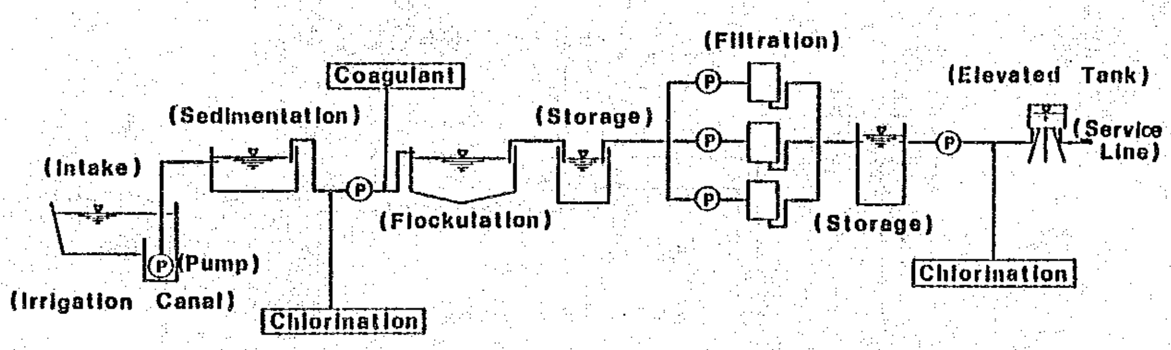
3.3.3 Water Suply with Surface Water Source

The source of the urban water supply for Showak and Khashim el Gerba Towns is the surface water. A part of water source for Gedaref Town is piped for 70km from Showak.

The treatment plant at Khashim el Gerba Town was constructed by the Chinese Aid in 1977 taking the water from the Atbara Riber. The design capacity of the system is 2,160 m^3/day and the design population is 20,000 people. Total length of service pipes is 15km with diameters ranging from 50mm to 200mm. The chemicals for water treatment are all imported from England. The system is illustrated in Fig. 16.

Fig. 16 Flow System of Khashim el Gerba Town Water Supply



3.4 Institutional System for Water Supply

1. Office of Commissioner for Refugees (COR)

The COR is an official agent under the Ministry of Internal Affairs to undertake various activities to assist refugees in cooperation with UNHCR. At present the number of staff of the COR is 15,000 people.

There are five departments under the Commissioner and the Assistant Project Manager for Water Supply Undertakes Water Supply Projects for refugees. The budget in the last three years is a few million Sudanese pounds;

1983	S£6,949,000	(US$2.8 mil)
1984	S£7,893,000	(US$3.2 mil)
1985	S£2,989,000	(US$2.0 mil)

Of these budgets about 26% was spent for the water supply for refugees.

2. National Water Cooperation

This cooperation is responsible for procurement, training and research, underground water development and construction of boreholes for the whole country. Operation and maintenance of boreholes in village water supplies is also under responsibility of the NWC, therefore, a close coordination with COR is necessary for the rural water supply project.

At present the drilling section of the NWC holds the following equipment for construction and rehabilitation of boreholes;

Ballerini ST6	5
Gardener Denver	2
Mayhuew	5
Percussion 22W	10
Sankyo T24	2
Sankyo Cable Tool	3
Farcom (Testing Unit)	3
Tone THR 300	2

Of these Sankyo Cable Tools and Farcom are the service machines and the percussion types are too old for drilling. Existing serviceable equipment are 19 units. Since the NWC is responsible for the whole country it is very much unlikely to save equipment for a certain project for a long period.

The drilling division of the NWC has been playing an important role in the underground water development and has a considerable experience. These more than 500 boreholes existing in the Eastern Region were also constructed by the NWC. Number of experts and technicians of the drilling section is listed as below;

Type of Field	Number of Staff
Chief Drilling Engineer	10
Chief Driller	30
Driller	80
Shift Driller	35
Geologist	24
Hydrologist	32

Usually a drilling crew consists of the following members;

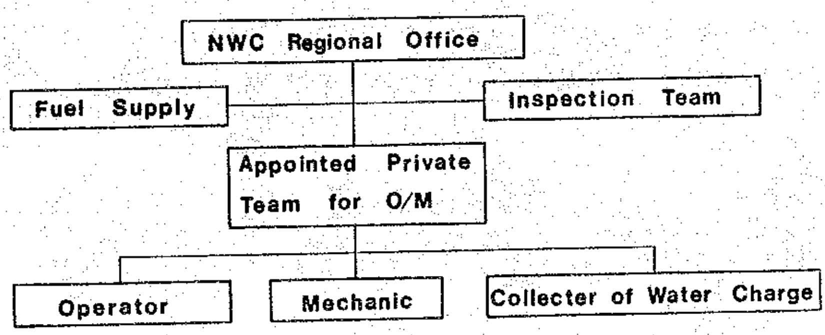
Type of Job	Number of Staff
Chief Driller	1
Shift Driller	2
Hea Rig Man	3
Drilling Crew	12
Driver	4
Assistant Driver	2
Store Keeper	1
Mechanic	1
Total	26

3. Operation and Maintenance of Village Water Supply

Operation and maintenance of village water supply is undertaken by three villagers appointed by the NWC. Major duties of these three operators are operation and maintenance of facilities and collection of water charge.

The organization chart of operation and maintenance is shown in Fig. 17.

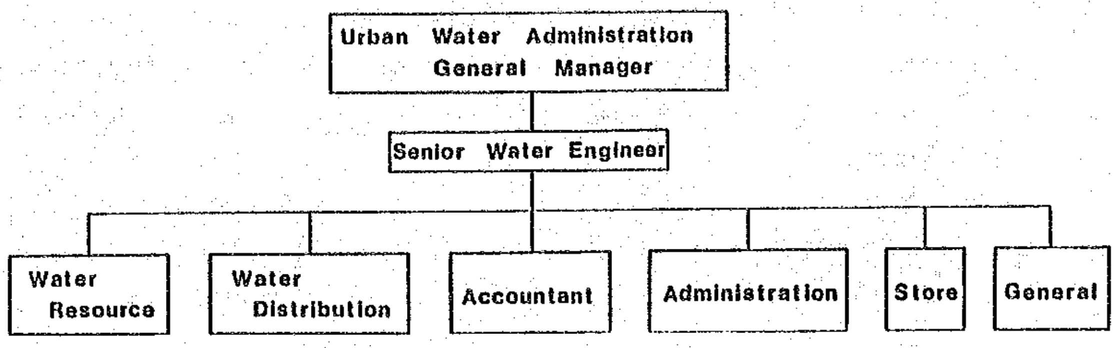
Fig. 17 Operation & Maintenance of Village Water Supply



4. Operation and Maintenance of Kassala Town Water Supply

The Urban Water Administration in the Eastern Region is responsible for operation and maintenance of the Kassala Town water supply. The organization chart of the Urban Water Administrationat Kassala is shown in Fig. 18.

Fig. 18 Organization Chart of the Urban Water Adminisration at Kassala



Since there are sufficient manpower with experience and the organization at present no difficulty in operation and maintenance will be expected.

CHAPTER 4 FORMULATION OF THE PROJECT

CHAPTER 4
FORMULATION OF THE PROJECT

4.1 Objectives

There are about 1.1 million rural population in the project area. Of these rural population about 400,000 people including refugees are suffering from shortage of domestic water. One of objectives of the Project is to ease this urgent problem serving suitable domestic water for 210,000 people in rural areas and refugee camps.

At the same time, Kassala Town, the Regional Capita is also suffering from the shortage of water; Due to rapid increase in the urban population about 75% of the urban area became the problematic area of urban water supply. Another objective of the project is to solve this problem and maintain the target supply capacity of 75 l/day/cap.

For this purpose, necessary equipment, machinery and materials are to be provided including construction of a part of facilities under the Grant Aid Cooperation of Japan.

4.2 Confirmation of the Project Background

4.2.1 Village Water Supply for Refugees and Sudanese Villagers Influenced by Refugees

1. General Description

The following items were requested by the Government;

1) Construction of New Village Water Supply Facilities for 41 places including 6 refugee camps.

2) Rehabilitation of Boreholes of Existing Village Water Supply Facilities for 165 holes including 15 holes at Refugee Camps.

2. Construction of New Village Water Supply Facilities

Requested new village water supply facilities are to be constructed in the place near by existing facilities because capacities of the existing facilities are insufficient due to rapid increase in population.

Through the site investigation it is found that a total of 46 facilities in 42 sites are requested instead of 41 sites. For construction of the new boreholes it is critical to confirm the hydro-geological conditions at proposed drilling sites. Background information of existing boreholes are available at 31 sites of facilities (Table 5). It is, therefore proposed that the construction of new village water supply facilities will be made on 34 sets at 31 sites (Fig. 19).

3. Rehabilitation of Existing Boreholes of Village Water Supply Facilities

In the Eastern Region the underground water has been playing an important role for supply of domestic water. However, many of these boreholes are very old and the machinery deteriorated.

At present 165 boreholes including 15 holes at refugee camps require rehabilitation. The request is the Government's intention to ease this problem. Of these boreholes, the necessary hydrological conditions are available at 73 holes (Table 6).

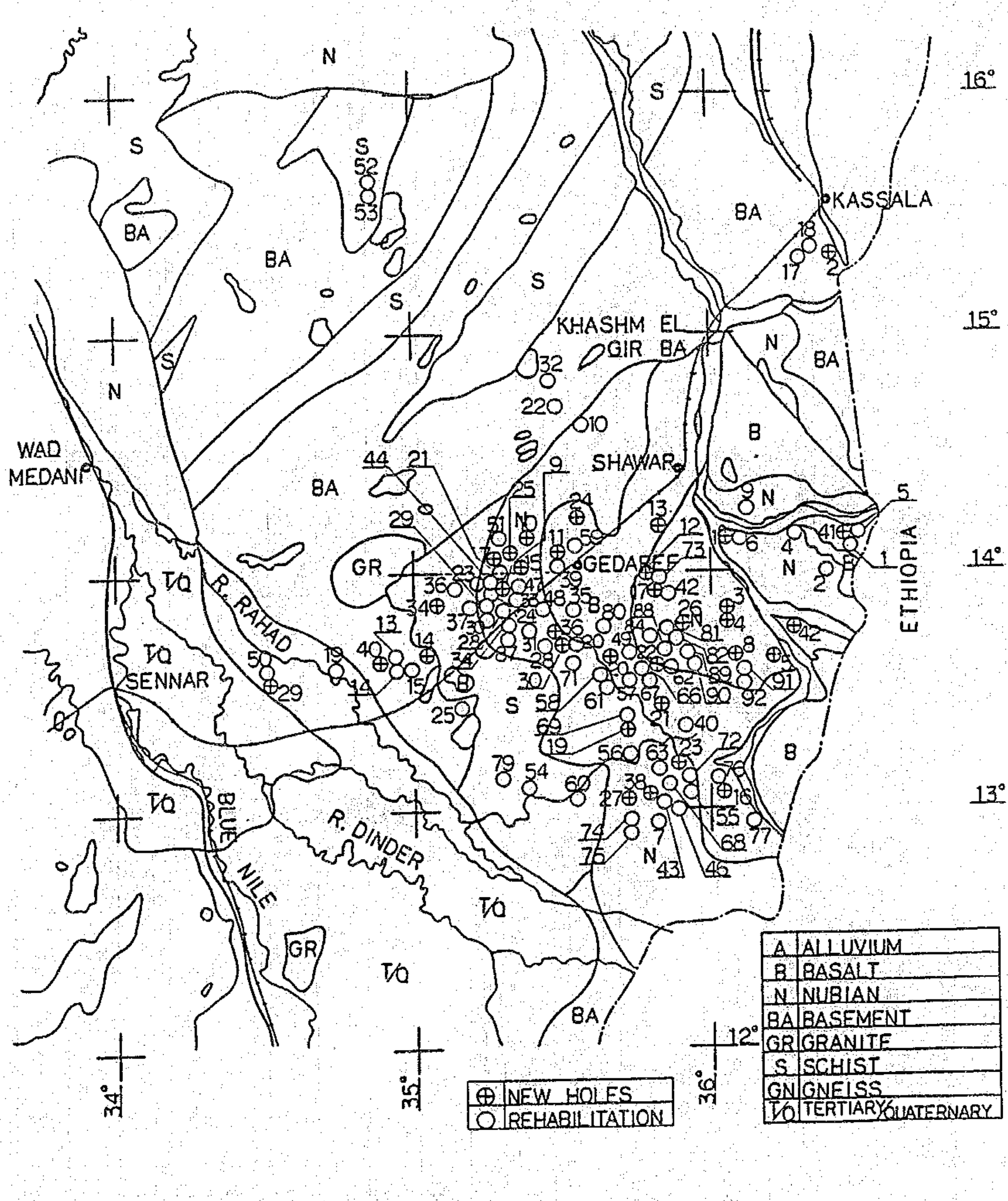


Fig. 19 Location of Boreholes

Table 5 BACKGROUND INFORMATION OF NEW BOREHOLES

	Location	Type of Aquifer Aquifer	Available Hydogeogical Suvey	Population to be Served	Present Water Source	No of Boreholes
1	WAD EL HELLOW Long. 36 ° -02' Latt. 14° -13'	NUBIAN SANDSTONE	D=56m, S.W.L=43m Q=75.5 ℓ/min	12,000	Boreholes	2
2	WAD SHEREF 36 ° -25', 15° -21'	ALLUVIUM	D=45m, S.W.L= 6m Q= 227 ℓ/min	80,000	"	2
3	HELAT HCOMA(No.1) 36 ° -05', 13° -52'	NUBIAN SANDSTONE	D= 220m, S.W.L=40m Q= 380 ℓ/min	70,000	ATBARA RIVER existing will not working	2
4	" (No.2)	Basalt/NUBIAN SANDSTONE	"	10,000	ATBARA RIVER	1
5	UMM ALI 36 ° -54', 14° -19'	ALLUVIUM	D=60m, S.W.L= 9m Q= 380 ℓ/min	20,000	Borehole	1
6	WAD WIDAIDA 35 ° -19', 14° -01'	Basalt/Nubian Sand stone	D= 200m, S.W.L=75m Q=75 ℓ/min	5,000	"	1
7	TABARAKALLA 36 ° -07', 13° -36'	"	D= 210m, S.W.L=87m Q=75 ℓ/min	10,000	"	1
8	UMM SHORABA 35 ° -24', 14° -07'	"	D= 270m, S.W.L= 120m Q= 380 ℓ/min	5,000	"	1
9	EL GAMMAN 35 ° -47', 14° -00'	"	D= 130m, S.W.L=57m Q=75 ℓ/min	6,000	Borehole	1
10	A BU GALLOT 35 ° -03', 13° -40'	"	D= 150m, S.W.L=40m Q=60 ℓ/min	4,000	Boreholes	1
11	Galabat 35 ° -23', 14° -03'	"	D= 220m, S.W.L=40m Q= 200m³	8,000	"	1
12	KINANA 36 ° -02', 13° -05'	"	D= 295m, S.W.L=22m Q=52 ℓ/min	3,000	"	1
13	WAD KASIBA	"	D= 360m, S.W.L=75m Q= 145 ℓ/min	4,000	"	1
14	EL KAFIO 35 ° -44', 13° -21'	"	D= 150m, S.W.L=16m Q=80 ℓ/min	5,000	"	1
15	EL SAHINA 35 ° -43', 13° -37'	"	D= 330m, S.W.L=16m Q=90 ℓ/min 5.4	6,000	"	1

