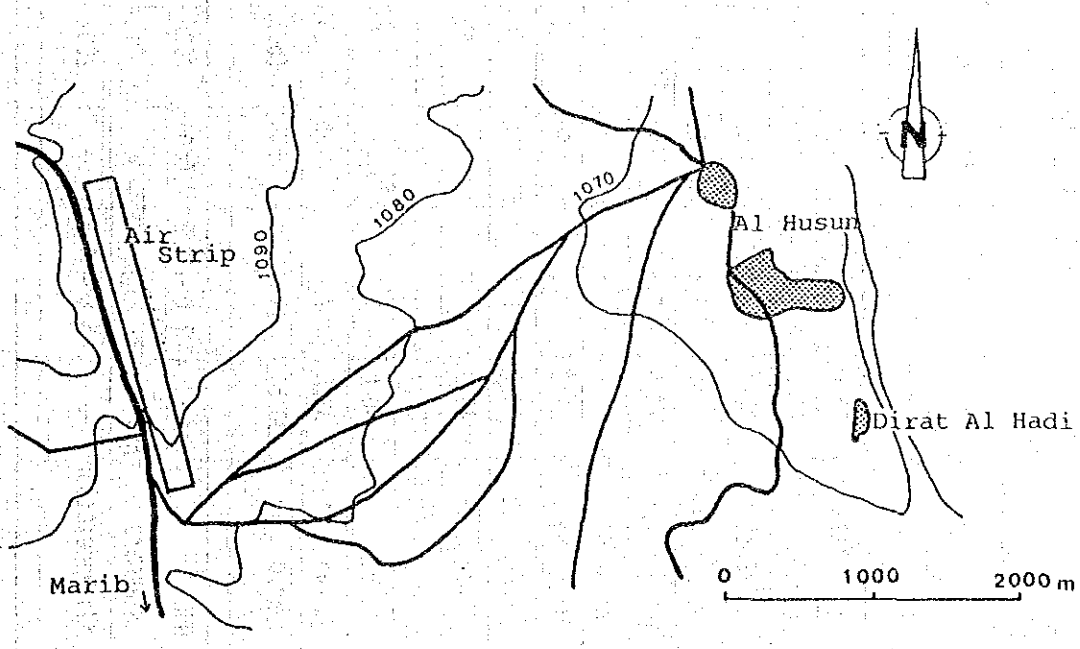
8 HARAD



9 Dimuna



10 AL HUSUN



i. Water Quality (Results of Analysis in the Field)

(1/2)

Site	T	pH	EC	Cl	Hardness	Fe	N		NO^2	F	Coliform	Note
							NH_3	NO_3				
	℃		μS/cm	ppm	ppm	ppm	ppm	ppm	ppm	ppm		
Wadi Asfan	23.0	7.4	1,350	55	685	0.3>	0.8>	1.6	0.02>	1.5	nd	Handdug Well
Dimuna	23.0	7.2	360	10	175	0.2>	0.4>	0.46	0.006	1.5	〃	Spring
Al Khashna	25.5	7.2	450	8	205	0.2>	0.4>	3.45	0.006	1.5	〃	Deep Well (Private)
Al Zakira	24.0	7.6	110	17	520	0.2>	0.4>	0.23>	0.006>	1.5	〃	-do-
AL Kheisen	24.5	7.5	680	7	445	0.2>	0.4>	0.23	0.03	1.0	〃	Deep Well of MPW
Al Husun	—	—	—	—	—	—	—	—	—	—	—	—
Al Rajam 1	23.0	7.0	285	15	230	0.2>	0.4>	0.46>	0.006>	1.0	nd	Deep Well
〃 2	16.0	6.8	150	20	120	0.2>	0.4>	0.46	0.006>	0.5	〃	Spring
Shihara 1	26.2	7.4	765	40	470	0.2>	0.4>	0.46>	0.006>	1.5	〃	Handdug Well
〃 2	23.4	—	772	—	—	0.2>	0.4>	—	—	—	〃	Surface Water
Ad Dahi	30.0	7.2	1,450	180	480	0.2>	0.4>	5.75	0.006>	1.5	〃	Deep Well
Harad 1	32.5	7.6	730	70	310	0.2>	0.4>	4.6	0.006>	1.0	〃	Deep Well in the south
Harad 2	(30.5)	(7.2)	(620)	(50)	(340)	(0.2>)	(0.4>)	(4.6)	(0.006>)	(1.0)	—	Tank Water by Deep well in the north
WHO Standard	—	7.0～8.5	2,000>	200>	500>	0.3>	0.5>	40>	—	1.0>	MPN 1.0>	
MHJ Regulation	—	5.8～8.6	—	200>	300>	0.3>	—	10>		0.8>	nd	

(* Ministry of Welfare of Japan)

Water Quality (Results of Analysis in Japan)

(Unit : mg／ℓ)

Item	1	2	3	4	5	6	7	8	9
	Wadi Asfan	Al Khashna	Al Zakira	Al Kheisen	Al Rajam 1	Shihara	Ad Dahi	Harad 1	Al Rajam 2(Spring)
	1986.10.31	1986.11.05	1986.11.10	1986.11.13	1986.11.24	1986.12.03	1986.12.10	1986.12.11	1986.11.27
Cl	39	27	62	19	12	27	144	46	9
F	0.4	1.2	0.9	0.8	0.2	0.5	1.0	0.5	0.2
Ca	143	38	78	59	32	88	84	53	25
Mg	16	7	33	32	14	30	35	19	5
So_4^{2-}	369	27	71	60	4	30	125	91	7
Na	82	35	82	37	9	33	145	69	7
K	1.6	3.0	3.1	5.4	3.0	4.9	4.2	2.9	1.0
Alkali values	217	108	335	278	123	304	250	175	72
Hardness*	423	123	331	279	138	343	354	211	83

* Estimated values from values of Ca and Mg

j. Water Rights and Land Acquisition

(1/2)

Site	Wadi Asfan	Dimuna	Al Khashna	Al Zakira	Al Kheisen
Water Rights	Necessary to obtain the approval from land owners.	Impossible to establish to water supply plan in this site. Necessary to find the water source points due to no availability of appropriate water source. Problems to find other water source out of this site such as water rights and land acquisition.	Existing water source is available.	Existing water source is available. Wells are installed out of the site.	Existing water source (MPW) is available.
Land Acquisition	Basically private tenure. Necessary to provide the stock yard of materials and equipment for construction before the commencement of construction. Problem for water tank and some parts of pipeline.		Problem for new water tank.	Problem for water tank and some parts of pipeline.	Problem for some parts of pipeline and pump station.

Site	Al Husun	Al Rajam	Shihara	Ad Dahi	Harad
Water Rights	To be constructed by MPW.	Necessary to obtain the approval from land owners in order to establish new water source in this site. Necessary to obtain the adjustment and approval through MPW in order to establish new water source out of this site.	Necessary to solve the problems related to water rights by the Government of Yemen Arab Republic before the commencement of the construction.	Existing 2 water sources are available.	Existing 2 water sources are available.
Land Acquisition		Problem for water tank and some parts of pipeline (crossing part of field).	Problem for water tank and some parts of pipeline (crossing part of field). Necessary to provide the stock yard.	No problem.	Problem for elevated water tank and some parts of pipeline.

k. Existing Water Supply Facilities

(No. 1)

Site	Well	Pump				Tank	Pipe	Others
		Class	Maker	Type	Capacity atc.			
Wadi Asfan	Hand dug well (more than 8 wells) Available 4 wells 20-35m deep	Borehole pump Moter	Private use for irrigation					Cisterns
Dimuna								Spring and cisterns 500 (500 lit/day)
Al Khashna	Deep well (more than 4 wells) available 2 wells 90-200m deep Water Table; about 80m deep (including 2 wells by JPN $ MPW)	. Borehole pump . Engine	Caprari (Italy) Agrip	R/25/4L/24A	Rapp. 1 : 1.5 yield 0.31 m^3 /min BD 130 50 Private facilities of 3 owners	Iron-made 1.15m × 1.10m × 2.4m × 3 Total 11.37 m^3	Water pipe 2 1/2in : 約700m Distributing pipe 2", 1"	Cistern (diameter;19m)
Al Zakira	Deep wells (by JPN) 180m deep W.L.: 7.1m Drawdoun: more than 65m	Submarsible Pump Generator Centrifugal pump pump Motor Centrifugal pump Pump Engin	EBARA DENYO EBARA TOSHIBA EBARA YAMMER	658HS32-22 DcA70LOH 50Hs(8)8H TIKK 40HS7E TS155C	Head : 245m, Q : 4.25 m^3 60KVA (× 2) 0.41m^3 /min Head : 270m, Q : 0.2 M^3 /M 380vol, 50Hs, 41AMP Head : 100m : 10Hp 13Hp(max 15.5Hp)	Iron-made panel tank 6m×3m×6m= 100m^3 3m×4m×2m=24m^3 同 (送水) 5m×4m×3m=60m^3	3" to Al Kader 2" to school (supply Pipe)	
Al Kheisen	Deep well (by MPW) 315m deep	. Borehole pump . Engine	POMPE ELVIO PORCELL 1 FIAT	CR80 8081-1	200m head 0.43 m^3 /min 0.16 m^3 /min BD 130 50 70Hp	Available well and pumping facilities in Sofa village near .		6 cisterns

Site	Well	Pump				Tank	Pipe	Others
		Class	Maker	Type	Capacity etc.			
Al Husun	Deep well more than 5 wells about 100m deep	Borehole pump Engine	CAPRARI VM	R25/3L/24 A 1054SU	Rapp. 1 : 1.5 Max. 30 private facilities RPM. 2800			
Al Rajam	Deep well : (6 wells in the site ,but of them 5 dry wells) 100~150m, or 200~300m deep	·Borehole pump ·Engine ·Submersible pump ·Generator	CAPRARI AGRIP Fl EBARA DENYO	R25/3L/24 A 1054, 420128	Rapp. 4 : 1.5 Max. 80 0.42 m^3 /min 15KW, 174m, 350 ℓ /m for Block-B by JPN's Aid 100KVA		Tanks and pipes are available in the Blocks A,B,C	Many cisterns Spring water at Mojum (22 lit/min)
Shihara	Deep well mountainous MPW's 2wells of low capacity (200m, 300m deep) W.L.; 15m, 7.9m 1 dry well by CYDA Fund(300m deep) 2 dry wells by Saudi Project. (250m, 200m) Some handduq wells in wadi areas Wadi Woar Some handduq wells (around 10m deep) WT : 2~3m ex. SWL 2.5m DWL 3.7m 0.5t/min 6cm/min ∅drawup	Al Qabain * by MPW Borehole pump Engine * Private Borehole pump Engine * Wadi woar Borehole pump Engine	ELVIO POROEFT (Desch) Daimler Ben2 DESTECO YAMMER ROTAS(ITALY) MITSUBISHI	 R880 (D5760) OM352 DIESEL N22Y-0389N2S HD300	Low capacity to supply water Rapp 1 : 7.5 (Planox PMA 111/3) 63KW, 1800/min D/N 6270 4" pipe 3.5~ 1hr/day operate SWL 12.3m 8HP 20~33 DWL 13.5m = 0.5m^3 /min (by test) 0.55 m^3 /min 25Hp Speed 1000(No. D13481)	Iron-made tanks (1m^3) Concreat-made tanks 2m×2m×3m=12m^3 5× 1.5× 2=15m^3 at Mosque 1.3× 5.5× 2.8 =20m^3	Piping to tanks for public taps at Mosque & AL Qabain. (300m,500m) Piping to tanks for irrigation. (100m)	6 large cisterns in Shihara at top & small many cisterns. Some springs (around 100 lit/day)
		Some hand carriable engines (YAMMAR N22Y)						

(No. 3)

site	Well	Pump				Tank	Pipe	Others
		Class	Maker	Type	Capacity etc.			
Ad Dahi	2 deep wells: (60m deep) (80m deep) 80m deep(MPW)	Borehole pump Engine Borehole pump Engine Pumping pip	un-known YAMMAR ERCOLE MORELL MITSUBISHI		22Hp/1000rpm Q : 90m^3 /h, H : 64m 23Hp/1000rpm ϕ 110× 3.0 18 Supplied equipment by USAID	Elevated water tank (but impossible to use due to detrioration)	piping networks available but deteriorate.	
Harad	2 deep wells 50m & 81.4m deep (themof one dugged by JPN's Aid)	Borehole pump" Engine Generator Submarsible - pump	un-known YAMMER DENYO EBARA		13Hp/1200rpm 45KVA Q 400 ℓ /min, H : 50m, P.7.5KW	6× 6×3(100t) Iron-made panel type 8× 7×4(200t)	None	

A - 3 WATER SOURCE

1. Water Source Condition

Available referred information on the water source are as follows:

- . MPW's design Information
- . Construction reports performed by the previous Grant Aid by Japan,
- . Report on The Rural Water Supply Project Part II, and
- . Results of the site survey including pumping test.