	Location	Type of Aquifer Aquifer	Available Hydogeogical Suvey	Population to be Served	Present Water Source	No of Boreholes
16	EL SARAF EL AHRMER 35 ° -51'. 13° -27'	NubianSandstone	D=85m, S.W.L=20m Q=90 ℓ/min 5.4	6,000	"	1
17	WAD GANOFA 35 ° -50'. 13° -36'	"	D= 120m, S.W.L=30m Q= 225 ℓ/min 13.5	4,000	"	1
18	ALLANA 35 ° -55'. 13° -11'	Nubian/Basalt	D= 300m, S.W.L=50m Q= 230 ℓ/min 13.8	7,000	"	1
19	EL AZAZ EL MATAR 35 ° -33'. 14° -12'	"	D= 200m, S.W.L=20m Q= 115 ℓ/min 6.9	3,000	"	1
20	SHEIKHAIN 35 ° -55'. 13° -43'	"	D= 150m, S.W.L=30m Q= 115 ℓ/min 6.9	8,000	Borehole	1
21	DOKA 35 ° -46'. 13° -02'	"	D= 160m, S.W.L=30m Q=90 ℓ/min 5.4	7,000	Borehole Hafir	1
22	TAGLI(1) 34 ° -30.5'. 13° -33'	NUBIAN	D= 150m, S.W.L=28m Q=65 ℓ/min 3.9	3,000	Borehole	
23	TAGLI(2) 35 ° -31'. 13° -41'	NUBIAN SANDSTONE	D= 150m, S.W.L=28m Q=75 ℓ/min 4.5	5,000	"	
24	DOMAT(1)	Nubian Sandstone	D= 105m, S.W.L=43m Q=90 ℓ/min 5.4	3,000	"	
25	DOMAT(2) Long.35 ° -06'Latt. 13° -52'	Nubian Sandstone	D=55m, S.W.L=30m Q=90 ℓ/min 5.4	8,000	Borehole	
26	ZERGA(1) 不明	Nubian	D=95m, S.W.L=22m Q= 110 ℓ/min 6.6	5,000	"	
27	UMM HRELAHA	Nubian/Sandstone	D= 265m, S.W.L= 327m Q= 190 ℓ/min 11.4	5,000	"	
28	UMM MILEHA 35 ° -50'. 13° -02'	Basalt Nubian/Sandstone	D= 370m, S.W.L=65m Q=75 ℓ/min 4.5	5,000	"	
96	GALA EL NAHL(1)	Nubian/Basalt	D= 150m, S.W.L=44m Q= 110 ℓ/min 6.6	10,000	Hafile	
30	GALA EL NAHL(2) 34 ° -57'. 13° -37'	Fractured Basement Complet	D=90m, S.W.L=57m Q=75 ℓ/min 4.5	7,000	Borehole	
31	UMM EL TYOUN 36 ° -29'. 14° -12'	Nubian Sandstone	D= 180m, S.W.L=56m Q=70 ℓ/min 4.2	3,000	"	

Table 6 BACKGROUND INFORMATION OF BOREHOLE REHABILITATION

No.	Code No.	Location	Const. Year	T-Depth (m)	Casing (mm)	Tyep of Aquifer	S.W.L. (m)	Yield (ℓ/min)	Population Served
1	5385	N. 36.29 E. 14.12	1949	183	6 5/8	Basalt/Nubian Sandstone	57	68	2,000
2	2287	36.19 14.13	1967	163	"	"	133	68	3,000
3	6707	36.06 14.11	1974	212	"	"	32	166	6,000
4	4248	35.51 12.56	1967	340	"	"	53	54	2,000
5	6218	36.09 14.15		194	"		32	76	3,000
6	6181	36.09 14.15	1973	179	"	Nubian Sandstone	17	76	4,000
7	6708	35.35 14.36	1973	211	"	"	29	136	5,000
8	1415	34.56 13.37	1968	41	"	"	19	32	2,000
9	2604	34.56 13.37	1969	118	"	"	58	70	3,000
10	3529	34.57 13.36	1969	92	"	"	27	333	10,000
11	2425	36.20 15.20	1970	22	"	"	19	151	6,000
12	3024	36.24 15.22	1970	37	6 5/8	Sandstone	6	378	15,000
13	3289	34.43 13.34	1969	275	"	Basalt/Nubian Sandstone	13	197	6,000
14	4303	35.32 13.40	1971	187	"	"	28	245	7,000
15	5409	35.19 14.01	1972	205	"	"	76	79	3,000
16	222	35.29 13.42	1948	114	8 5/8	"	23	109	3,000
17	173	35.14 13.53	1947	237	6 5/8	"	49	91	3,000

No.	Code No.	Location	Const. Year	T-Depth (m)	Casing (mm)	Tyep of Aquifer	S.W.L. (m)	Yield (ℓ/min)	Population Served
18	3994	N 35.11 E 13.25	1971	270	6 5/8	Basalt/Nubian Sandstone	35	257	7,000
19	2276	35.20 13.50	1947	128	"	"		61	3,000
20	4270	35.18 13.55	1971	229	"	"	50	243	3,000
21	3111	35.18 13.54	1969	210	"	"	46	243	3,000
22	4268	35.25 13.43	1971	239	"	"	53	227	3,000
23	3110	35.27 13.48	1968	225	"	"	53	227	3,000
24	3112	35.22 13.53	1971	253	"	"	62	230	5,000
25	4272	35.21 13.45	1971	92	"	"	62	63	2,000
26	2412	35.34 13.49	1967	311	6 5/8	Basalt-Nubian Sandstone	159	42	2,000
27	172	35.11 13.54	1957	55	8 5/8	"	31	45	2,000
28	173	35.14 13.53	1947	55	"	"	48	91	4,000
29	222	35.29 13.42	1948	96	"	"	23	109	4,000
30	703	35.30 14.03	1956	153			49	98	4,000
31	3296	35.55 13.19	1971	370	6 5/8	Basalt-Nubian Sandstone	32	99	5,000
32	2001	35.52 13.54		116	"	Nubian Sandstone		51	2,000
33	5392	35.51 13.02	1971	371	"	B-N	68	50	2,000
34	2451	35.18 13.55	1971	89	"	"	18	605	20,000

No.	Code No.	Location	Const.Year	T-Depth (m)	Casing (mm)	Tyep of Aquifer	S.W.L. (m)	Yield (ℓ/min)	Population Served
35	2471	N E		272	6 5/8	B-N	45	210	8,000
36	3500	35.55 13.00	1971	287	"	"	70	177	6,000
37	4265	35.22 13.56	1971	278	"	"	10	303	9,000
38	3151	35.27 13.51	1969	345	"	"	89	179	7,000
39	3145	34.30 13.33	1968	157	"	"	29	64	2,000
40	1641	35.21 14.11	1963	138	"	"	38	53	2,000
41	1414	34.49 15.37	1962	76	6 5/8	"	15	61	2,000
42	5393	35.55 13.07	1972	258	"	N-B	20	76	3,000
43	2197	35.46 13.15	1968	185	"	"	30	91	4,000
44	3160	35.46 13.35	1969	121	"	B-N	21	45	1,000
45	3991	35.39 13.34	1971	214	"		20	254	6,000
46	3992	35.34 14.11	1971	186	"	B-N	14	210	3,000
47	4309	35.32 13.05	1971	271	"	"	88	173	3,000
48	4300	35.43 13.35	1971	354	"	"	34	227	5,000
49	2742	35.50 13.36	1969	121	"	"	32	189	5,000
50	2920	35.52 13.13	1969	162	"	"	69	76	2,000
51	1909	35.49 13.33	1966	214	"	"	22	45	1,000

No.	Code No.	Location	Const. Year	T-Depth (m)	Casing (mm)	Tyep of Aquifer	S.W.L. (m)	Yield (ℓ/min)	Population Served
52	1788	N.35.49 E.13.33	1965	262	6 5/8	B-N		76	2,000
53	2176	35.43 13.37	1968	336	"	Basalt	16	91	2,000
54	2923	35.44 13.21	1969	90	"	B-N	16	89	2,000
55	3288	35.34 13.38	1971	260	"	"	31	236	5,000
56	3297	35.55 13.13	1971	363	"	"	87	145	4,000
57	5391	35.45 13.00	1972	211	"	"	88	64	2,000
58	2903	35.45 13.00	1969	143	"	"	40	151	4,000
59	3301	36.02 13.05	1971	301	"	"	23	52	1,000
60	3302	36.10 12.58	1971	312	"	Basalt	76	62	1,000
61	3185	36.29 14.12		177	"	B-N	72	53	1,000
62	1924	35.20 13.09	1966	267	"	"		454	1,5000
63	4308	35.39 13.47	1971	136	"	"	59	151	4,000
64	1787	35.53 13.42	1965	169	"	"	102	91	2,000
65	4310	30.06 13.45		171			78	227	4,000
66	2489	35.51 13.43	1968	137	"	"	72	76	3,000
67	2490	35.22 13.73	1968	185	"	"	59	129	3,000
68	4254	35.51 13.42	1971	179	"	"	87	151	5,000

No.	Code No.	Location	Const. Year	T-Depth (m)	Casing (mm)	Tyep of Aquifer	S.W.L. (m)	Yield (ℓ/min)	Population Served
69	2281	N. 35.53 E. 13.40	1968	200	6 5/8	B-N	70	68	3,000
70	2034	35.56 13.37	1967	303	"	"	104	53	2,000
71	2011	35.56 13.37	1967	265	"	"	70	53	3,000
72	2070	36.07 13.36	1967	191	"	"	92	73	3,000
73	2059	36.07 13.36	1967	212	"	"	88	73	4,000

The construction period of these existing boreholes is summarized as below;

Time of Construction	Number of boreholes
The 1940s	7
1951-1955	0
1956-1965	6
1966-1070	29
1971-1975	29

Even the latest construction of boreholes was made in 10 years ago. Pumps and engines installed before 1965 appear to be worn out. Even these machinery installed after 1951 they are all old no more than safe use.

As for boreholes more than 15 years old need juvenilation and cleaning.

Most of these 73 boreholes distribute in the areas covered by Nubian Sandstones and Tertiary Basalts.

4. Standard Design

There are design criteria for major components of rural water supply facilities in Sudan.

Design Capacity

Type of Facility	Daily Consumption l/day/cap
Water Point	10
Public Taps	15 - 30
With Pipeline	50 - 100
Large Animal	27
Small Animal	7

Standard design capacity 30% of the average daily consumption.

However, when water source is taken from the underground water, the available amount of water source is the key factor to determine the design capacity. For this reason a standard design as the standard unit of the village water supply facility is applied in practice. When one unit is insufficient additional unit is provided near by the existing unit.

The standard design of the village water supply facilities summarized as below;

1)	Water Source	:	Borehole and pump house
2)	Elevated Tank	:	FRP, 50 m^3, 3 m
3)	Public Taps	:	1 l/sec, 4-8 pcs
4)	Cattle Trough	:	1-4 pcs
5)	Water Yard	:	50m x 50m

Under the project, the construction of new village water supply facilities requires all 5 items above and the rehabilitation of boreholes of existing village water supply requires only water source rehabilitation and replacement of pumps and engines.

5. Water Source

All the boreholes are to be constructed in the same area where existing boreholes are operated. Hydrogeological conditions of these new boreholes will be similar to the existing borehole conditions.

The relationship between available amount of water assuming 12 hrs pump operation and design population in each site of the proposed sites of construction of new village water supply facilities is shown in Fig. 20. Comparing these plots with the line of the standard water demand it is observed that all the sites are able to supply domestic water more than the minimum standard volume of 10 l/day/cap.

In this comparison an assumption is made that operation hours of pump and engine is 12 hrs. Therefore increasing operation hours from 12 hrs to 16 hrs the more supply capacity will be available.

These 6 sites where the available water source is insufficient for the demand even with the minimum supply level of 10 l/day/cap; these are sites No. 1, 3, 21, 29 and 30 as summarized below;

Hole No.	Yield l/min	No. of B/H	Operation Hour hr	Available Water Source l/d	Population	Unit Consumption l/day/cay
1	75.5	2	12	108,720	12,000	9.1
	75.5		16	217,440	12,000	12.1 > 10
3	380	2	12	532,800	70,000	7.6
	380	2	16	729,600	70,000	10.4 > 10
21	90	1	12	64,800	7,000	9.3
	90	1	16	86,400	8,000	10.8 > 10
25	90	1	12	64,800	8,000	8.1
	90	1	16	86,400	8,000	10.8 > 10
29	110	1	12	79,200	10,000	7.9
	110	1	16	105,600	10,000	10.6 > 10
30	75	1	12	54,000	7,000	7.7
	75	1	16	72,000	7,000	10.3 > 10

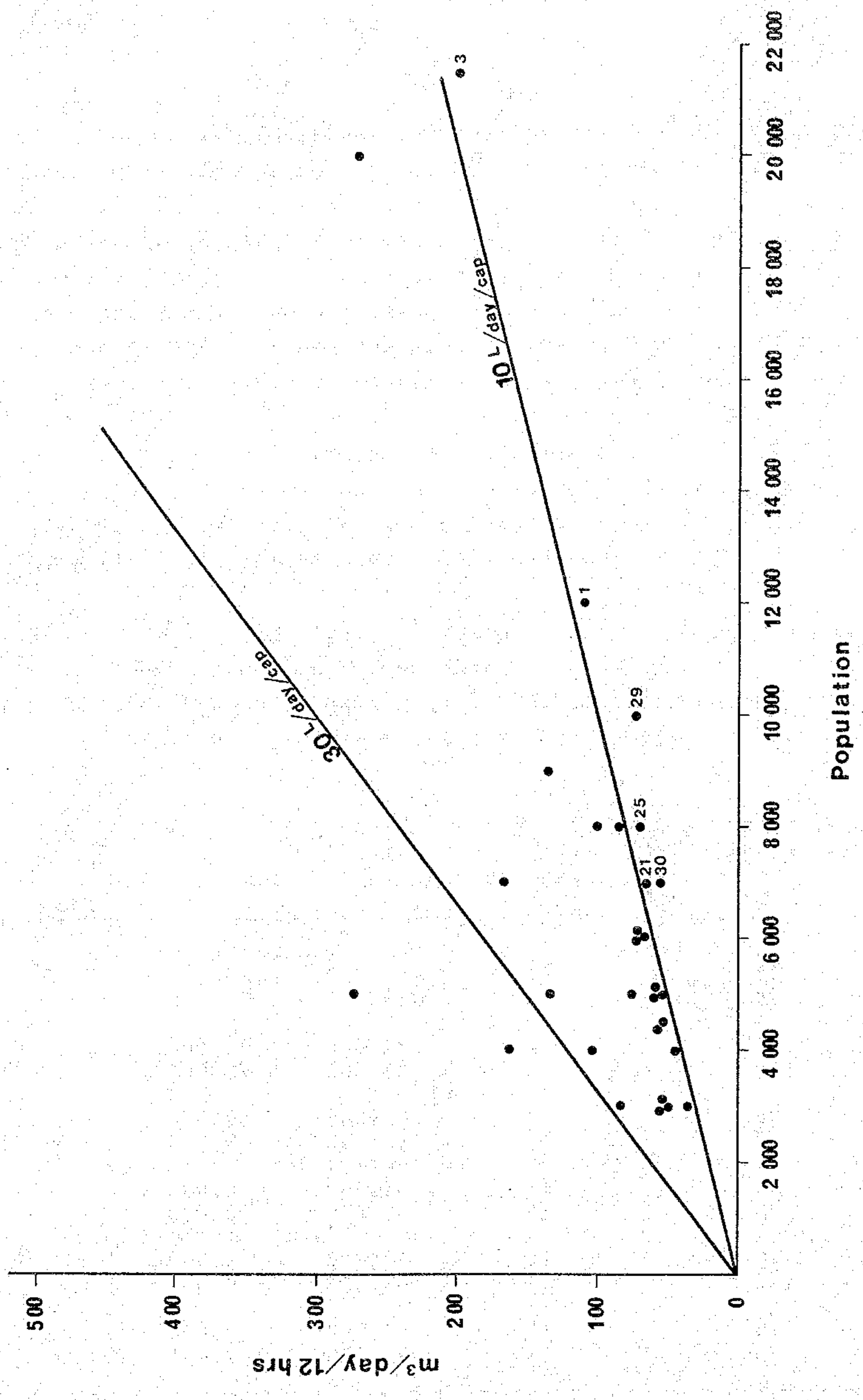


Fig. 20 Water Source/ Population New Boreholes

However, all these boreholes can meet the minimum demand of 10 lit/day/cap by increasing the operation time of pump and engine from 12hrs to 16hrs. It has to be born in mind that most of these existing boreholes are installed with stout type screens which results in reduction of the borehole yield. Therefore, a proper construction borehole has to be applied for efficient usage of the underground water.

Also it has to be minded that the yields of these boreholes in themselves are quite favourable since the unit yield ranges between 70 l/min and 300 l/min.

Therefore, insufficiency of supplying domestic water is due to the demand of these sites. Accordingly, for future increase in water demand the construction of additional units of water supply facilities will be the solution.

In the same manner a composition of available water source and demand is made for 73 sites of the proposed rehabilitation of boreholes (Fig. 21).

As shown in Fig. 20 all the sites for rehabilitation of boreholes satisfy to supply the minimum supply level of 10 l/day/cap. However, these yields of borehole to be rehabilitated are the yields obtained from the data at the construction of these boreholes. Since a long span of time passed after construction these boreholes will require juvenilation and pump tests to confirm the actual safe yield.

6. Elevated Tank

The standard design capacity of the elevated tank is $50m^3$ of 3m high and the design criteria of water tanks is 30% of the daily consumption. These criteria are applicable where population is less than 7,000 and the daily consumption rate is less than 30 l/day/cap (Fig. 22). However, where the site population exceeds 15,000 people the volume of tank, 50 m^3 is no more than 30% of the daily consumption of the unit. For these sites arrangement will be required to distribute the peak demand into certain duration of time to maintain equitable water supply (Fig. 23).

7. Pumping Facility

Three types of pumps are analyzed and it is recommended to use the vertical turbine pumps for the project.

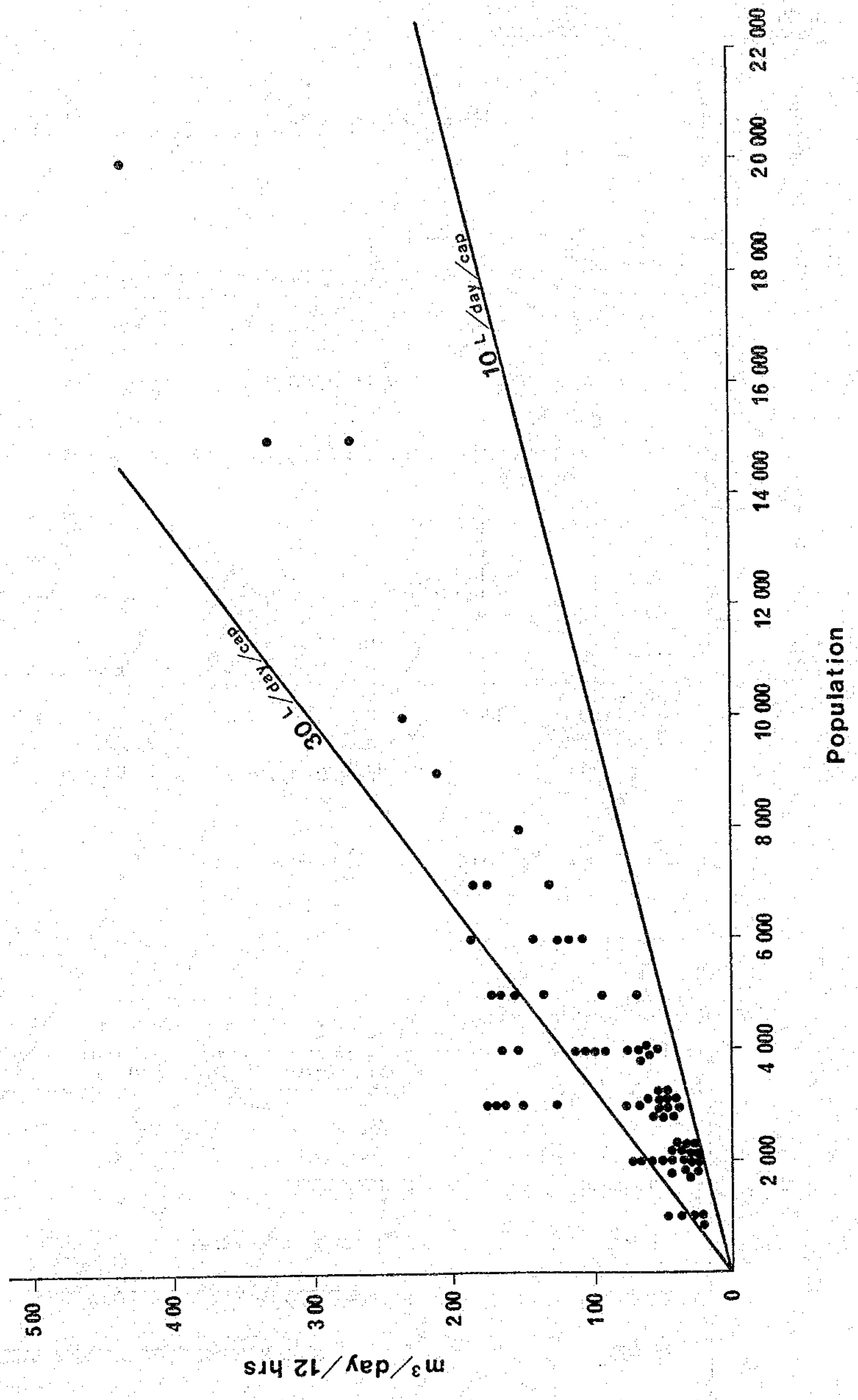


Fig. 21 Water Source / Population Rehabilitation of Boreholes

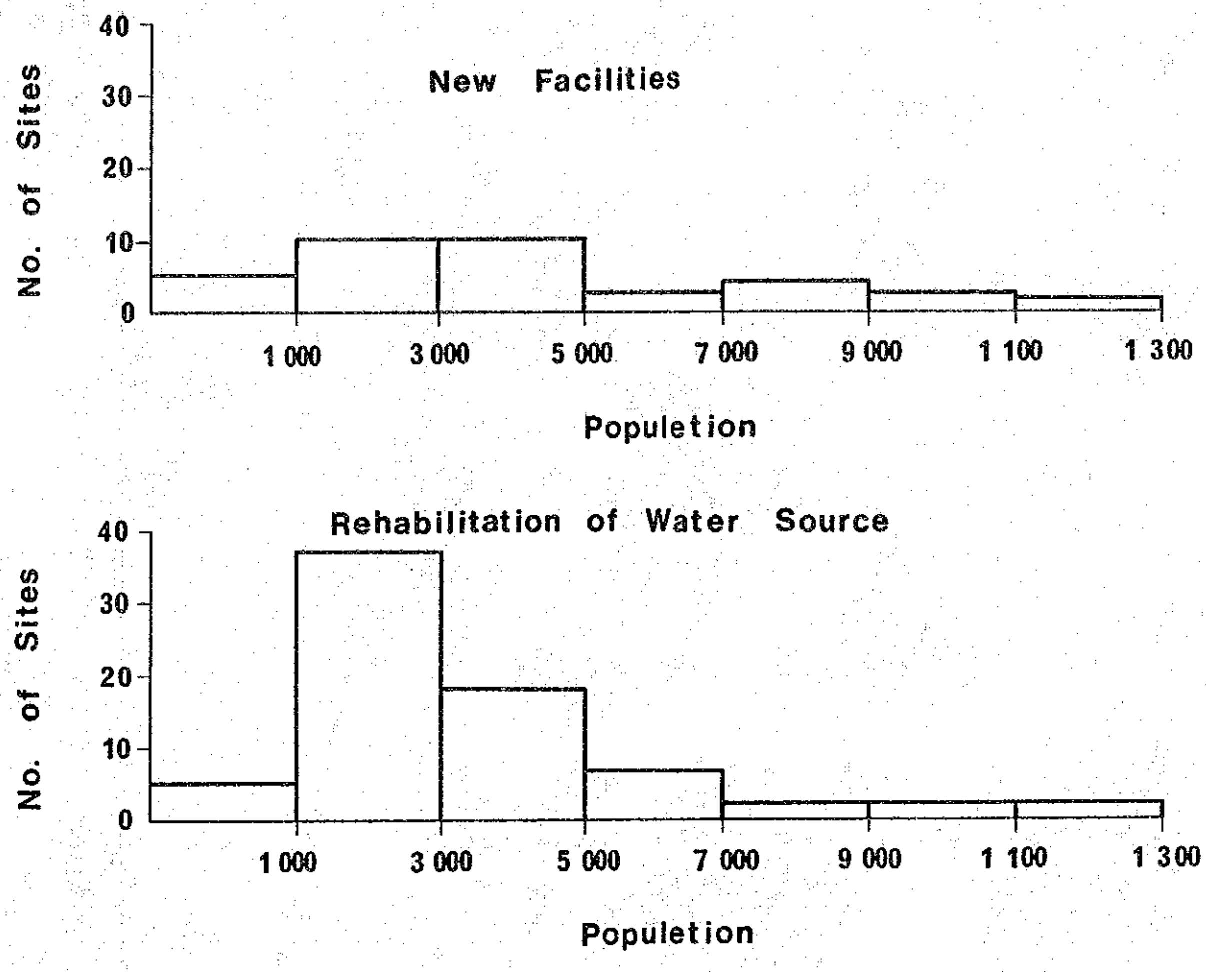


Fig. 22 Distribution of Population

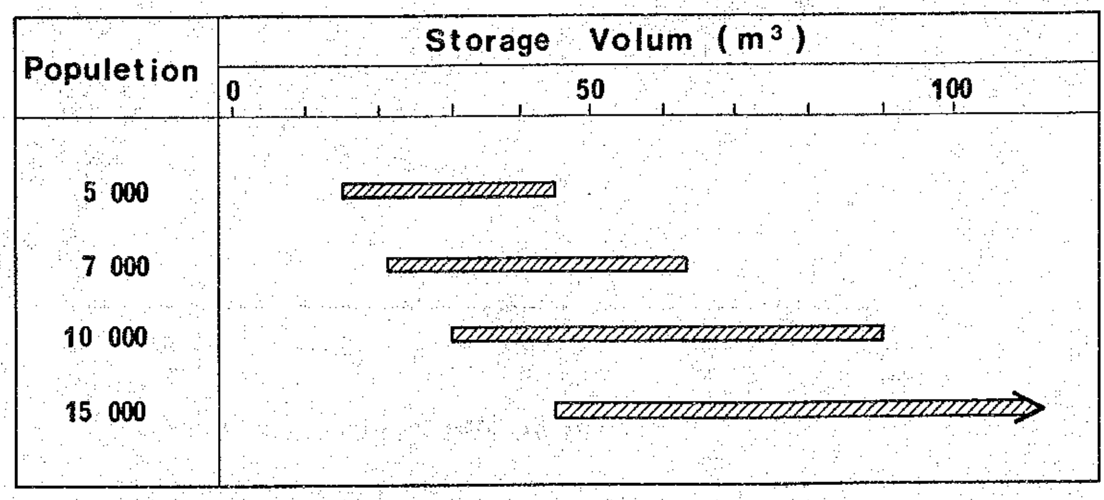


Fig. 23 Required Capacity of Storage Tank

4.2.2 Kassala Town Water Supply

1. Introduction

The urban area of Kassala Town is divided into two parts, the West and East by the Gash River. There is only one bridge between the two parts. The Gash River dries up during five months in the dry season.