1) Geological columnar section

Geological columnar sections at existing and planned wells located near of objective water source points in Al Khashna, Al Zakira, Al Rajam, and Harad were obtained through construction reports.

2) Hydrogeological characteristics

Hydrogeological parameter based on simple pumping test, construction reports, and MPW' design information are summarized as follows.

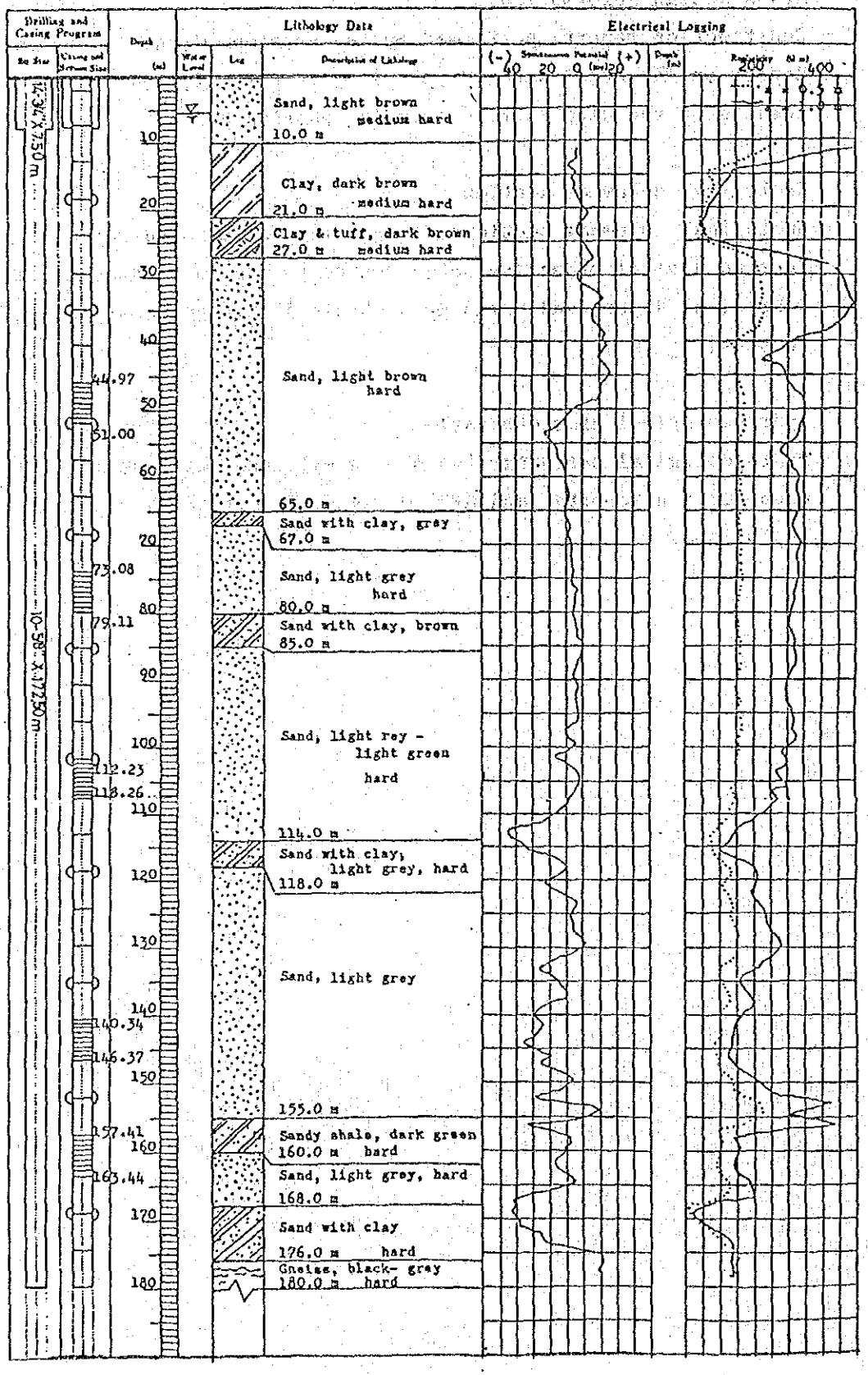
1 Geological Columnar Section.

WELL LOG

PROJECT NAME	RURAL WATER SUPPLY PROJECT NO. JY-III	WELL NO.	T - 6
AREA AND LOCATION	TAIZZ, AL - ZAKIRA		
ELEVATION	1,455 m	LATITUDE 13°10'00" LONGITUDE 44°07'00"	
TOTAL DEPTH	180.00 m	DRILLING RIG	TOP - 300 S
DRILLING STARTED	APRIL 18, 1983	DRILLED BY	MR. H. ISUCHI
WELL COMPLETED	JUNE 14, 1983	LOGGED BY	MR. S. TAKAHASHI

① Al Zakira

STATIC WATER LEVEL	5.44 m	WATER TEMPERATURE	°C
DYNAMIC WATER LEVEL	80.40 m	CONDUCTIVITY	μ℧/m
PUMPING RATE	250 l/min (360 m³/d)	pH	
SPECIFIC CAPACITY	4.80 m³/d/m	TOTAL HARDNESS	



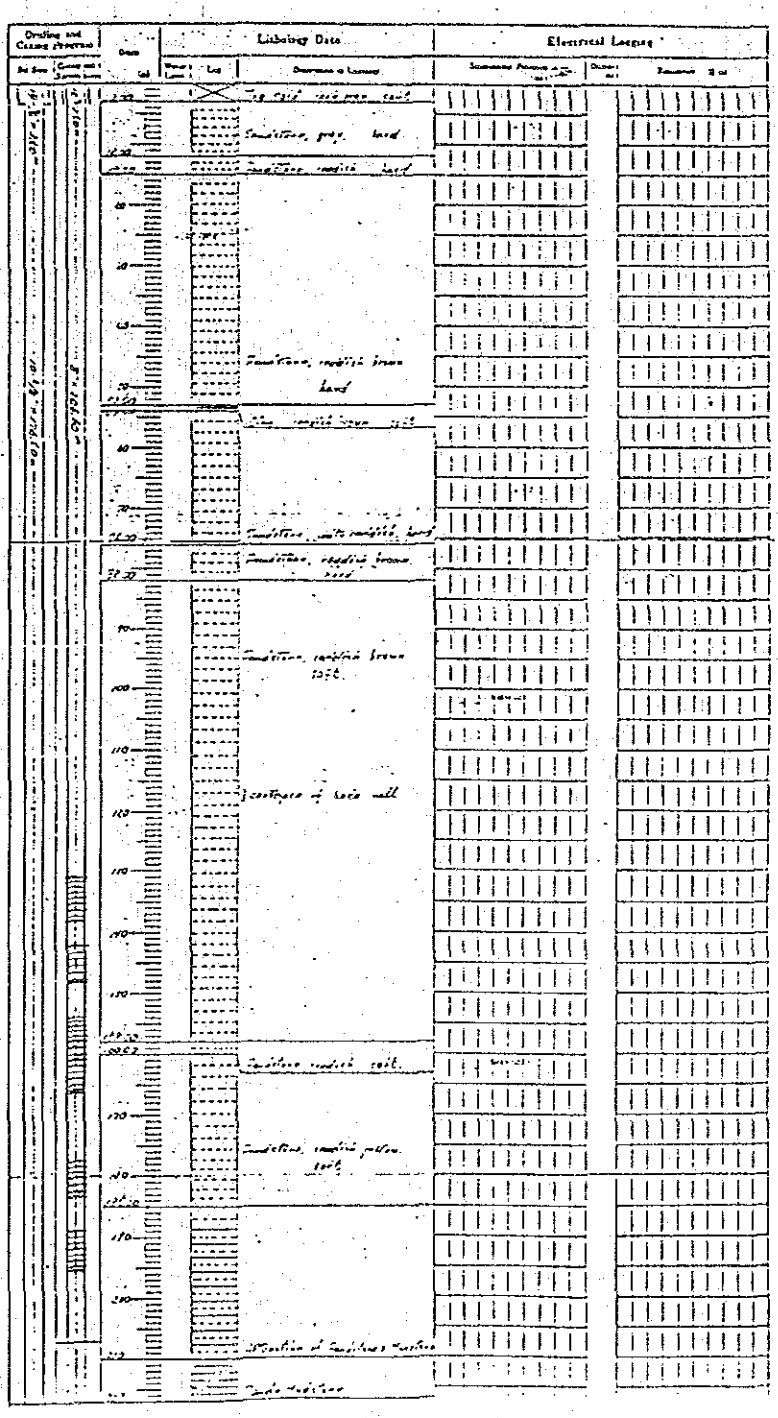
② Al Rajam

WELL LOG

Data No.