At present there are 500,000 refugees in Kassala Town, which resulted in serious water shortage of the town together with deteriorated water supply facilities.

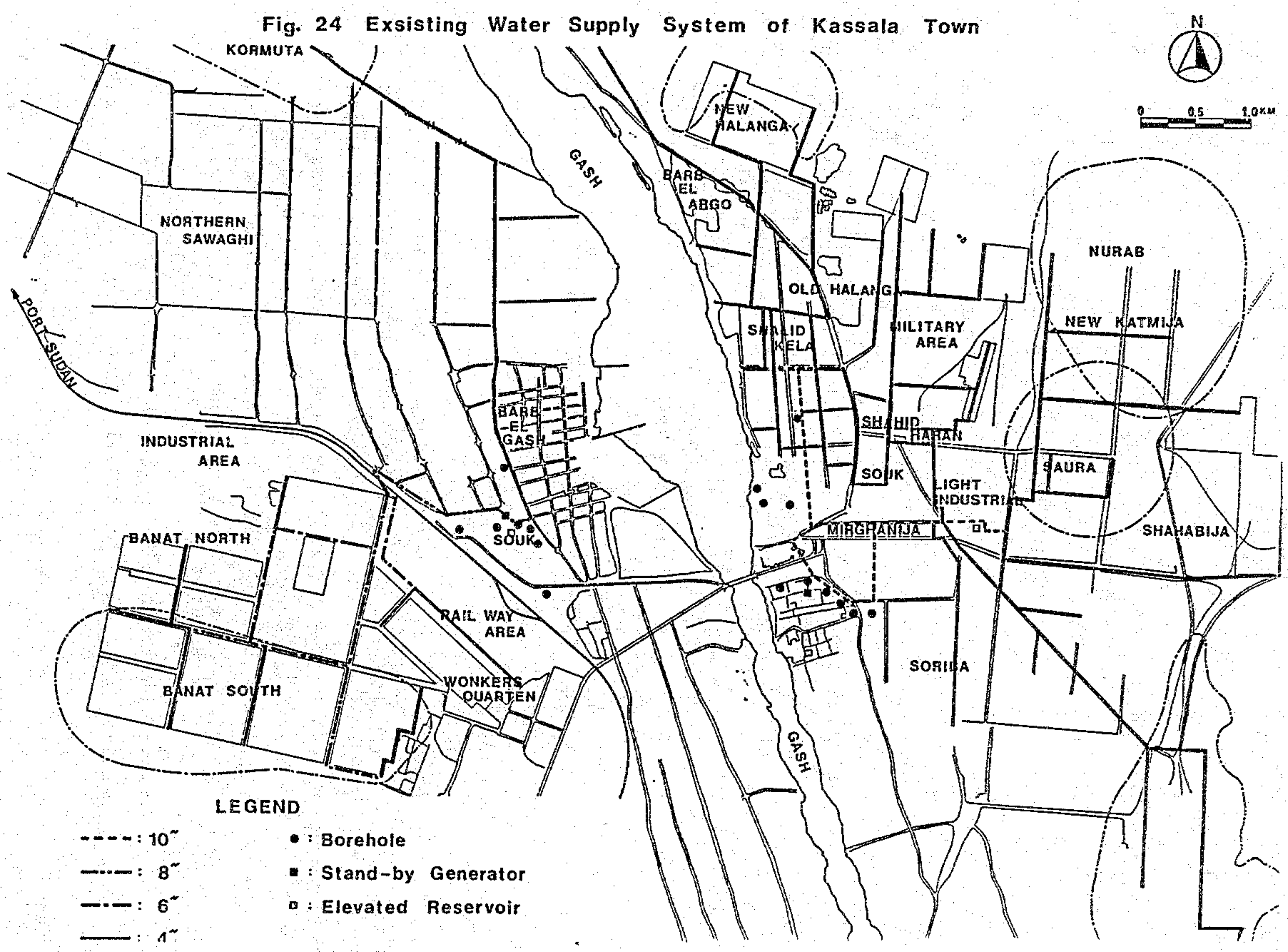
Existing distribution pipes are 10", 8", 6", 4" and 3" of asbestocement pipes and 2" and 1/2" of P.V.C. pipes as summarized below;

Pipes	East Bank	West Bank
10"	5.4 km	-
8"	-	1.0
6"	18.2	6.1
4"	33.8	8.3
3"	20.5	2.5
2"	68.5	38.7

Since small size pipes occupy rather long length in the piping network, there would be low hydraulic pressure zone in the network. These problematic area of 25% of the urban areas where hydraulic pressure is too low for 24 hrs and other 50% of urban areas receive water only during night time. The remaining 25% of urban areas only receives normal services.

It is therefore urgent to rehabilitate the water supply facilities of Kassala Town (Fig. 24).

Fig. 24 Exsisting Water Supply System of Kassala Town



2. Target Year

At present no future projection of the town water supply is made, however the growth rate of the town population is only 5.8% in the past 10 years from 1983 which corresponds to less than 1% of the annual population growth rate. The increase in the future water demand may be mainly caused by increase in numbers of private connections and increase in refugee population if any, however not in a significant level. Therefore the design target is to meet the present demand with the target design capacity of 75 l/day/cap.

3. Service Area

The service area consists of two parts, the east bank area and the west bank area. The water supply systems on the both bank sides are completely independent. The size of the service area is 14 km^2 and 8 km^2 on the east and the west bank sides respectively.

4. Water Source

1) General

The only prospecting water source for the Kassala Town Water Supply is the underground water from the alluvial deposits of the Gash River since the near by Gash River dries up during the dry seasons and the perenial rivers, the Nile and the Atbare Rivers, are available at 70 km away from the Town.

2) Boreholes

The safe yield of existing boreholes varies from 35 m^3/hr to 80 m^3/hr. Therefore, 40 m^3/hr is applied as the design capacity of boreholes. Available amount of the underground water from the alluvial deposits of the Gash River is estimated at 78 million m^3/year and only a part of it is utilized at present. The draw down is estimated to be 5 m and the dynamic water level is about 35 m.

The standard design of the boreholes is proposed as below;

Diameter	:	10 inch
Yield	:	40 m^3/hr/hole
Draw Down	:	5.0 m
Dynamic Water Level	:	35.0 m
Operation Time	:	16 hrs
Distance Among Holes	:	More than 100 m

3) Water Quality

The quality of the underground water is quite potable and meet the WHO standard as shown below;

Table 7 Water Quality

Items	Ground Water	WHO-Recommended	WHO-Tolerable	Japanese Standards
1. Turbidity mg/l	2.7	5	25	2
2. Color mg/l	Nil	5	50	50
3. pH	7.7	7.0-8.0	6.5-9.2	5.8-8.5
4. Electric conductivity μ℧/cm	750	-	-	-
5. Hardness mg/l	165	100	500	300
6. Alkalinity mg/l	55	80	400	-
7. Cl mg/l	128	200	600	200
8. Fe mg/l	-	0.7	0.8	0.8
9. Fe mg/l	Nil	0.1	1.0	0.3
10. Mn mg/l	-	-	-	0.3
11. Hg mg/l	-	-	-	0
12. Cu mg/l	-	-	-	1.0
13. Zn mg/l	-	-	-	1.0
14. Pb mg/l	-	-	-	0.1
15. As mg/l	-	-	-	0.05
16. Cd mg/l	-	-	-	-
17. Total Solid	460	500	1,000	500

5. Population To Be Served

The design population to be served is determined based on the existing conditions of the service system. There are 11,700 private connections; 7,590 in the east bank and 3,750 in the west bank. An average size of one family is 9 people. The design population is summarized as below;

Table 8 Population of Kassala Town

	East Bank	West Bank	Total
Total (including refugee)	112,000	53,000	165,000
Private Connection	72,000	34,000	106,000
Communal Taps	40,000	19,000	59,000

6. Water Consumption

Due to insufficient water sources of the both systems on the east and the west banks an average water consumption is 65 l/day/cap and 36 l/day/cap in the east bank and the west bank respectively.

The target daily consumption of the local town water supply for private connection is 75 l/day/cap - 100 l/day/cap in Sudan.

Daily water consumption rates of the similar countries are summarized in Table 9.

Table 9 Common Value of Daily Water Consumption (lit/day/cap)

	Privage Connection	Communal Tap
Developing countries	50-150	20-40
Kenya	75	25
Sri Lanka	180	45
Indonesia	100-125	40

Considering the similarity of environment and socio-economic conditions between Sudan and Kenya, the target of 75 l/day/cap of the water consumption in local town private connection appears to be quite reasonable and is applied for the design criteria of the project. As the design criteria for the daily water consumption at public taps, 25 l/day/cap, is proposed in the same reason.

7. Water Consumption for Public Purposes and Losses

Since Kassala Town is the Regional Capital there are many public institutions like government offices, schools and hospitals. The design criteria for the water consumption of public purposes is 1/3 of the total design capacity in Sudan. Considering the high rate of losses due to old asbestocement pipes used in the system, losses are estimated to be about 20% of the total design capacity. Therefore, remaining 13% out of 1/3 of the total design capacity is considered to be quite reasonable rate of the net public purpose water use considering the size of the town. Therefore the water consumption for public purposes and losses is determined to be 1/3 of the total design capacity.

8. Seasonal Variation of Water Demand

In Kassala Town water supply, the seasonal variation is determined to be 130% of an average consumption.

9. The Peak Hour Demand

The peak hour demand is one of the design basis to determine the design capacity of water supply facilities. For the water supply system of this size of capacity the ratio between an average demand and a peak hour demand is 1.5.

10. Water Demand

The water demands as the design basis are summarized in Table 10.

Table 10 Design Capacity of Kassala Water Supply

	East Bank	West Bank
Average Daily (1) Consumption	72,000 persons x 75 l/day/cap = 5,400 m^3 40,000 persons x 25 l/day/cap = 1,000 m3 Total 6,400 m^3	34,000 persons x 75 l/day/cap = 2,550 m^3 19,000 persons x 25 l/day/cap = 475 m^3 Total 3,000 m^3
Public Purpose (2) and Losses (1) x 0.33	6,400m^3 x 0.33 = 2,100m^3	3,000m^3 x 0.33 = 1,000m^3
Average Daily (3) Demand (1) + (2)	8,500 m^3	4,000 m^3
Max. Daily (4) Demand (3) x 1.3	11,050 m^3	5,200 m^3
Max. Hourly Demand (4) x 1.5	16,600 m^3/day = 692 m^3/hr = 5.3 m^3/min	7,800 m^3 = 315 m^3/hr 11.5 m^3/hr

The water distribution is designed based on the size of the service area;

East Bank Area 16,600m^3 1,400ha = 11.86m^2/ha
West Bank Area 7,800m^3 800ha = 9.75m^2/ha

11. Service Time

At present the water supply services are made for 24 hrs and the same service level will be maintained in the project.

12. Hydraulic Pressure

Since the existing hudraulic pressure is approximately 2.0 m. Considering friction losses of pipe network of the smallest diameter necessary hydraulic pressure in the service line network is estimated to be 5.0 m at the level of the pipe diameter of 100 mm.

13. Service Line Network

The service line network is already installed in Kassala Town water supply system. However, existing capacity of the pipes is insufficient to meet the demand with the target water consumption rates. Therefore, it is proposed to design the pipe line system to utilize the existing system as much as possible with installation of additional distribution mains to allow the proposed design capacity so as to maintain the hydraulic pressure in the existing pipe line network in the same level as present conditions to prevent leakage from existing asbestocement pipes due to increased hydraulic pressure.

For sure to prevent leakage in the existing asbesto cement pipes, additional pipelines are to be installed to form loops among terminal points to maintain an even hydraulic pressure. For this purpose polyvinyle chloride pipe is recommended because of its durability and the price.

14. Function of the Existing Facilities in the Proposed Design

The proposed design basis is to utilize existing facilities as much as possible in the basic design of the project.

These 10 boreholes on the east bank shall be used as they are at present. Five boreholes out of seven on the west bank are also to be used in the project.

The elevated tanks on the both bank sides will be discarded due to required hydraulic pressure in the proposed design.

The booster pump facility on the west bank will be used only for a supplementary function of the project.