PROJECT NAME	Rural Water Supply Project IV-A	WELL NO.	2
AREA AND LOCATION	Bait Al Bidri		Rajam B-Bench
ELEVATION		LATITUDE	LONGITUDE
TOTAL DEPTH	207.20	DRILLING RIG	
DRILLING STARTED	12/08/1994	DRILLED BY	
WELL COMPLETED	--/--/1994	LOGGED BY	

STATIC WATER LEVEL	125.62	WATER TEMPERATURE	32.2 °C
DYNAMIC WATER LEVEL		CONDUCTIVITY	260 µS/cm
PUMPING RATE	11 l/s	pH	6.5
SPECIFIC CAPACITY		TOTAL HARDNESS	

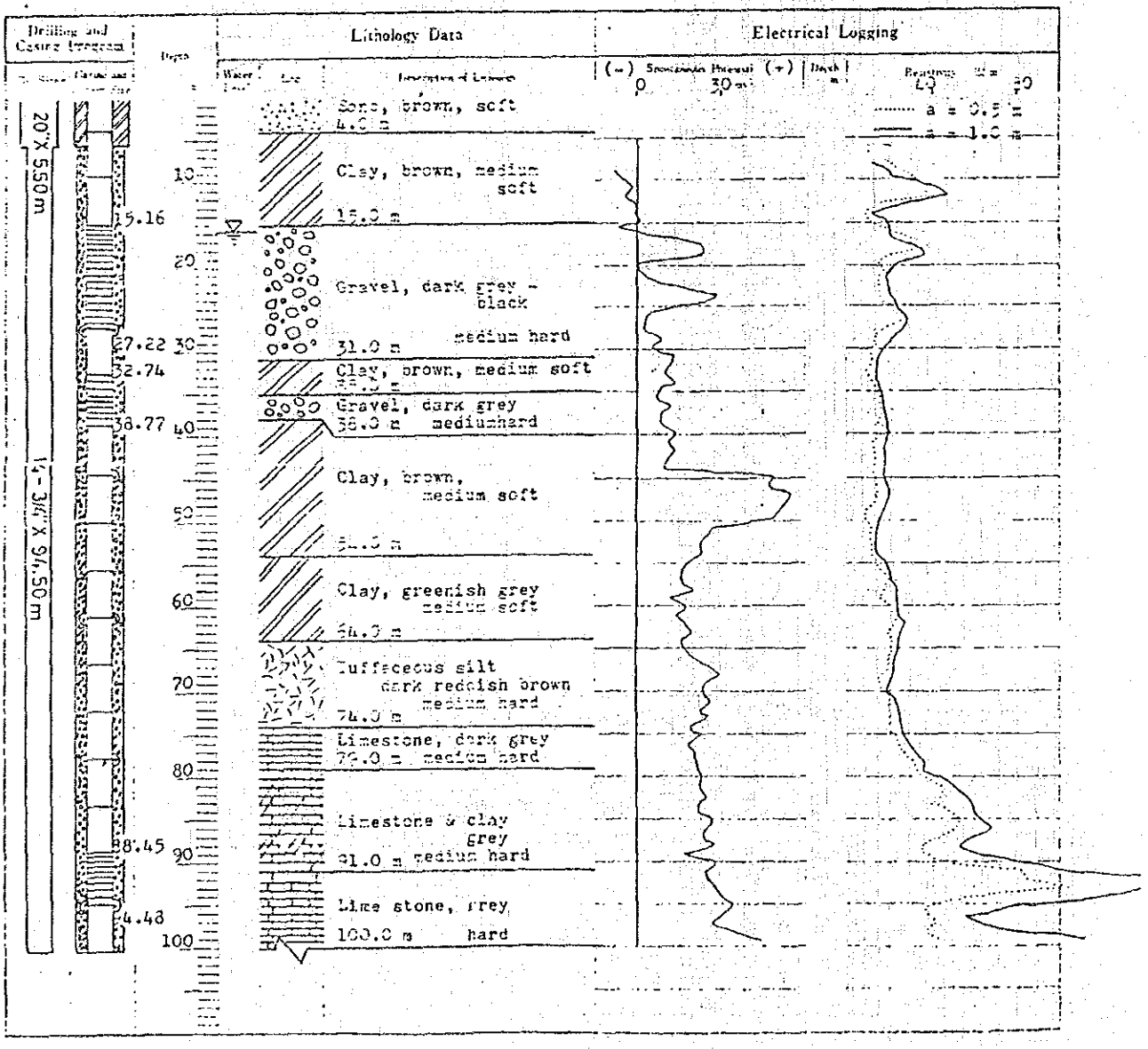


③ Harad

WELL LOG

PROJECT NAME	RURAL WATER SUPPLY PROJECT L.O. JY-II	WELL NO.	HA - 4
AREA AND LOCATION	HAJJA, HARAD		
ELEVATION	150 m	LATITUDE N 16° 25' 00"	LONGITUDE E 43° 00' 30"
TOTAL DEPTH	100.00 m	DRILLING RIG	TOP - 300 E
DRILLING STARTED	DECEMBER 18, 1982	DRILLED BY	MR. M. KUDO
WELL COMPLETED	JANUARY 16, 1983	LOGGED BY	Mr. S. TAKAHASHI

STATIC WATER LEVEL	15.70 m	WATER TEMPERATURE	32.0	C	
DYNAMIC WATER LEVEL	18.27 m	CONDUCTIVITY	500	μ℧/cm	
PUMPING RATE	500 m³/h = 720 m³/d =	pH	7.5		
SPECIFIC CAPACITY	230 m³/d/m	TOTAL HARDNESS			



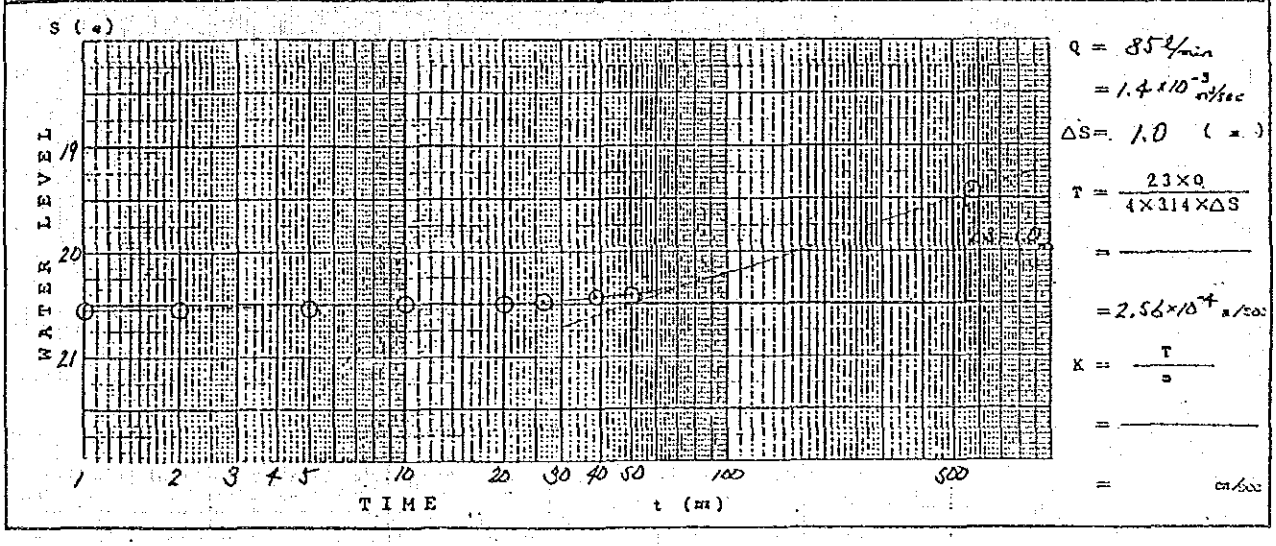
2 Pumping Test

① Wadi Asfan

PUMPING TEST RECORD (~~Drawdown~~ / Recovery)

Area	Wadi Asfan
Depth	m ~ 20.7 m
S.W.L.	− 18.45 m
Date	1986. 11. 7
Pumping Volume	Q = 85 ℓ/min
ΔS = 1.0	(m)
T = 2.56 × 10⁻⁴	(m²/sec)
K =	(cm/sec)

Pumping									Recovery					
Time (m)	Level (m)	Volume (ℓ)	Time (m)	Level (m)	Volume (ℓ)	Time (m)	Level (m)	Volume (ℓ)	Time (m)	Level (m)	Time (m)	Level (m)	Time (m)	Level (m)
0	19.15								0	20.54				
30	20.18								1	20.54				
40	20.25								2	20.53				
55	20.32								5	20.51				
85	20.53								10	20.49				
89	20.54								16	20.48				
									26	20.47				
									39	20.45				
									570	19.55				



Q = 85 ℓ/min
= 1.4 × 10⁻³ m³/sec

ΔS = 1.0 (m)

$T = \frac{2.3 \times Q}{4 \times 3.14 \times \Delta S}$

= ———

= 2.56 × 10⁻⁴ m²/sec

$K = \frac{T}{m}$

= ———

= cm/sec

Well data in Wadi Asfan

Source No.	1	2	
Type of Source	Hand-Dug Well		
Yield l/sec	2.52	2.52	
	40	40	
Static Water Level (m)			
Drawdown (m)	1.8	0.5	
Dynamic Water Level (m)			
Total Depth (m)	20.7	37.5	

② Dimuna

Well data in Dimuna

Source No.					Remarks
Type of Source		Hand dug well			
Yield	l/sec	2.52			
	US GPM	40			
Static Water Level (m)		20			
Drawdown (m)					
Dynamic Water Level (m)					
Total Depth (m)		24			
Pump Test Duration (hrs)					
Tested by					
Date of Test					
Diameter (m)		1.6m			

③ Al Khashna

PUMPING TEST RECORD (Drawdown / ~~Recovery~~)

Area	Al Khashna	Pumping Volume									Recovery					
	m ~ m	Time (m)	Level (m)	Volume (l)	Time (m)	Level (m)	Volume (l)	Time (m)	Level (m)	Volume (l)	Time (m)	Level (m)	Time (m)	Level (m)	Time (m)	Level (m)
Depth	~ 150	30	81.50													
S.W.L.	− 81.5 m	1	81.50													
		1.30	81.50													
Date	1986.11.5	2	81.50													
Pumping Volume	Q = 290 l/min	2.30	81.49													
		4	81.50													
Δ S ≒ 0	(cm)	5	81.51													
T =	(cm²/sec)	10	81.51		No observation of drawdown											
		15	81.51													
K =	(cm/sec)	20	81.51													

Well Data of MPW.:

Source No.		Remarks
Type of Source	Drilled Dug Well	
Yield l/sec	2.52	
Static Water Level (m)	85	
Drawdown (m)	25	
Dynamic Water Level (m)	110	
Total Depth (m)	150	
Pump Test Duration (hrs)		
Tested by		
Date of Test		
Casing Diameter (inches)	8 5/8"	
Material of Casing		

$Q =$

$=$

$\Delta S =$ (cm)

$$T = \frac{2.3 \times Q}{4 \times 3.14 \times \Delta S}$$

$=$

$\therefore$

$$K = \frac{T}{a}$$

$=$

$=$ cm/sec

④ Al Zakira

PUMPING TEST RECORD (Drawdown / Recovery)