The existing service line networks will be utilized in the proposed design as much as possible.

15. Future Extension

At resent, no significant future increase in water demand is expected and minor increase of future demand will be absorbed by addition of required units of facilities.

16. Storage Capacity

The design capacity of the storage capacity for distributing function is determined by two factors; the capacity of water sources and the design capacity of the whole system. Usually available water source is limited so that the storage capacity is determined to be the capacity equivalent to the daily maximum demand for 8 to 12 hrs with the design capacity of the daily maximum for the water source.

In Kassala Town, however, the design capacity of the storage tank is equivalent to the hourly maximum demand for 3 hrs. Therefore, the storage capacity tends to be small compared with the whole design capacity of the system. For this reason it is proposed to take the hourly maximum demand for the design capacity of the water source since sufficient underground water is available.

Advantage of this design consideration is to minimize construction costs of the reservoir in the project and to be able to reserve allowance in the design capacity of water sources for future extension of the water supply system by providing additional storage capacity. Accordingly, the proposed design capacities of the storage tanks are determined as shown below included additional $500m^3$ to the storage capacity of the west bank system.

East Bank System	$16,600m^3$	24 x 3	= $2,000m^3$
West Bank System	$7,800m^3$	24 x 3 + 500	= $1,500m^3$

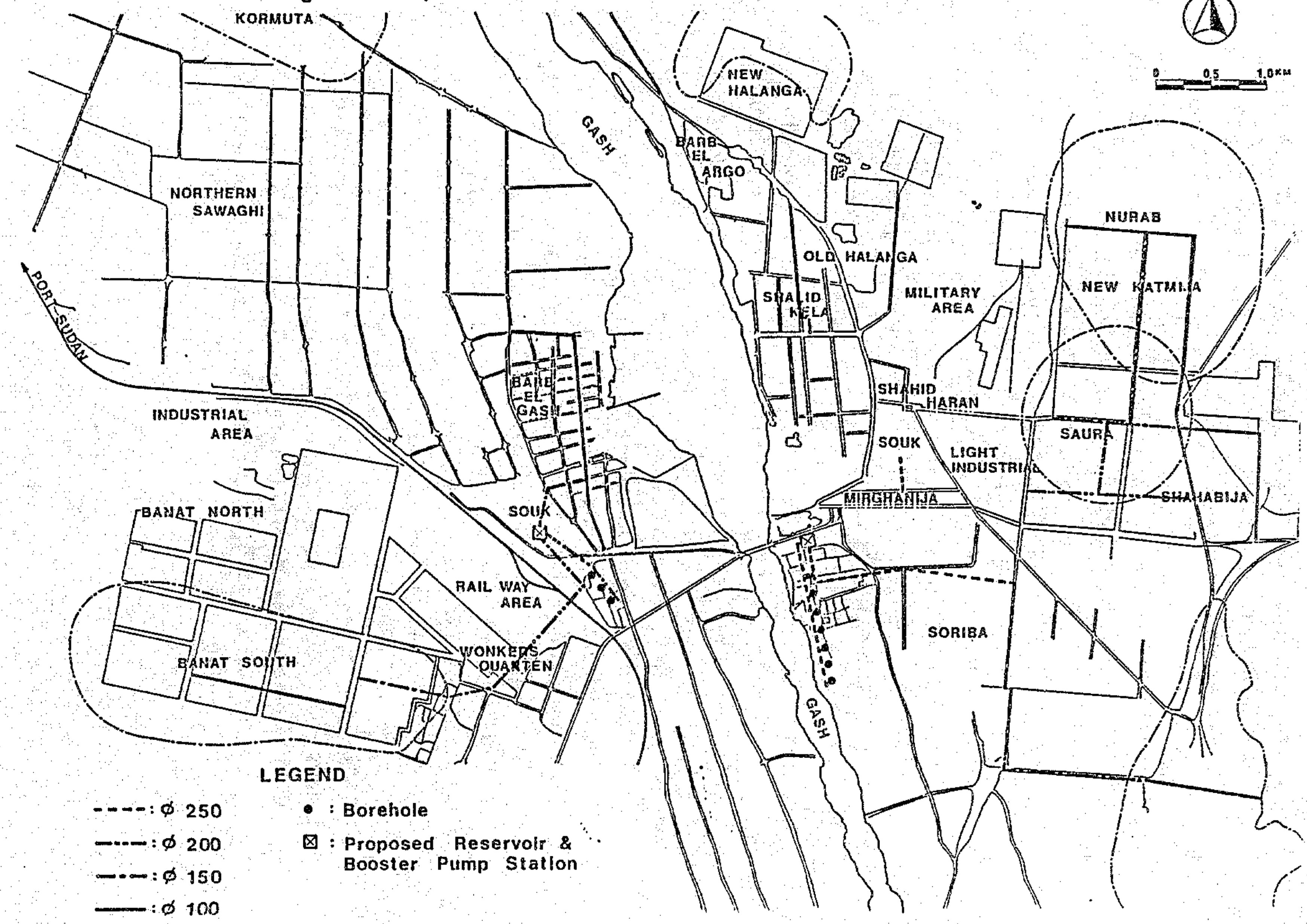
17. Service System

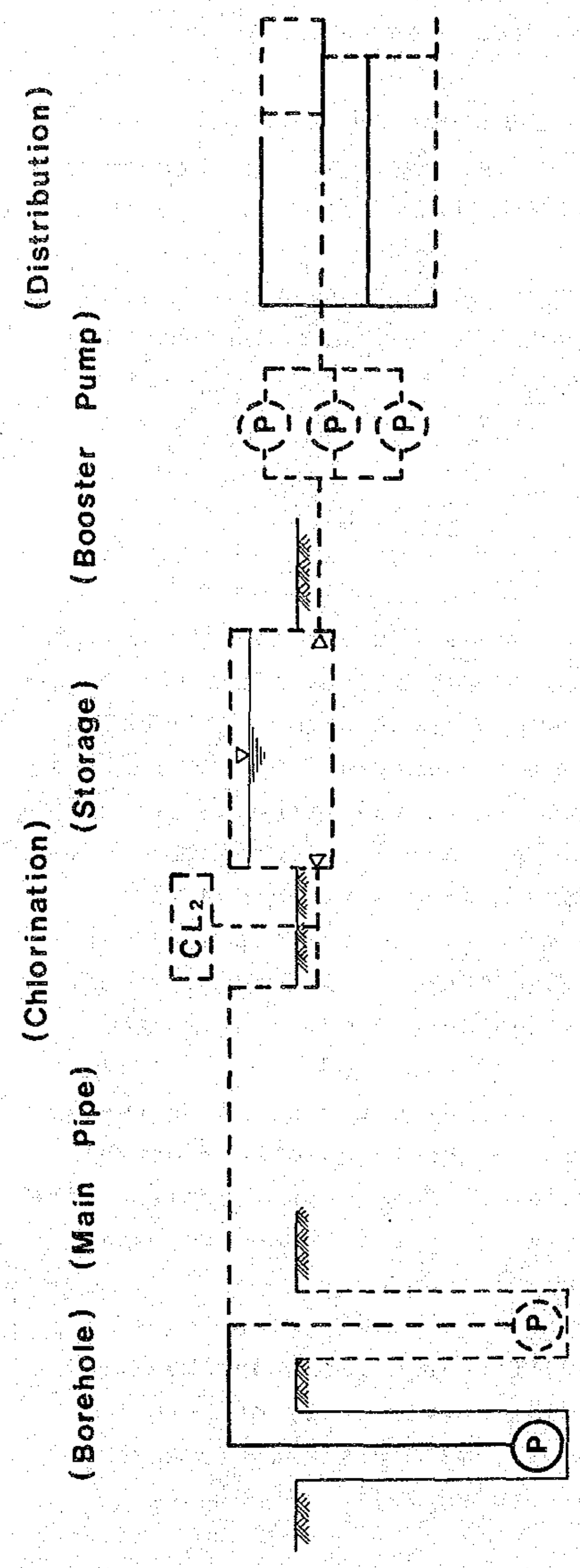
The water supply systems on the both bank sides are independent. In the both systems a booster pump station is provided. The design basis of each facility is the hourly maximum demand (Fig. 25 and Fig. 26).

18. Metering System

There are 11,700 water meters installed at private connections, however most of them are out of order which results in difficulty in collection of water charge. No additional meters are to be provided in the project.

Fig. 25 Proposed Additional Facilities of Kassala Town





Exsisting	Proposed	Total
East Bank 57.4Km	19.0Km	76.4Km
West Bank 15.5Km	8.0Km	23.4Km
East Bank Non	One 11.5m^3/min	One 11.5m^3/min
West Bank Non	One 2.7m^3/min	One 2.7m^3/min
East Bank 150m^3	2,000m^3	2,000m^3
WEST Bank 75m^3	1,500m^3	1,500m^3
East Bank abandoned	5	5 2,076gr/hr
West Bank abandoned	3	3 945gr/hr
East Bank 412m^3／hr	280m^3／hr	692m^3／hr
West Bank 193m^3／hr	120m^3／hr	313m^3／hr

Fig. 26 Water Supply System of Kassala

19. Supply of Electricity

The power supply at Kassala Town is made by 4 generators at 4,000 kW capacity. Power source of the town water supply is obtained from the same source.

Since there often occurs power supply failure it is proposed to provide the stand by generator for the Kassala Water Supply System.

4.3 Description of the Project

4.3.1 Village Water Supply

It is requested by the Government to construct 42 village water supply facilities and to rehabilitate 165 boreholes of existing village water supply facilities. All these sites requested require urgent measures. Of these sites, 34 village water supply facilities and 73 rehabilitation of existing boreholes are proposed in the project due to various reasons. The water shortage problems will be solved at 107 sites. Accordingly the remaining 100 sites which are not proposed in the project will be provided for an urgent measures by the Government.

For construction of new boreholes a few drilling team will be required considering urgency and extent of the distribution of sites of the project. For rehabilitation of existing boreholes also a few service machine teams will be required by the same reasons.

At present there are 19 drilling equipment in the NWC, however, they have to provide services all over the nation. It is, therefore very much unlikely to save drilling equipment for the project.

By all reasons above it is proposed to provide a few sets of drilling equipment and also a few sets of service machine for rehabilitation. For this reason sufficient technology transfer will be required for drilling and rehabilitation of boreholes. This is advantageous in two aspects. The number of the proposed sites is not small. Therefore providing necessary technology transfer through construction of new village water supply facilities and rehabilitation of existing boreholes, the remaining work of the project will be able to be completed by the Sudanese counter parts. Even after completion of the project there are 100 sites where urgently require water in the region. For this purpose the equipment and crew with sufficient technology to be provided by the project can serve the solution of the wter problem.

There are two major type of aquifers in the area; the alluvial deposits and the Nubian Sandstones. Therefore construction of 10 boreholes in each type of aquifer will be sufficient to make necessary technology transfer of drilling. For rehabilitation of existing boreholes, different conditions are expected in each borehole. For this reason the rehabilitation of 30 to 40 numbers of existing boreholes will be required to make sufficient technology transfer.

The technology transfer is to be given to the staff from the NWC which holds sufficient numbers of staff for the project.

These equipment to be provided by the project will be transferred to the NWC after completion of the project.

Under the project, the village water supply includes following two items;

1. Construction of Village Water Supply facilities: 34 places

2. Rehabilitation of Boreholes of Existing Village Water Supply Facilities: 73 places

Above two items include water supply schemes at refugee camps as summarized below;

	Site Name	No. of Boreholes
New Village Water Supply	Wad El Hellow	2
	Wad Sheref	2
	Helet Hcoma	1
	Wad Kole	2
	Um Ali	1
Rehabilitation of Boreholes	Um Gargour	2
	Karkorer	2
	Wad El Helow	3
	Wad Sharef	4
	El Suki	2
	Tawewa	2

The rural population to be served by these schemes is estimated to be 210,000 people including refugees.

4.3.2 Kassala Town Water Supply

Rehabilitation of the Kassala Town water supply facilities includes construction of civil works and pipe laying for distribution main, as summarized below;

1. Boreholes : 10 holes
2. Submersible Motor Pumps : 10 units
3. Storage Tank, 2,000 m^3 and 1,500 m^3 : one each

4. Chlorination Facilities : 8 units
5. Booster Pump Stations : 2 places
6. Distribution Main : 27 km

For drilling boreholes, the equipment to be provided for the village water supply facility will be utilized. Further details of the drilling equipment is discussed in 5.5 Equipment in Chapter 5 BASIC DESIGN.

A significant extent of the problematic area in the Town results in problems of the water revenue of Kassala UWA, however, this situation will be much improved by the project.

4.3.3 Operation and Maintenance

Responsibility for operation and maintenance of the village water supply falls on the branch office of NWC at Kassala. On the other hand, UWA at Kassala is responsible for operation maintenance of the Kassala Town Water Supply.

CHAPTER 5 BASIC DESIGN

CHAPTER 5
BASIC DESIGN

5.1 Basic Considerations for Design

Since this is an urgent project, easy implementation with the reasonable design is required. The standards and criteria officially used in Sudan are to be applied unless there found any difficulties.

In addition, existing climatic conditions and transportation are another importance for determination of the work schedule.

5.2 Village Water Supply

5.2.1 Introduction

The project includes 34 new village water supply facilities and 74 rehabilitation of existing boreholes. For this purpose the standard specifications are applied for the Basic Design. For the Detail Design further determination of specifications will be required. The proposed village water supply system is shown in drawing No. 7.

5.2.2 Standard Design for New Boreholes

1. Boreholes (Drawing No. 1)

   The standard specification of the borehole depth is proposed to be 180m since this depth is an average depth of boreholes in the project. The finish diameter of the borehole is proposed to be 6 5/8 inches which is the most common diameter of the existing boreholes aiming at easiness of construction and high exchangeability of material and machinery. Accordingly drilling diameter is required in 9 5/8 inches.

The length of screens is 10% of total depth of the borehole on an average referring to the existing borehole design.

Construction of new boreholes are required for 34 sites and the standard design of the proposed borehole is shown in the drawing No. 1.

2. Pump and Engine (Drawing No. 2)

There are three types of pumps for boreholes;

1) Submersible Motor Pump
2) Reciprocal Pump
3) Vertical Turbine Pump

Considering availability of power source and operation and maintenance requirements submersible motor pump shall be discarded in the project. Vertical turbine pumps are commonly used in a wide areas over the East African countries. Boreholes recently constructed at refugee camps in Sudan are also equipped with this type of pumps. However, there used to be installed reciprocal pumps at older boreholes in the Eastern Region. In order to determine the type of pumps to be used under the project comparison between the vertical pump and the reciprocal pumps is made as below;

Comparison	Reciprocal Pump	Vertical Turbine Pump
Efficiency		higher
Installation	same	same
Durability	same	same
Maintenance	easier	
Cost	much higher	
Running cost		lower

Although reciprocal pumps are installed on the old boreholes in the project sites, vertical turbine pumps are common in boreholes recently constructed and are familiar to the local people. In addition the advantage of vertical pumps are the high efficiency and the small price. Therefore the vertical turbine pumps are applied for the project. A standard capacity of Q=180 l/min and H=100m is applied for this basic design since almost of 60% of required pump capacity of the project sites falls on the range of this capacity.

The standard specifications of the pump and engine are summarized as below;

1) Pumps
   Q = 180 l/min
   H = 100 m
   HP = 11 HP
   ∅ = 142 mm — 34 units

2) Engines:
   Vertical, Water Cooling Four cycles
   HP = 15 HP, 1,800 rpm — 34 units

3) Pipes and Accessories — 34 sets

3. Pump House (Drawing No. 3)
Prefabrication Type — 34 units

4. Storage Tanks (Drawing No. 4)

The standard specification of the NWC is applied;

FRP Panel type
$Q = 50\ m^2$

Prefabricated Steel Holder; 3 m
Dimension; 5m x 5m x 2m — 34 units

5. Pipings (Drawing No. 5) — 34 units

6. Public Taps, Q = 1 lit/sec. — 34 sets

7. Fences, 50m x 75m (Drawing Nos. 8 & 9) — 34 units

5.2.3 Standard Design of Existing Boreholes

The same standard designs as new village water supply boreholes, and pump and engine are proposed.

1) Pumps — 73 units
2) Engines — 73 units
3) Piping Connection — 73 units

5.3 Rehabilitation of Kassala Town Water Supply

5.3.1 Water Source

The standard design of the boreholes for Kassala Town water source is shown in the drawing No. 1 and No. 2.

1. Design Capacity

The design basis is the hourly maximum demand; 16,600 m^3/day for the east bank system and 7,5000 m^3/day for the west bank system. Therefore, it is determined as below;

East Bank System; 16,600m^3/day   24 hrs
= 1,038m^3/hr

West Bank System; 7,500m^3/day   24 hrs
= 469m^3/hr

2. Number of Boreholes

The safe yield of boreholes at the aquifer of alluvial deposits of the Gash River is estimated to be 40 m^3/hr. Therefore the required number of boreholes is determined as below;

East Bank System; 692m^3/hr   40m^3/hr = 17
West Bank System; 313m^3/hr   40m^3/hr = 8

Considering the number of existing boreholes the number of additionally required boreholes is determined as below;

East Bank System; Existing 10 holes + New 7 holes
West Bank System; Existing 5 holes + New 3 holes

3. Depth of Boreholes

Referring to the depth of existing boreholes at Kassala Town it is proposed to be 50 m.

4. Diameter of Boreholes

The diameter of boreholes is proposed to be 250 mm (10 inches) considering the capacity of aquifer and the size of pump.

5. Length of Strainer

The required length of the strainer is obtained by the following formula;

$$L = \frac{Q}{A \times N \times V}$$

where,

A: area of aquifer facing to strainer; m^2

N: opening ratio of strainer; %

V: critical velcity; m/sec

and,

$A = 2 r = 2 \times 3.14 \times 0.125 = 0.875 m^2$

$N = 15\%$

$V = 1.5 cm/sec = 54 m/hr$

Therefore, L is determined to be 8m and the length of strainer is proposed to be 10m.

6. Location of Boreholes

Location of boreholes is on the banks of the Gash River.

7. Drilling Diameter

Considering necessary spacing allowance for casing, the drilling diameter is proposed to be 450 mm.

8. Pumps

Considering availability of the power source and the efficiency of pumps, the submersible motor pump is proposed:

$Q = 40\ m^3/hr$
$H = 60\ m$
$\phi = 150\ mm$
$P = 22\ kW$ 10 units

5.3.2 Chlorination

The hypochlorous potadium acid is recommended for chlorination considering existing type of equipment. Required capacity is 3ppm injection to maintain more than 0.4ppm residual chlorine for the hourly maximum demand;

East Bank System; $692m^3/hr$ x 3ppm = 2,076kg/hr
500gr/hr x 5 units
West Bank System; $315m^3/hr$ x 3ppm = 945kg/hr
500gr/hr x 3 units

5.3.3 Storage Tanks

The basic designs of the proposed storage tanks are shown in the drawing No. 6.

Required capacities of the storage tanks are;

East Bank System; $2,000m^2$
West Bank System; $1,500m^2$

The reinforced concrete structure is proposed in the dimension below;

East Bank System; 3m x 29m x 3m
West Bank System; 3m x 18m x 3m

5.3.4 Distribution Mains

Asbesto cement pipes are installed in the existing pipe network, however polyvinyl chloride pipes are recommended for additional pipes considering the durability, workability and costs. Proposed piping network is summarized as below;

Proposed Piping Network

	East Bank			West Bank		
Diameter	Existing	Proposed	Total	Existing	Proposed	Total
10"	5.4km	3.5km	8.9km	-	-	-
8"	-	3.0km	3.0km	1.0km	2.5km	3.5km
6"	18.2km	6.1km	24.3km	6.1km	1.9km	8.0km
4"	33.8km	6.4km	40.2km	8.3km	3.6km	11.9km
Total	57.4km	19.0km	76.4km	15.4km	8.0km	23.4km

The piping density will be much improved by the proposed additional pipe lengths of 27 km (Fig. 27).

5.3.5 Booster Pump Station

Design basis of the booster pump station is the hourly maximum demand.

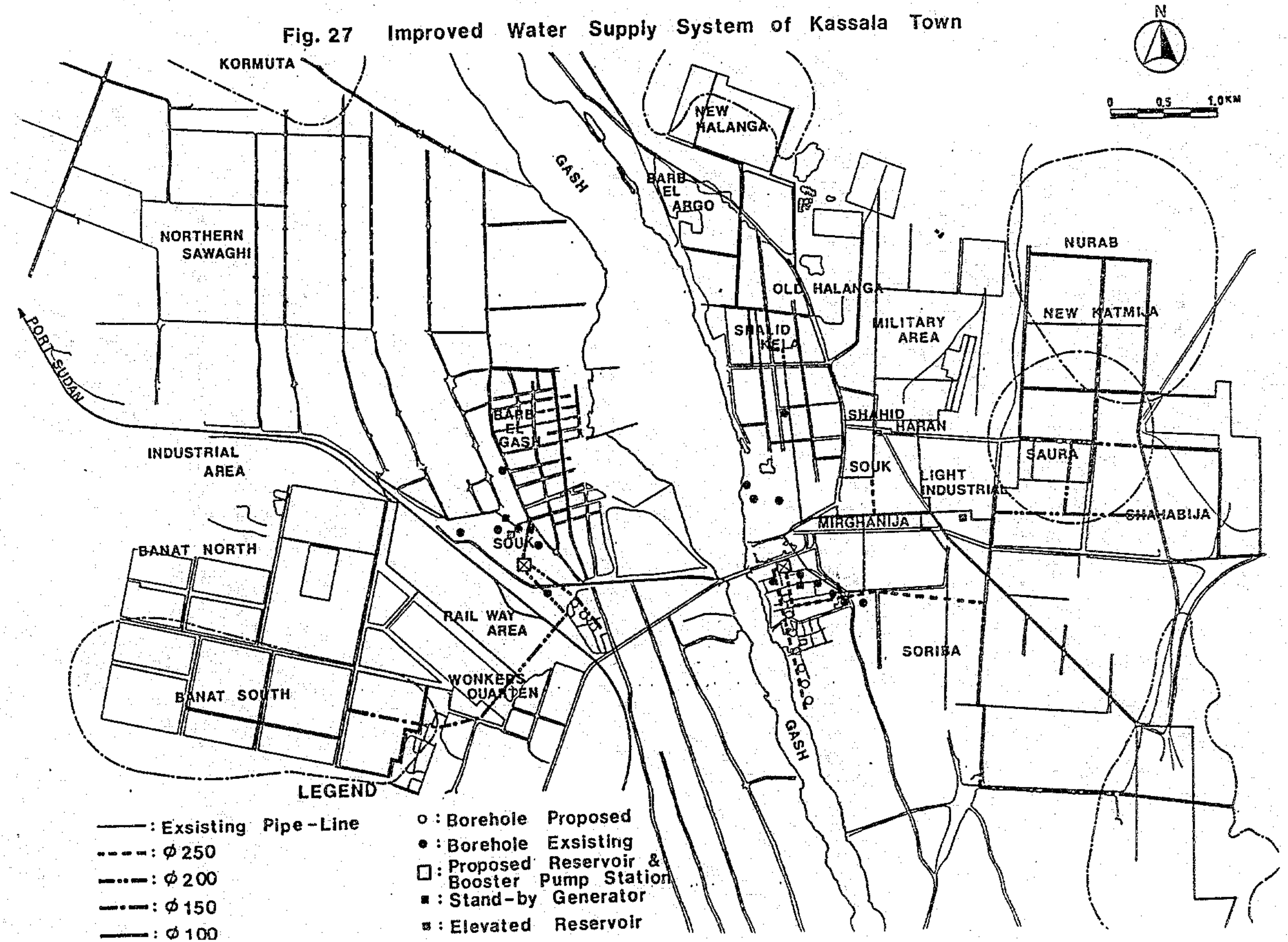
East Bank System; $5.8m^3$/min x 3 units
West Bank System; $2.7m^3$/min x 3 units

Specifications of pumps are proposed as below;

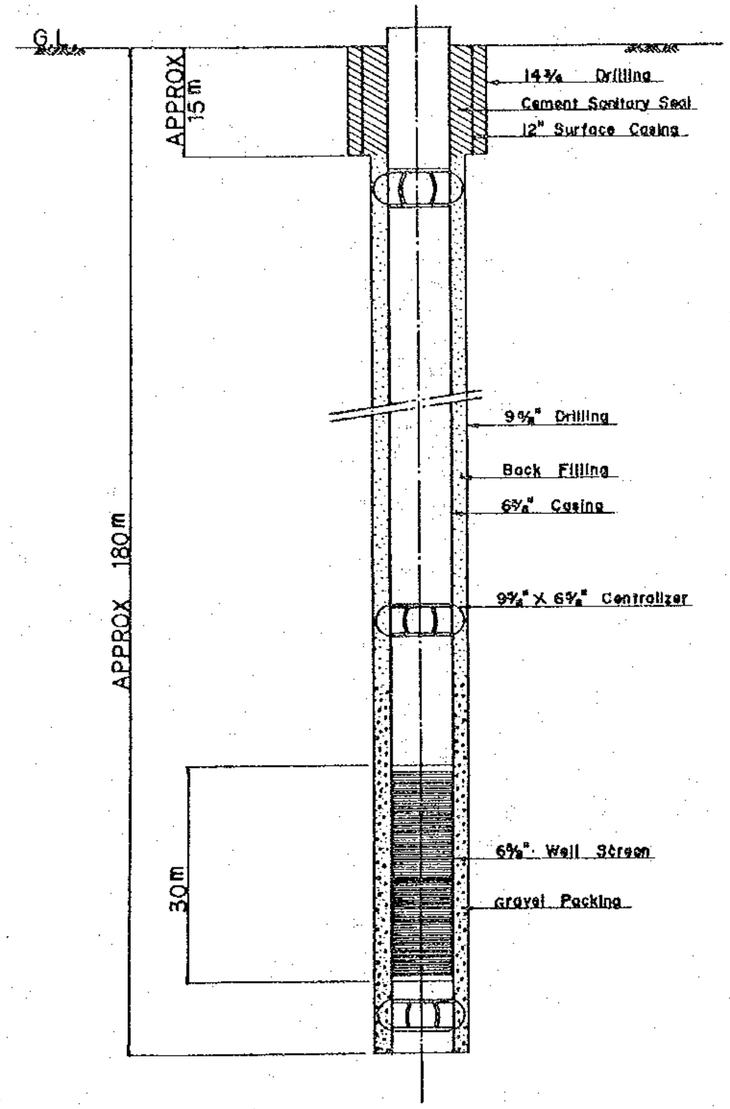
	East Bank	West Bank
Type;	Volute Pump	Volute Pump
Diameter;	ø 300mm	ø 200mm
Head;	40m	40m
Power;	75kW	30kW
Number	3 units	3 units

The Basic Design of the booster pump station is shown in the drawing No. 7.