Area: Al Zakira

Depth: m ~ m

S.W.L.: - 7.1 m

Date: 1986.11.10

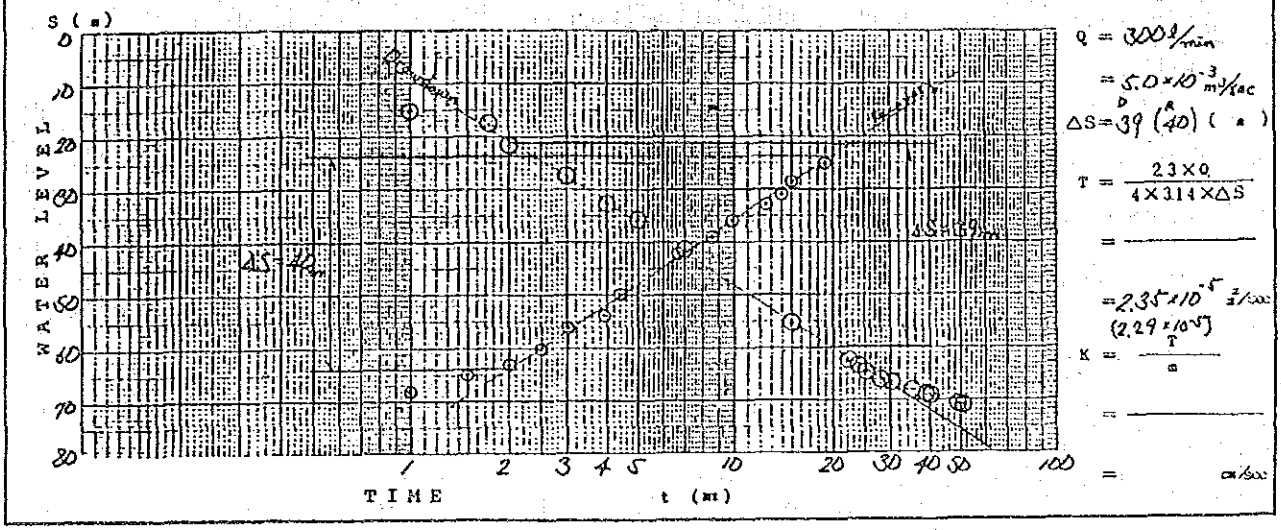
Pumping Volume: Q = 300 l/min

ΔS = (cm)

T = 2.35×10⁻⁵ (m²/sec) (2.29×10⁻⁵)

K = (cm/sec)

Pumping									Recovery					
Time (mn)	Level (m)	Volume (l)	Time (mn)	Level (m)	Volume (l)	Time (mn)	Level (m)	Volume (l)	Time (mn)	Level (m)	Time (mn)	Level (m)	Time (mn)	Level (m)
30			24	83.10					1	68	12 40	33		
1	14.10		25 30	84.45					1 30	65	13	31		
1 45	17.8		28	86.10					2	63	15	28		
2	21.52		30	86.45					2 30	60	19	25		
3	27.65		35	88.60					3	58				
4	32.50		39	89.00					3 30	54				
5	35.35		40	89.16					4 20	50				
7	41.53		49	90.81					6 40	42				
10 30	55.00		51	91.14					8 30	39				
22	82.30								10	36				



Q = 300 l/min
= 5.0×10⁻³ m³/sec

ΔS = 39 (40) (m)

T = 2.3×Q / 4×3.14×ΔS

= ———

= 2.35×10⁻⁵ m²/sec
(2.29×10⁻⁵)

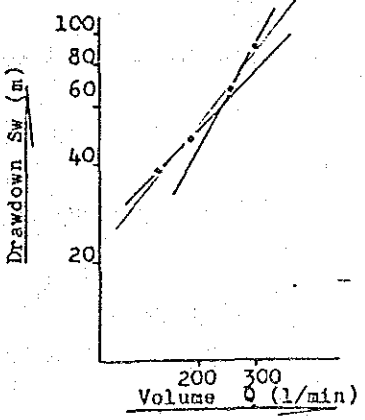
K = T/m

= ———

= cm/sec

STEP DRAWDOWN TEST

(log Q ~ log Sw CURVE)



Spacific Capacity

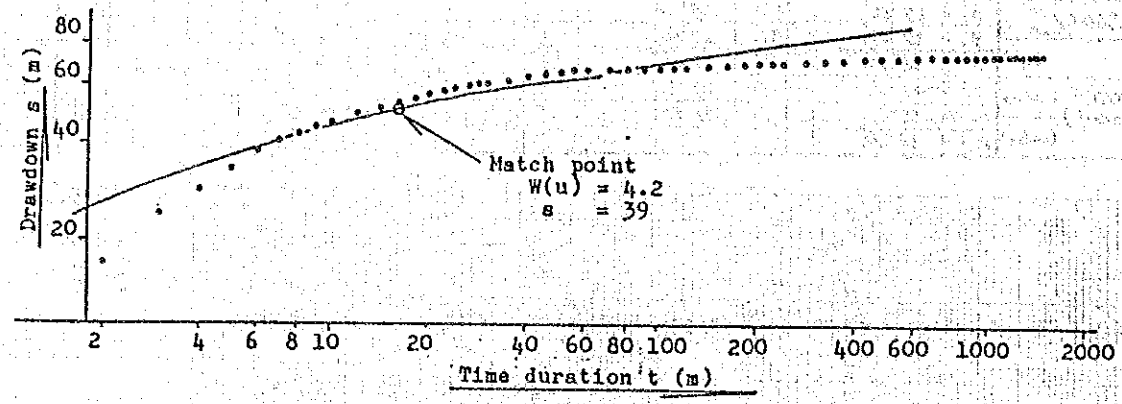
Volume Q (l/min)	Water level s (m)	Drawdown Sw (m)	Q/Sw (l/min/m)
150	43.02	37.58	3.99
190	52.92	47.48	4.00
252	75.94	70.50	3.57
306	96.33	90/89	3.37

Date : 7-8 Jun,1983

AQUIFER TEST (THEIS'S METHOD)

DRAWDOWN TEST (log t ~ log s CURVE)

S.W.L. : 5.44 m
Q : 250 l/min.
SCREEN : 30 m



Coefficient of Transmissibility

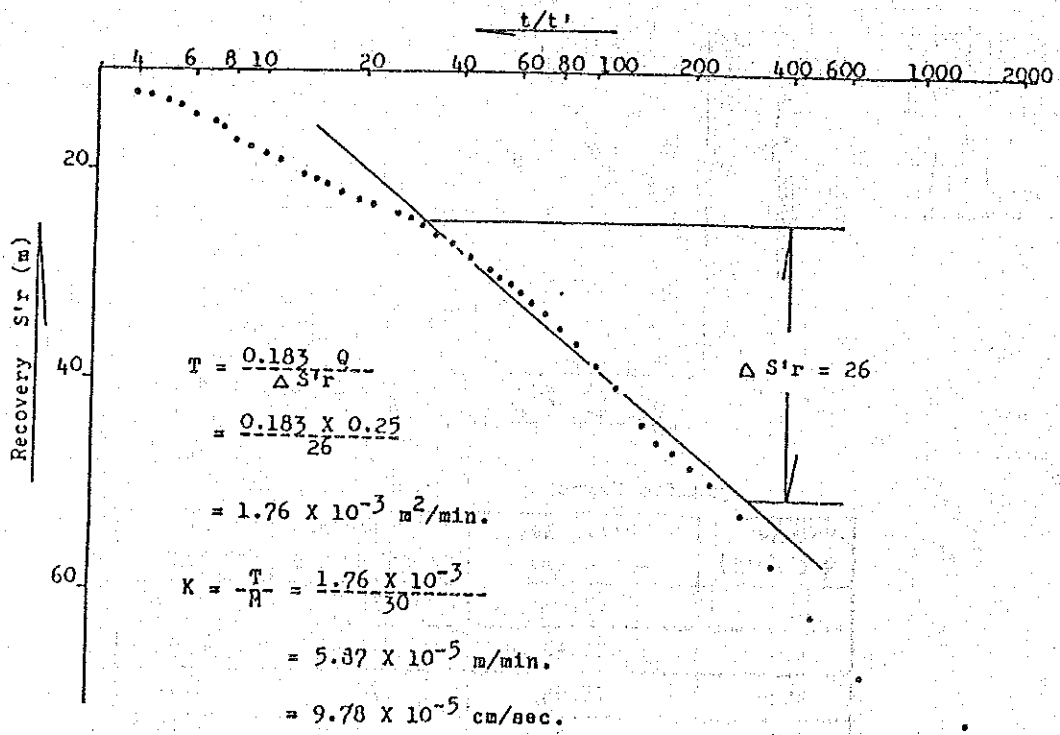
$$T = \frac{0.0796\ Q}{s}\ W(u) = \frac{0.0796 \times 0.25}{39} \times 4.2 = 2.14 \times 10^{-3}\ m^2/min$$

Coefficient of Permeability

$$K = \frac{T}{H} = \frac{2.14 \times 10^{-3}}{30} = 7.13 \times 10^{-5}\ m/min. = 1.19 \times 10^{-4}\ cm/sec.$$

AQUIFER TEST (JACOB'S METHOD) Date : 8 Jun. 1983

RECOVERY TEST (log t/t' ~ S'r CURVE)



$$T = \frac{0.183\ Q}{\Delta S'r} = \frac{0.183 \times 0.25}{26} = 1.76 \times 10^{-3}\ m^2/min.$$

$$K = \frac{T}{H} = \frac{1.76 \times 10^{-3}}{30} = 5.87 \times 10^{-5}\ m/min. = 9.78 \times 10^{-5}\ cm/sec.$$

⑤ Al Kheisen

Well data in Al Kheisen

No.		1		Remarks
Name of source				
Yield	Lit/sec	3.15		
	US GPM	50		
Static Water Level (m)		100		
Drawdown (m)		80		
Dynamic Water Level (m)		180		
Total depth (m)		250 (315*)		
Pump Test Duration (hours)				
Tested by				
Date of Test				
Casing Diameter (inches)				

* The depth of interview

⑥ Al Husun

Well data in Al Husun

Source No.				Remarks
Name of source				
Yield	Lit/sec	6.31		
	US GPM	100		—
Static Water Level (m)		20		
Drawdown (m)		30		
Dynamic Water Level (m)		50		
Total depth (m)		90		
Pump Test Duration (hours)				
Tested by				
Date of Test				
Casing Diameter (inches)		8 5/8		

⑦ Al Rajam

According to the feasibility study(Part II) report and constraction report of Al Rajam area, the deep groundwater development at crossing points of many fault is the most appropriate.

Type C1: Horizontal Drilling-proposed for future development-

⑧ Shihara

Consideration on water source are shown as follows;

1. The drilling directions should be set in the east to west direction in general, because dyke rocks are aligned from north to south with almost vertical inclination and the ground surface is sloping to the east.
2. Dykes prevail from the foot of the western mountain up to the level of 1,700 m A.S.L. The dykes are located several hundreds meters apart.
3. A single bore hole may penetrate 1 or 2 dykes because of construction convenience.
4. The existing roads are only passable with four-wheel-drive small vehicles, so road construction is inevitable once this type of water source construction is decided.

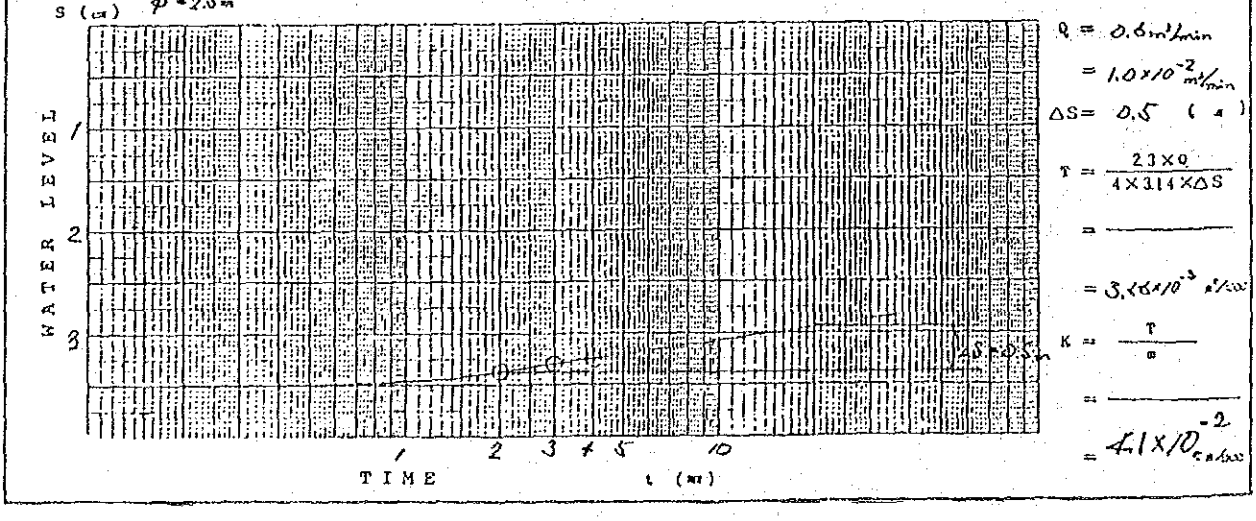
   In addition detailed study is necessary to estimate the safe yield.

Type A: Deep Groundwater-recommended for the water source of the project-

1. The major consumers are the residents on the hill summits above the 2,300 m A.S.L. LEVEL.
2. The recommended drilling sites are located in the wadi bed at 1,200 - 1,250 m A.S.L. in the east, based on consideration of the hydrogeological conditions and transportation of materials.
3. The location of borehole should be determined based on other facilities and the local topography.
4. Operational waters can be drawn from dug wells in the wadi.

PUMPING TEST RECORD (~~Drawdown~~ / Recovery)

Area	Shihara	Pumping Volume									Recovery					
		Time (mi)	Level (m)	Volume (l)	Time (mi)	Level (m)	Volume (l)	Time (mi)	Level (m)	Volume (l)	Time (mi)	Level (m)	Time (mi)	Level (m)	Time (mi)	Level (m)
Depth	m ~ 9.0 m															
S.W.L.	~ 2.4 m										0.6~7cm/min a Recovery					
Date	1986.12.2															
Pumping Volume	Q = 0.6 m³/min															
ΔS =	0.5 (m)															
T =	3.88×10⁻³ m²/sec															
K =	4.1×10⁻² (m/sec)															



⑨ Ad Dahi

Well data in Al Dahi

Source no.	1	2	Remarks
Type of Source	Old well	New well	
Yield l/sec	8.2	3.15	
	130	60	
Static Water Level (m)	28	45	
Drawdown (m)	6	20	
Dynamic Water Level (m)	34	65	
Total Depth (m)	40	30	
Pump Test Duration (hrs)			
Tested by			
Date of Test			
Casing Diameter (inches)	8	8	
Material of Casing			

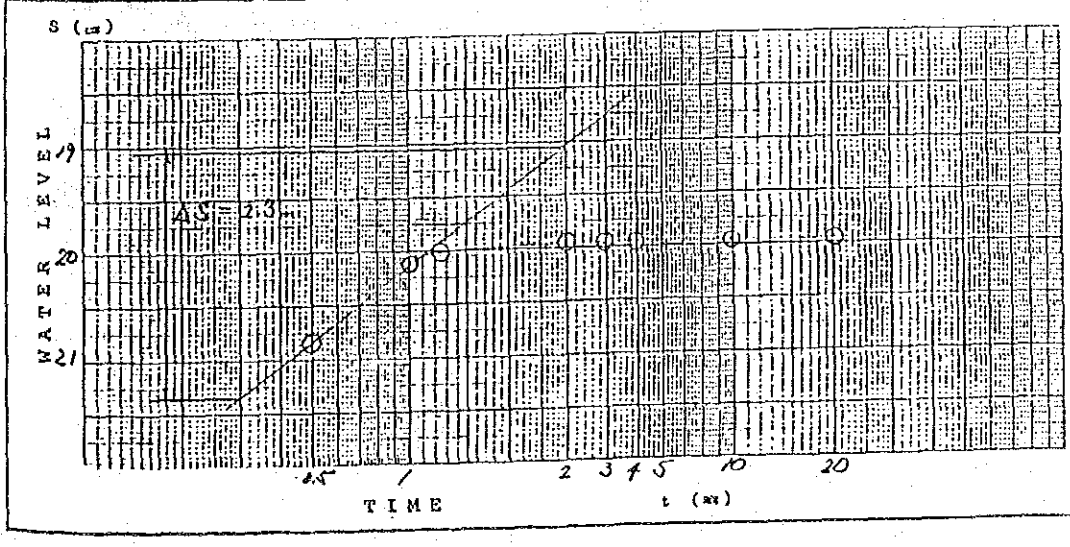
⑩ Harad

(1/3)

PUMPING TEST RECORD (~~Drawdown~~ / Recovery)

Area	Harad (old)
Depth	m ~ 50 m
S.W.L.	— 19.95 m
Date	1986. 12. 11
Pumping Volume	Q = 0.42 m³/min
ΔS = 2.3	(m)
T = 5.6×10⁻⁴	(m²/sec)
K = 1.87×10⁻³	(m/sec)

Pumping Volume									Recovery					
Time (min)	Level (m)	Volume (l)	Time (min)	Level (m)	Volume (l)	Time (min)	Level (m)	Volume (l)	Time (min)	Level (m)	Time (min)	Level (m)	Time (min)	Level (m)
									30	20.35				
									1	20.10				
									1.15	20.02				
									2	19.96				
									3	19.98				
									4	19.96				
									10	19.98				
									20	19.98				



Q = 0.42 m³/min
= 7.0×10⁻³ m³/sec
ΔS = 2.3 (m)

$T = \frac{2.3 \times Q}{4 \times 3.14 \times \Delta S}$

= ———

= 5.6×10⁻⁴ m²/sec

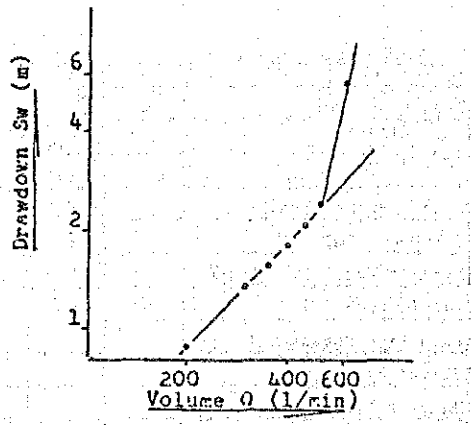
$K = \frac{T}{m}$

= ———

= 1.87×10⁻³ m/sec

STEP DRAWDOWN TEST

(log Q ~ log Sw CURVE)



Specific Capacity

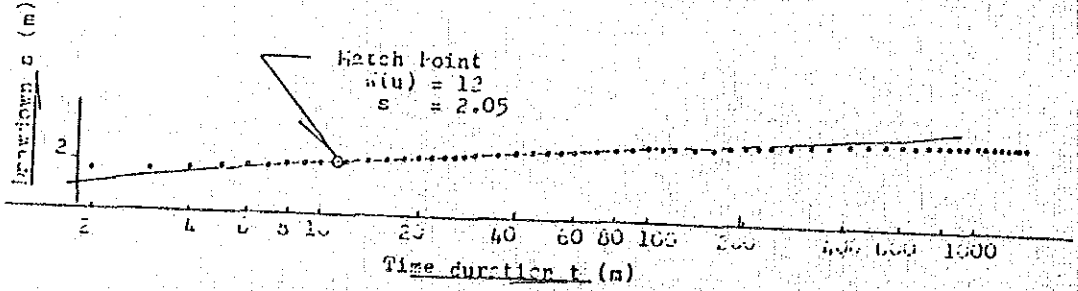
Volume Q (l/min)	Water level s (m)	Drawdown Sw (m)	Q/Sw (l/min/m)
200	16.58	0.88	227
300	17.04	1.34	224
350	17.24	1.54	227
400	17.43	1.73	231
450	17.88	2.18	206
500	18.15	2.45	204
600	21.35	5.65	106

Date : 14-15, 1, 1983

AQUIFER TEST (THEIS'S METHOD)

DRAWDOWN TEST (log t ~ log s CURVE)

S.W.L. : 15.70 m
Q : 500 l/min.
SCREEN : 24 m



Coefficient of Transmissibility

$$T = \frac{0.0796\ Q}{s} W(u) = \frac{0.0796 \times 0.5}{2.05} \times 12 = 2.33 \times 10^{-1}\ m^2/min.$$

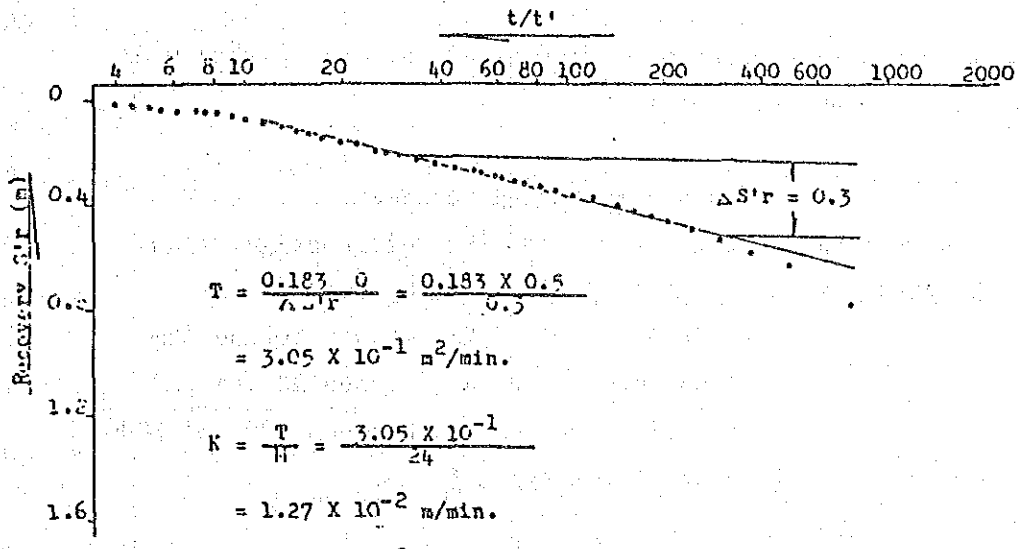
Coefficient of Permeability

$$K = \frac{T}{b} = \frac{2.33 \times 10^{-1}}{24} = 9.71 \times 10^{-3}\ m/min. = 1.62 \times 10^{-2}\ cm/sec.$$

AQUIFER TEST (JACOB'S METHOD)

Date : 15, 1, 1983

RECOVERY TEST (log t/t'～S'r CURVE)



$$T = \frac{0.183 \quad Q}{\Delta S'r} = \frac{0.183 \times 0.5}{0.3}$$

$$= 3.05 \times 10^{-1} \ m^2/min.$$

$$K = \frac{T}{H} = \frac{3.05 \times 10^{-1}}{24}$$

$$= 1.27 \times 10^{-2} \ m/min.$$

$$= 2.12 \times 10^{-2} \ cm/sec.$$

m. Geoelectric Prospecting

1 General Feature

The geoelectric prospecting was carried out at 3 sites; Wadi Asfan, Al Rajam, and Shihara.