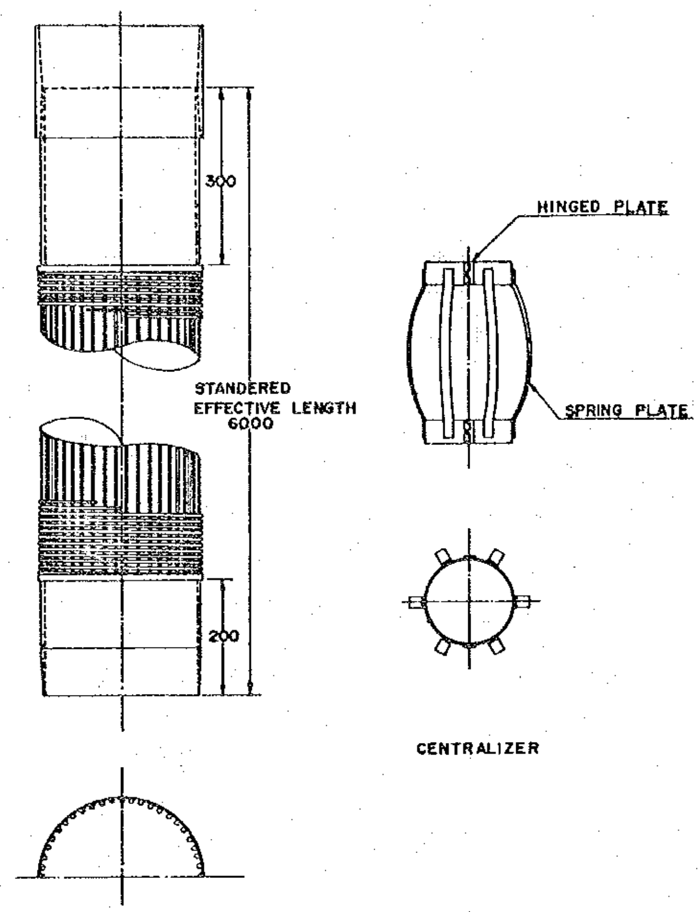
Fig. 27 Improved Water Supply System of Kassala Town



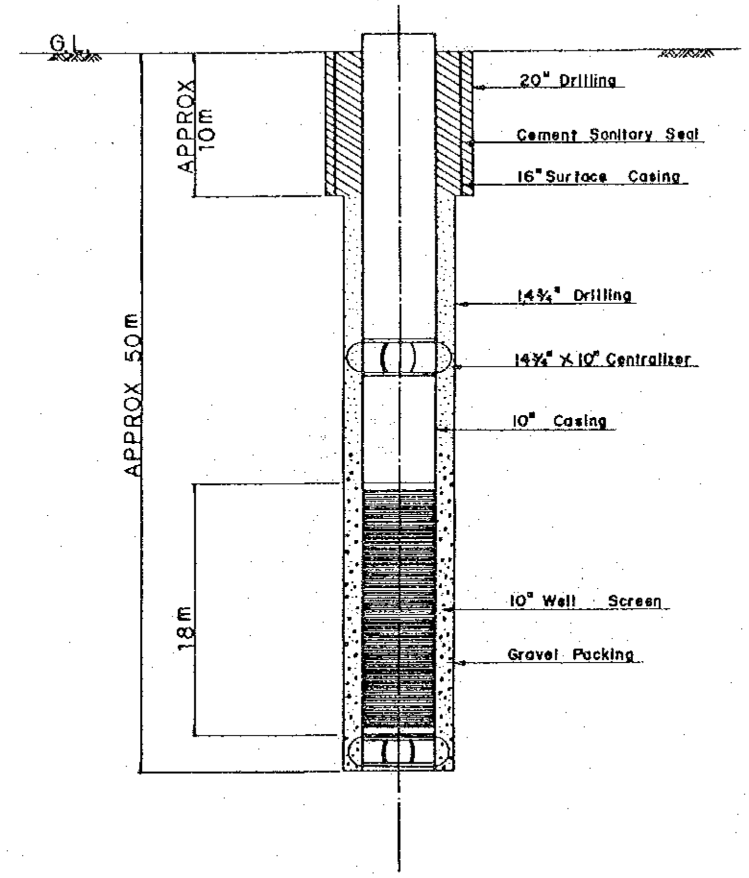
NEW-DRILLING WELLS



CONTINUOUS V-SLOT WELL SCREEN

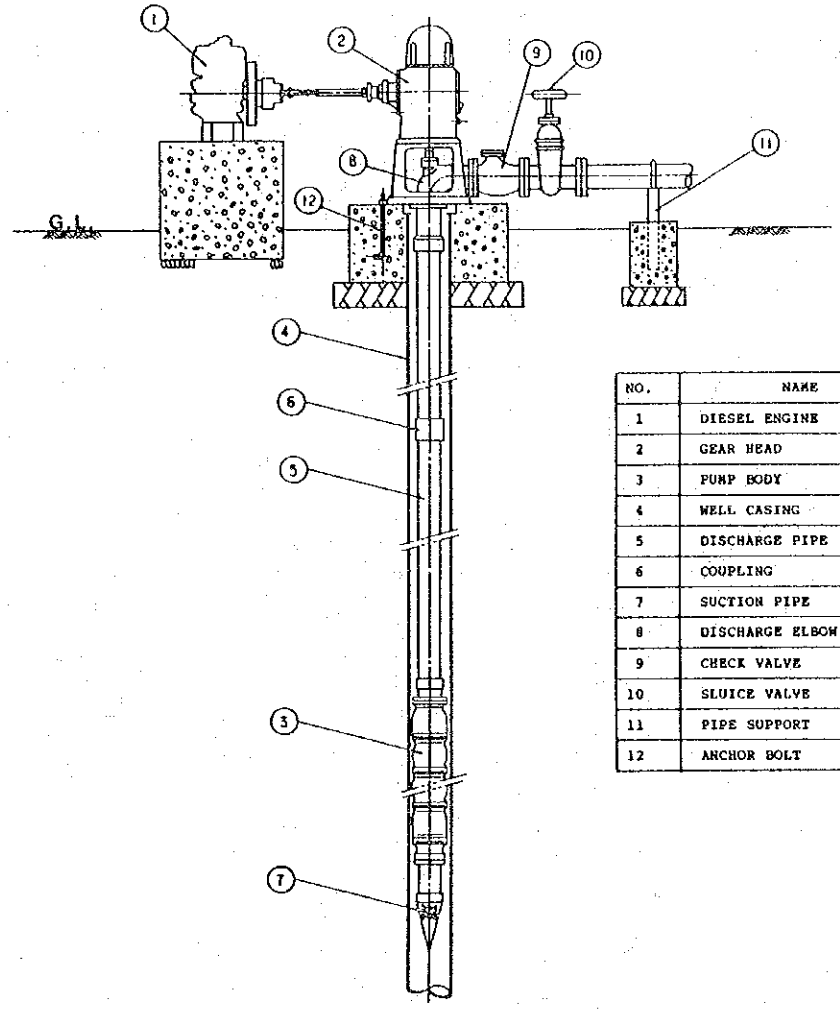


NEW-DRILLING WELLS FOR KASSALA



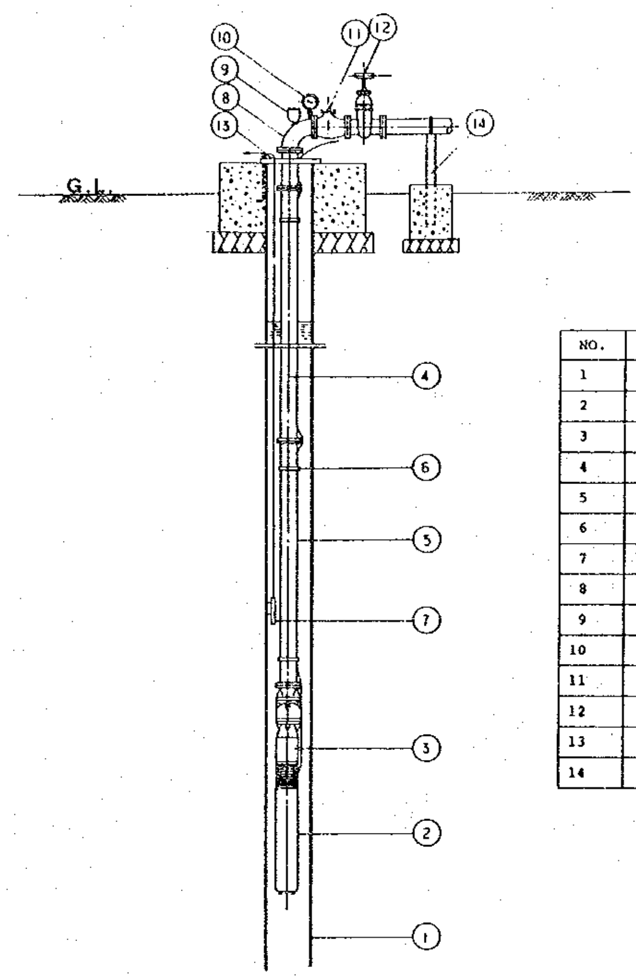
REPUBLIC OF THE SUDAN COMMISSIONER FOR REFUGEES (COR) MINISTRY OF INTERIO AFFAIRS		
WATER SUPPLY PROJECT RELATED TO ICARA II		
STANDARD DESIGN OF BOREHOLE		
DATE FEB. '86	SCALE NON-SCALE	DWG. No. 1
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)		

INSTALLATION OF VERTICAL TURBINE PUMP



NO.	NAME
1	DIESEL ENGINE
2	GEAR HEAD
3	PUMP BODY
4	WELL CASING
5	DISCHARGE PIPE
6	COUPLING
7	SUCTION PIPE
8	DISCHARGE ELBOW
9	CHECK VALVE
10	SLUICE VALVE
11	PIPE SUPPORT
12	ANCHOR BOLT

INSTALLATION OF SUBMERSIBLE PUMP



NO.	NAME
1	WELL CASING
2	SUBMERSIBLE MOTOR
3	PUMP BODY
4	DISCHARGE PIPE
5	SUBMERSIBLE CABLE
6	CABLE CLIP
7	WATER LEVEL ELECTRODE
8	90° BEND PIPE
9	AUTO AIR VALVE
10	PRESSURE GAUGE
11	CHECK VALVE
12	SLUICE VALVE
13	WELL COVER
14	PIPE SUPPORT

REPUBLIC OF THE SUDAN
COMMISSIONER FOR REFUGEES (COR)
MINISTRY OF INTERIO AFFAIRS

WATER SUPPLY PROJECT RELATED TO ICARA II

STANDARD DESIGN OF PUMP AND ENGINE

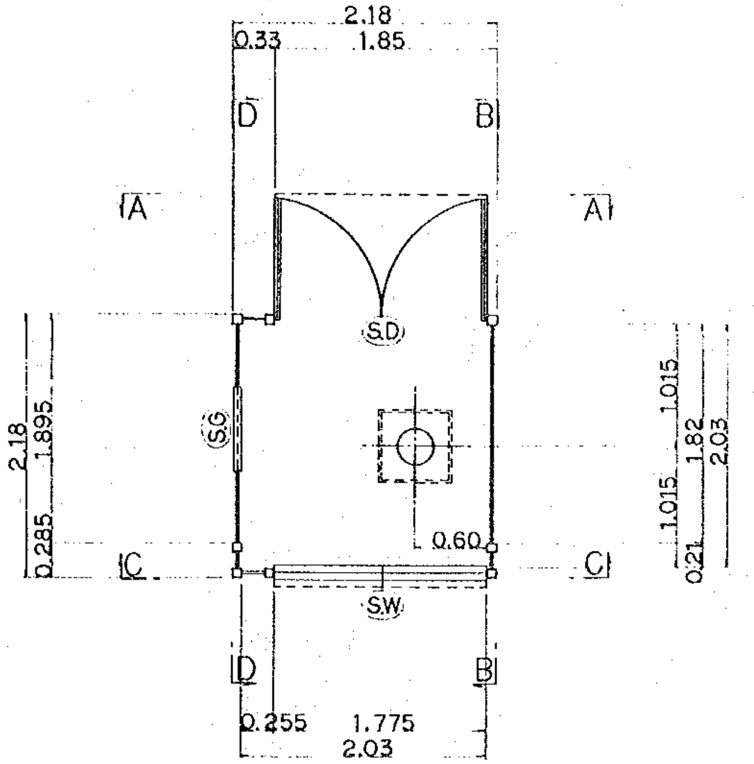
DATE FEB. '86	SCALE NON-SCALE	DWG. No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

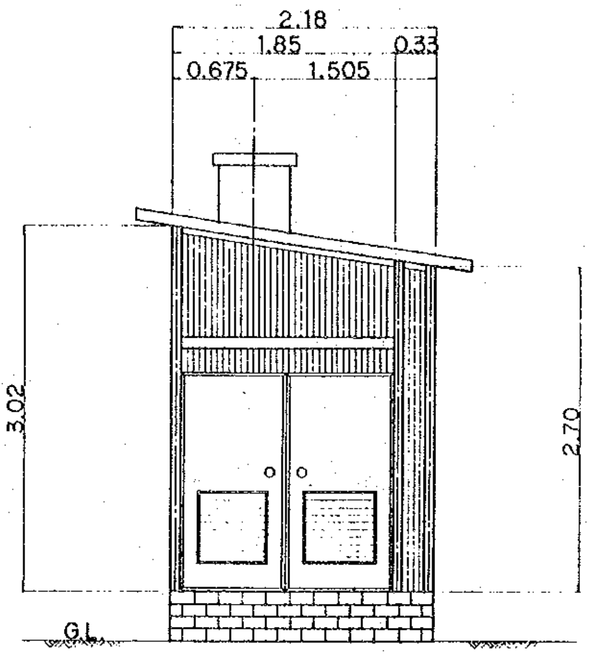
PUMP HOUSE

SCALE 1 : 30

PLAN



SECTION A – A



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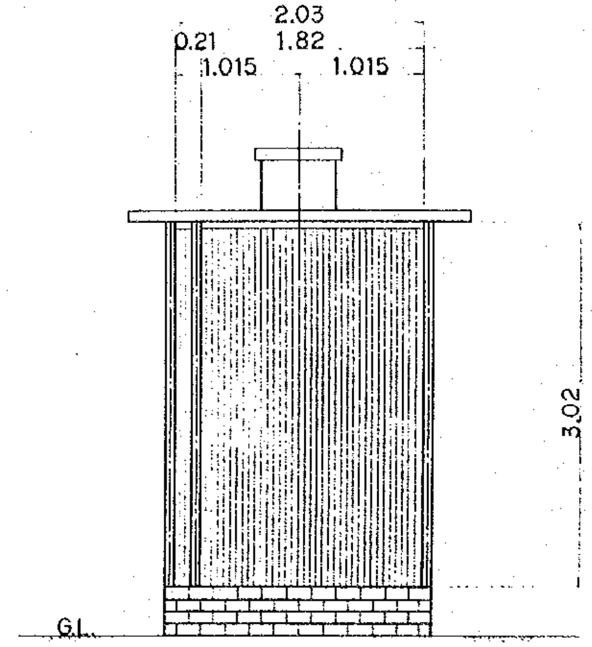