1) Prospecting method and measuring equipment

Prospecting method: Wenner's electrode configuration

Electrode separation: 1, 2, 3, 4, 6, 8, 10m,
at an interval of 2m between 10 and 32m
at an interval of 4m between 32 and 100m
at an interval of 10m between 100 and 200m

Measuring Equipment: ES-G2 type of OYO

2) prospecting points

Al Rajam	5 points
Shihara	3 points
Wadi Asfan	3 points

2 Results of Analysis

The results of geoelectric prospecting performed at 3 sites which are shown in geoelectric prospecting maps, are sumarized in the following information.

(1) Record of electric resistivity
(2) p-a resistivity curves and resistivity columnar section
(3) I-a Resistivity curves

Synthetic columnar sections were made on the basis of analysis results. Geological formations and aquifers are recognized based on geological survey and results of electric resistivity.

Schematic columnar sections and resistivity profiles are performed for each site.

Results of Geoelectric Prospecting at Wadi Asfan

Resistivity layer (Na)	Resistivity value -m	Depth (GL-m)	Geological component	Aquifer
No. 1	22 - 115	4 - 5	Surface soil, clay, sand, gravel	-
No. 2	15 - 21	15 - 21	Clayey sand and gravel	Seasonal aquifer
No. 3	25 - 44	58 - 76	Tuffaceous andesite, meteorized rocks	Flowing groundwater in fracture zones
No. 4	164 - 188	135 - 200	Andesite	Flowing groundwater in fracture zones
No. 5	117	185	Tuff	Flowing groundwater in fracture zones
No. 6	410	200	Andesite	-

As shown in table above, two types of groundwater were recognized: Shallow groundwater existing in clayey sand/gravel layer (No.2) located between GL-15 and -21m of the depth and deep groundwater existing in tuffaceous andesite/tuff layer (Nos. 3, 4, 5).

It's recommended E-3 point to obtain groundwater.

11) Al Rajam

Results of Geoelectric Prospecting at Al Rajam

Resistivity layer (Na)	Resistivity value -m	Depth (GL-m) (thickness m)	Geological component	Aquifer
No. 1	10 - 52	2 - 5 (2 - 5)	Surface soil	-
No. 2	19 - 198	11 - 40 (6 - 37)	Sand, gravel clayey sand/ gravel	Seasonal aquifer shallow water groundwater
No. 3	117 - 645	86 - 150 (75 - 112)	Fractured sandstone	Flowing groundwater in fracture zones
No. 4	27 - 55	120 - 200 (30 - 60)	Fractured calcareous sandstone	Flowing groundwater in fracture zones
No. 5	135 - 1550	120 - 200 (80 - 180)	Fractured sandstone high resistivity value correspond to no water-bearing sandstone	Flowing groundwater in fracture zones

As shown in table above, two types of groundwater were recognized: shallow groundwater (seasonal aquifer) existing in sand/gravel layer (No. 2) of 6 - 37m of the thickness located between GL-11 and -40m of the depth and deep groundwater existing in fracture zones of sandstone and calcareous sandstone layers (Nos. 3, 4 and 5).

Two points, E-1 and E-4, were selected as prospecting water source for this site.

Information of surrounding wells shows 300 -420 /min (8 hours of operation/day) the aquifer's yield.

iii) Shihara

Water source at Shihara is sought to obtain in the Wadi Woar flowing to the north along fault valley of NNE-SSW System located in the east of hill zone of an altitude of 1,200m A.S.L.

Result of Geoelectric Prospecting at Shihara

Resistivity layer (Na)	Resistivity value -m	Depth (GL-m) (thickness m)	Geological component	Aquifer
No. 1	7 - 18	5 - 8 (5 - 8)	Surface soil clay	-
No. 2	22 - 48	46 - 56 (41 - 42)	Clay, sand, clayey sand, gravel	Aquifer of low permeability
No. 3	322 - 540	62 - 102 (15 - 52)	Sandstone (partially fracture zone)	Flowing groundwater in fault fractures and fracture zones
No. 4	134 - 162	200 (98 - 138)	Fractures sandstone	Flowing groundwater in fault fractures and fracture zones

As shown in table above, two types of groundwater were recognized: Shallow groundwater existing in No. 2 resistivity layer and deep groundwater (flowing water) existing in fault fractures and fracture zones of sandstone layer (No. 3 and 4).

Deep groundwater is flowing water existing in small faults and fracture zones of N40°E system along NNE-SSW fault in sandstone layer.

Prospecting water source shall be E-2 point.

FIG RESISTIVITY PROFILE Wadi Asfan E-3

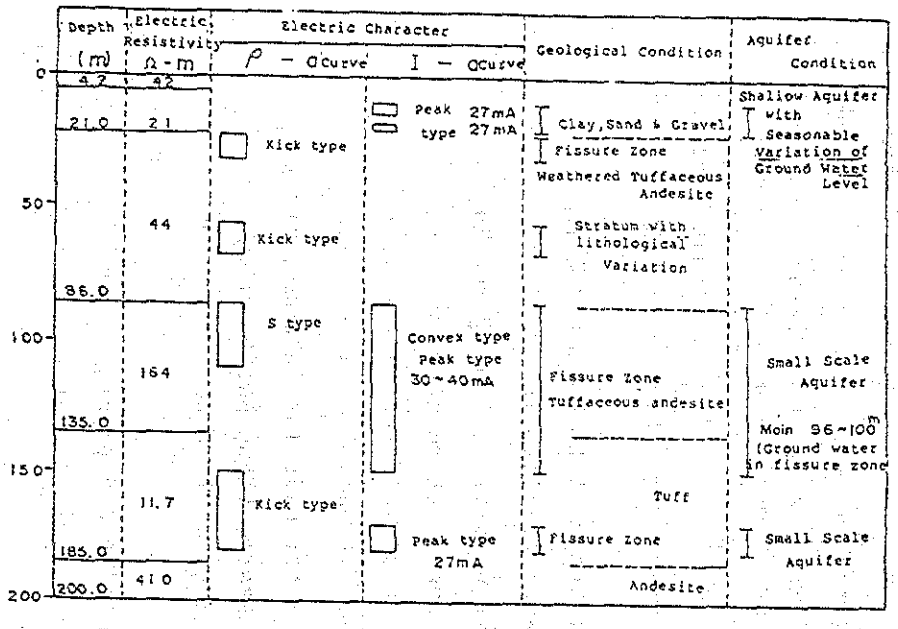


FIG RESISTIVITY PROFILE Al Rojom E-4

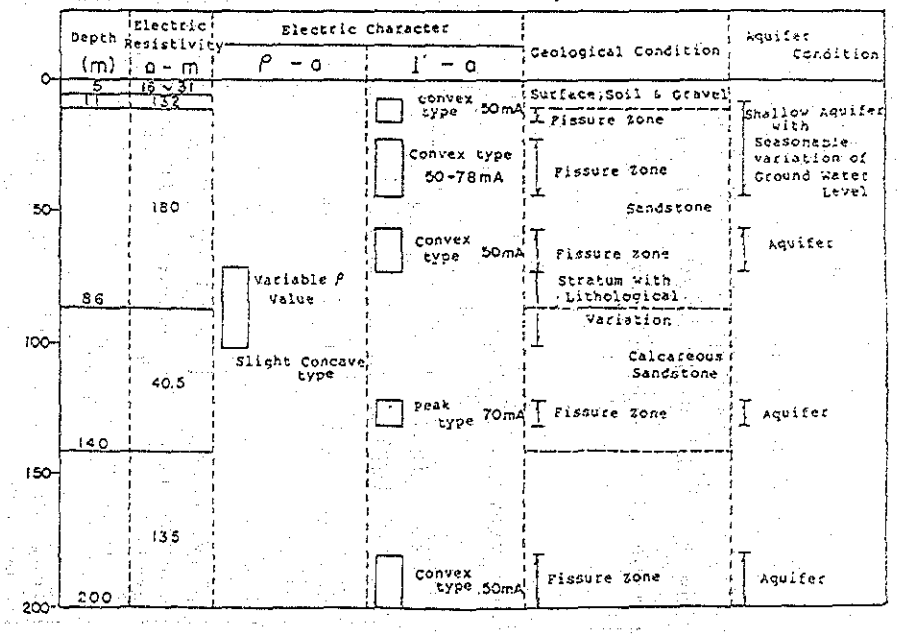


FIG RESISTIVITY PROFILE Al Rojom E-1

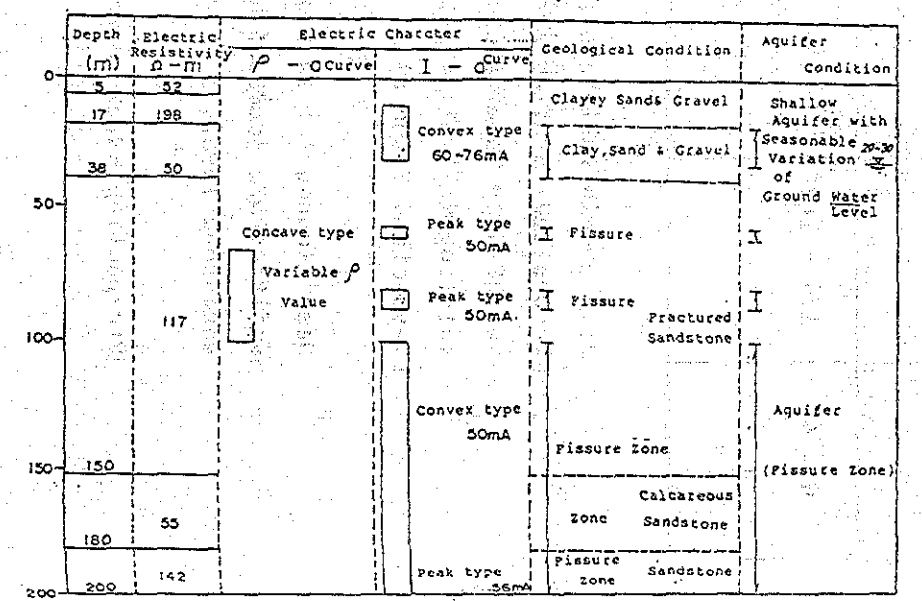


FIG RESISTIVITY PROFILE Shihoro E-2

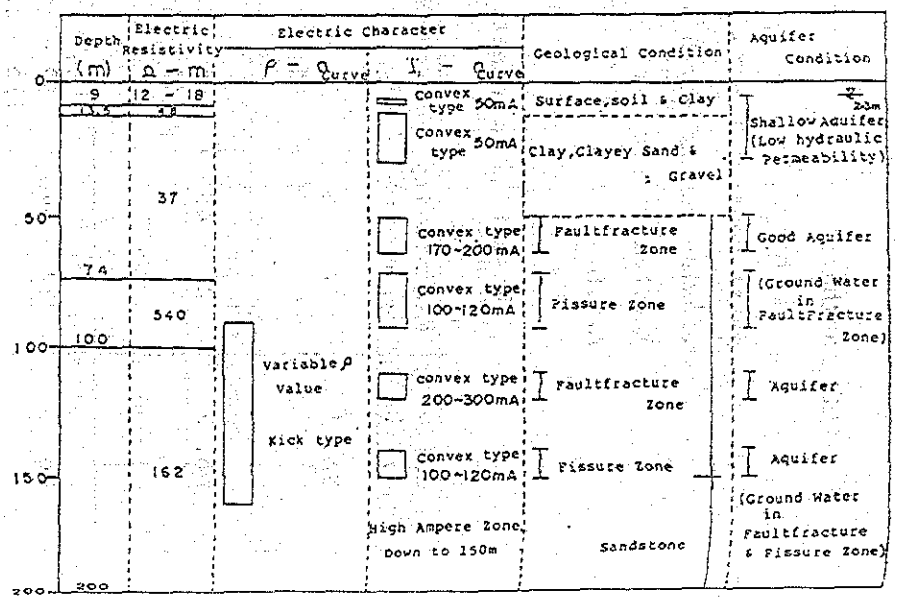
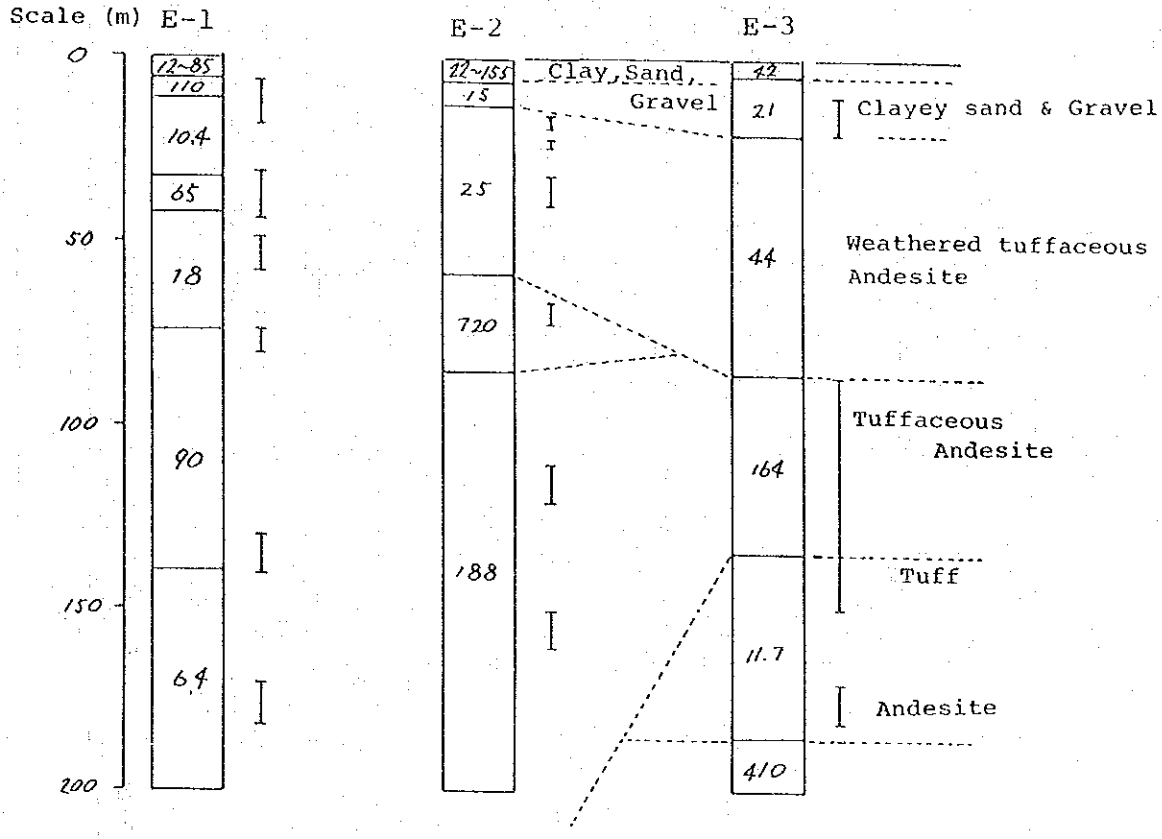


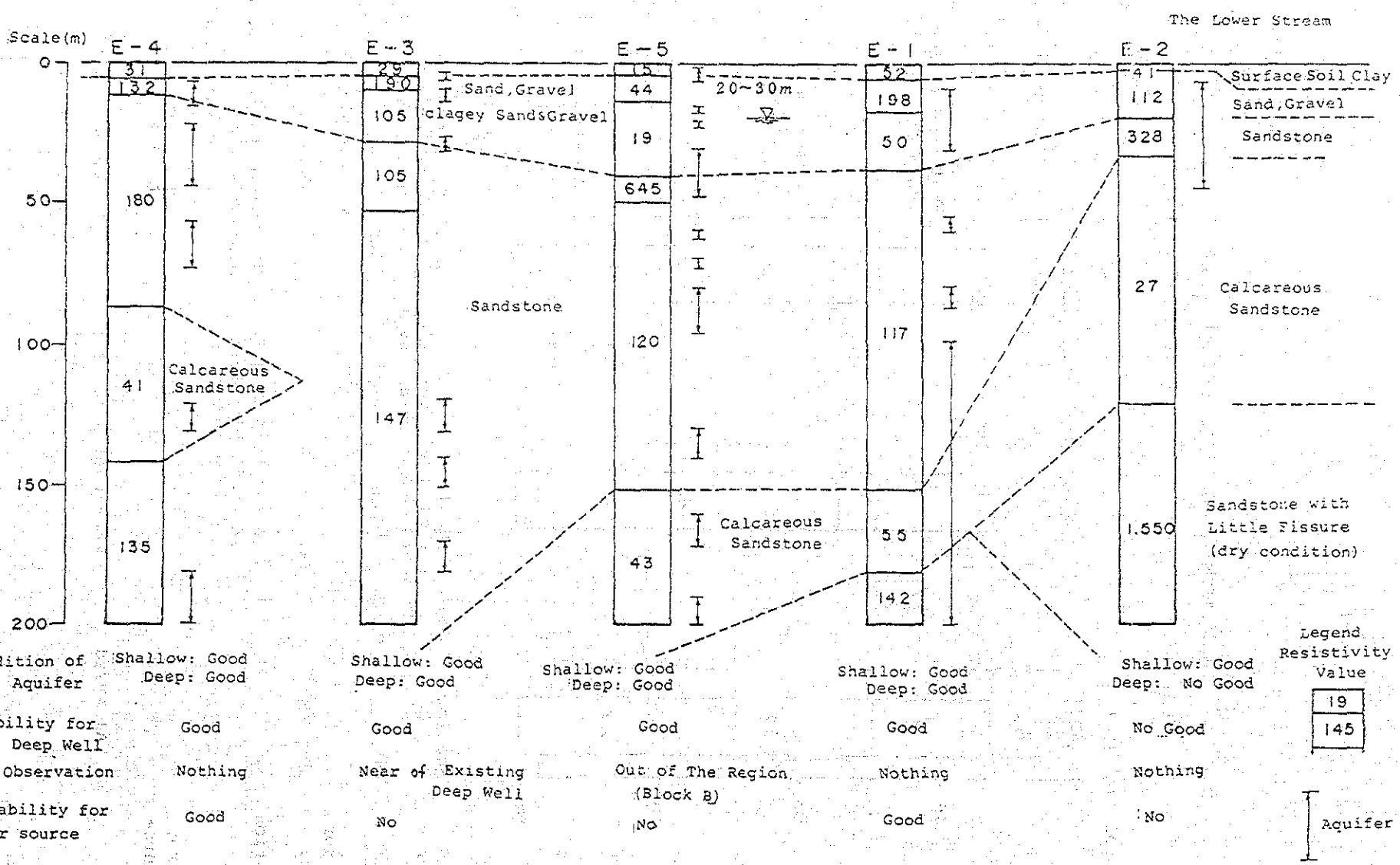
FIG ELECTRIC RESISTIVITY PROFILE

(WADI ASFAN)

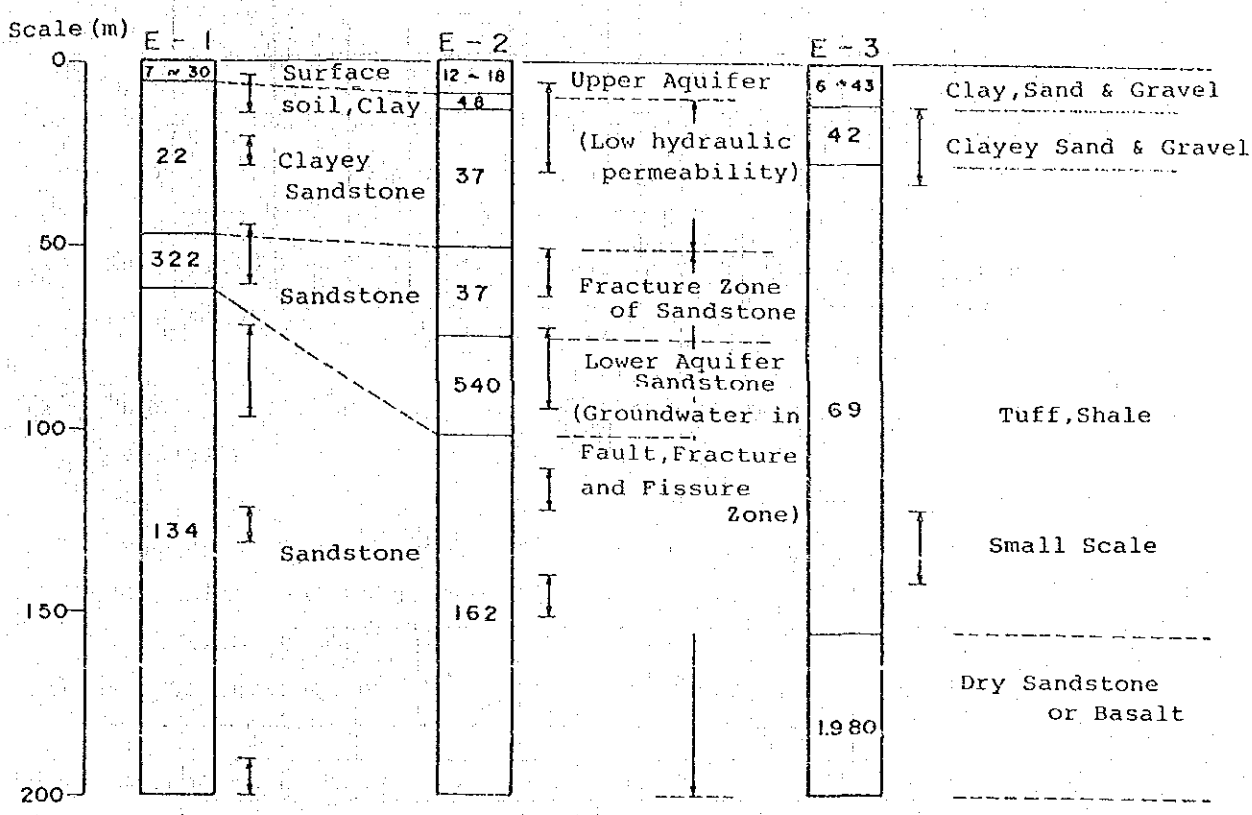


Condition of Aquifer	Shallow	Good	Shallow Good (Seasonable variation of ground water level)	Shallow Good (Seasonable variation of ground water level)
	Deep	Good	Deep Good (small scale)	Deep Good (small scale)
Suitability for Deep Well	Good		Good	Good
Othr Observation			So far from of Asfan No availablr place for water tank	Near from center of Asfan Available place for water tank
Suitability for Water Source			No	Good
Location	Al Abyad		Southwest site of Asfan	East site of Asfan

FIG ELECTRIC RESISTIVITY PROFILE (AL RAJAM)

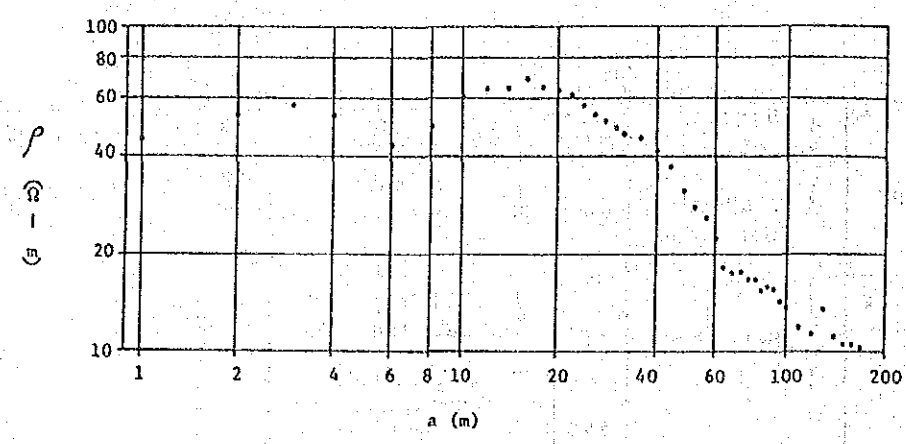


ELECTRIC RESISTIVITY PROFILE
(SHIHARA)

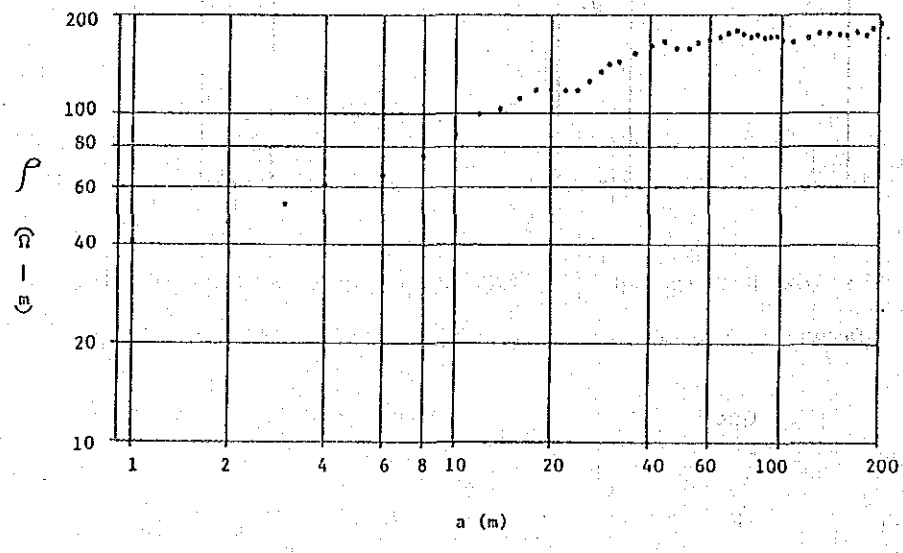


Condition of Aquifer	Shallow	Rarely good		Shallow	Rarely good		Shallow	Rarely good
	Deep	Good		Deep	Very good		Deep	No good
Suitability for Deep Well	Good			Very good			No	
Suitability for Water Source	No			Good			No	
Location	Wadi Woar			Wadi Woar			Small Wadi in lower terrace	

Ad-Dahi



Hadad



n. Examination of Safe Yield

In this chapter, groundwater development possibility is examined for rural water projects based on the geological survey and pumping test results.

The following four conditions shall be necessary to exploit and use the groundwater securely and continuously:

(1) Safe yield has not to exceed the annual mean recharge (recharge condition).

(2) Pumping cost has not to exceed the determined level (economic condition).

(3) Drawdown has not to be made to prevent the groundwater contamination (water quality condition).

(4) Not to infringe on the water rights (law condition).

The examination of groundwater development possibility will be carried out by the following two methods:

a. Hydrological method; to clarify the hydrological cycle by means of water balance.

b. Hydraulic method ; to assure pumping possibility.

a. The hydrological method is to study the groundwater recharge compared to precipitation based on the following equation:

(ground water recharge) = (catchment area) x (precipitation) x (rate of recharge)

Recharge for each prospecting water source area is shown as follows:

- Two sites of the coastal plain
  Annual rainfall : 100 - 200 mm
  Catchment area : more than 1,500 km^2
  Rate of recharge : 10 % (presumed)
  Consequently,
  (100-200)x1,500x0.1=15,000-30,000x$10^3$$m^3$/year(41,100-82,190$m^3$/day)

- Sites of the mountainous zone
  Recharge : about 40 m^3/year at Dimuna more than 200 m^3/year at other sites

Those estimated values can be applied only for shallow groundwater but not for deep groundwater. However, the groundwater development possibility can be examined based on these results.

Catchment Area and Estimated Recharge Volume on surrounding Area of Recommendded Well Site.

Area	Catchment Area (km^2)	Rainfall (mm/year)	Recharge*		
			Case 1 ($\times 10^3$ m^3 /year)	Case 2 ($\times 10^3$ m^3 /year)	Average m^3 /day
Wadi Asfan	24.1	300	723.0	1,084.5	1,980～ 2,970
Dimuna	0.9	400	36.0	54.0	100～ 150
Al Khashna	379.4	400	15,176.0	2,276.4	41,570～ 6,240
Al Zakira	9.6	400	384.0	576.0	1,050～ 1,580
Al Kheisen	22.0	300	660.0	990.0	1,810～ 2,710
Al Rajam	5.0	400	200.0	300.0	550～ 820
Shihara	54.1	400	2,164.0	3,246.0	5,930～ 8.890

Note : 1) * Case 1 : recharge % is 10%

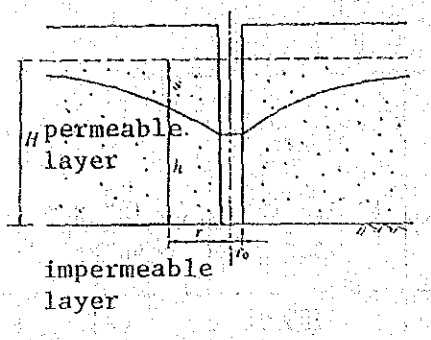
Case 2 : recharge % is 15%

2) The percentages are refered from below table;

Estimate of hydrological flow paths for the region of Dhamār (assuming a land surface two-thirds uncultivated and one-third cultivated; source: PRATT, 1976, p. 16)

COMPONENT	DRY YEAR mm	AVERAGE YEAR mm	WET YEAR mm
Rainfall	100	400	700
Evapotranspiration	85	200	295
Runoff	10	185	365
Groundwater	5	15	40

b. The Hydraulic method is to size quantitatively the grounwater yield on the basis of hydraulic equations. When fully penetrated well is planned as shown in the following figure,



discharge(Q) is given, in case of normal pumping, as the following equation:

$$T = Q \cdot \ln(R/r)/2 \cdot Sw$$

$$Q = \frac{T.2 \cdot Sw}{\ln (R/r)}$$

Q : Groundwater yield (m^3/day)
Sw : Drawdown (m)
R : Radious of influence (m)
r : Diameter of Well (m)
T : Coefficient of transmissibility (m^2/day)

Radious of influence(R) is assumed 3,000 times of diameter of well(r), therefore, the equation mentioned above is shown as follows;

$$Q=T \cdot 2 \cdot Sw/8$$

Taking into account the available information, the drawdown is used 0.8 x (water level in the aquifer,H) as a standard value for the sites where detailed data is not available.

The results of all items above are summarized in the following table.

	Wadi Asfan	Al Khashna	Al Zakira	Al Kheisen	Al Rajam	※ Shihara	Ad Dahi	Harad
Coefficient of Transmissibility (m^2/day)	22.12	3.74	1.97	7.2	14.4	316.8	(48.38)	380.2 48.38
Coefficient of Transmissibility (m^2/min)	2.02 $\times 10^{-3}$	2.6 $\times 10^{-3}$	1.37 $\times 10^{-3}$	5.0 $\times 10^{-3}$	1.0 $\times 10^{-2}$	2.2 $\times 10^{-1}$	(3.36 $\times 10^{-2}$)	2.64×10^{-1} 3.36×10^{-2}
Depth of Well (m)	200	150	180	315	200	200	60 80	50 81.4
Water Level (m)	20	85	5.44	100	100	2.4	28 45	19.0 15.7
Water Depth before Pumping (m)	180	65	174.5	215	100	71.6	32 35	31.0 65.7
Water Depth after Pumping (m)	144	40	83.6	135	80	57.3	24 14	24.8 63.25
Drawdown (m)	36	25	90.9	80	20	14.3	6 20	6.2 2.45
Diameter of Well (m)	0.25	0.2	0.25	0.25	0.25	0.25	0.20	0.25 0.35
Pumping Volume (m^3/day)	625.4	73.4	140.6	452.4	226.2	3558.0	228.0 760.0	1851.4 93.1

※ Shallow groundwater

Hydraulic constants are examined and following data are adopted for the respective sites:

Existing data for Al Zakira, Al Rajam, and Harad;
Obtained data by the site survey for Wadi Asfan, and Shihara;
Existing datas of similar sites for Al Khashna, Al Kheisen, and Ad Dahi

Site survey's data are also referred for Al Zakira and Harad.
Existing data of surrounding area are also used for Wadi Asfan.

Design intake volume is generally considered 1/1.5 times of the pumping volume mentioned above to satisfy the daily maximum yield.

Safe yield are summarized, based on these two methods, as follows:

Site	Exploitable Water Vlume(m3/day)			proposed
	Hydrological method	Hydlaulic method	Judgment	volume
Wadi Asfan	1980	416.9	416.9	39.6
Al Khashna	41570	48.9	48.9	19.6
Al Zakira	1050	93.7	93.7	32.8
Al Kheisen	1810	301.6	301.6	46.8
Al Rajam	550	150.8	150.8	242.8
Shihara	5930	2,372.0	2,372.0	337.6
Ad Dahi	40000<	658.7	658.7	634.0
Harad	40000<	1,296.3	1,296.3	488.0

Consequently, safe yield for all sites except Al Rajam exceeds planned one, therefore, the most of sites have no problem of water source. As far as Al Rajam project is concerened, it is necessary to install two wells due to the shortage of yeild about 100 m^3/day for one well.

Safe yield summarized in JICA's survey report (1982) is shown in table below for reference.

Number	Site	Proposed Water source	Water Source	Scale		Pumping Height(m)	Exploitable Vol. (m^3/day)
				Dia. (m/m)	Depth (m)		
T-6	Al-Zakira	A, C1, C2	A	200	250	200	100
A-3	Al-Rajam	A	A	200	300	200	200
HA-3-A	Sihara	A, C1	A	200	300	200	300
H-2	Al-Dahi	A, B4	A	200	80	50	1,000
HA-4	Harad	A	A	200	120	100	1,000