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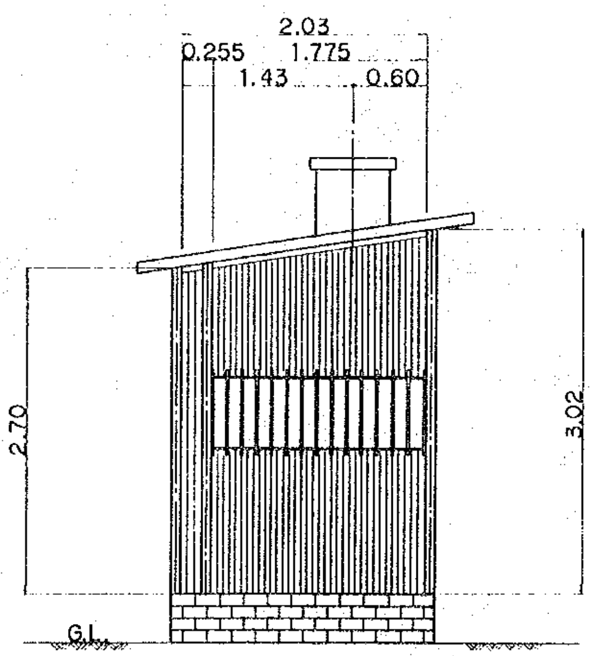

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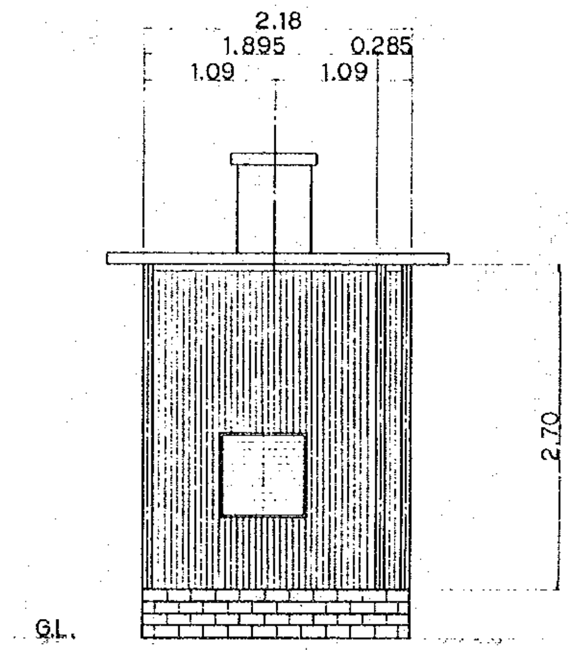
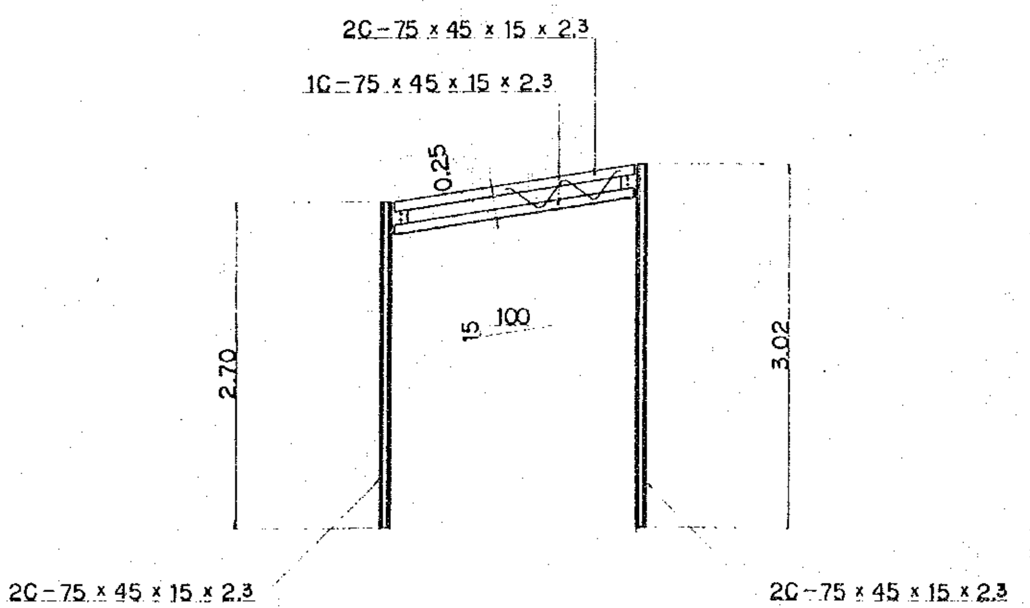
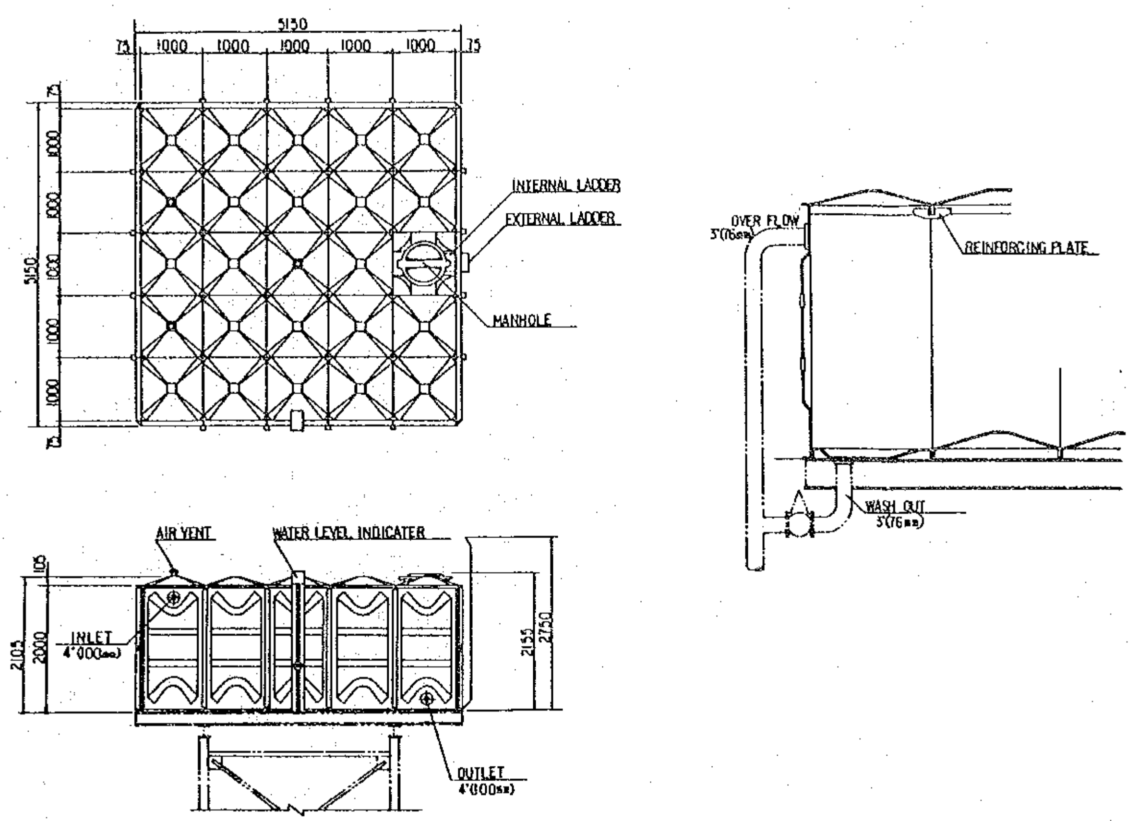


RECTANGULAR

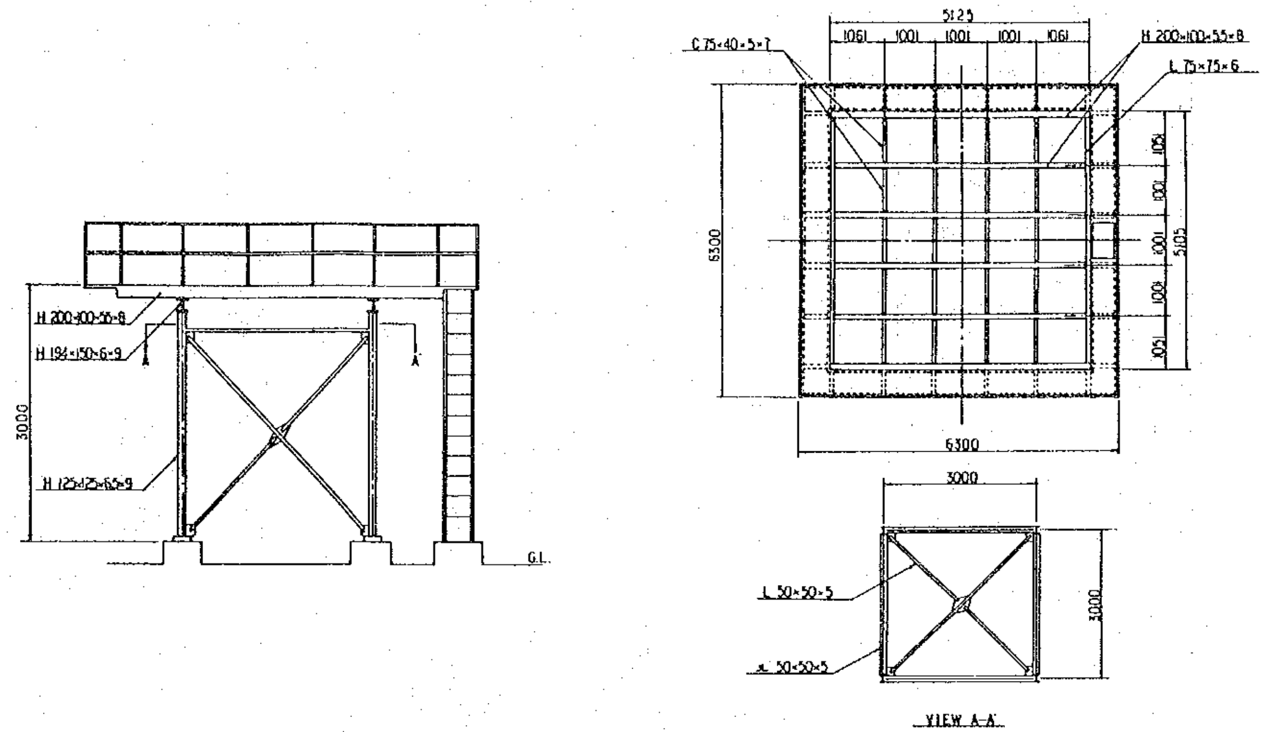


REPUBLIC OF THE SUDAN COMMISSIONER FOR REFUGEES (COR) MINISTRY OF INTERIOR AFFAIRS
WATER SUPPLY PROJECT RELATED TO ICARA II
STANDARD DESIGN OF PUMP HOUSE
DATE FEB. '86 / SCALE 1 : 30 / DWG. No. 3
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

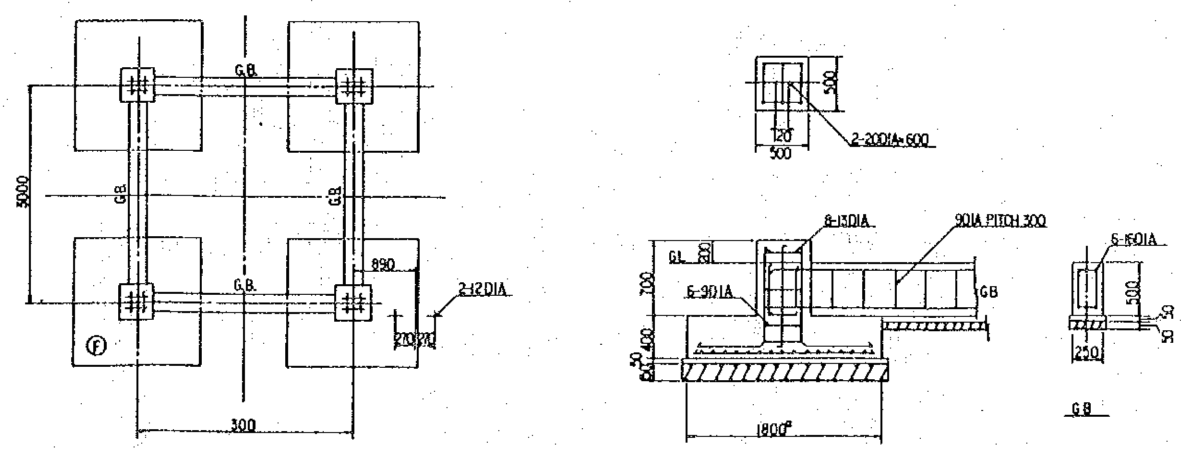
PANEL TYPE WATER TANK 50M3



SUPPORTING TOWER FOR 50M3 WATER TANK



CONCRETE FOUNDATION FOR 50M3 WATER TANK



REPUBLIC OF THE SUDAN
COMMISSIONER FOR REFUGEES (COR)
MINISTRY OF INTERIOR AFFAIRS

WATER SUPPLY PROJECT RELATED TO ICARA II

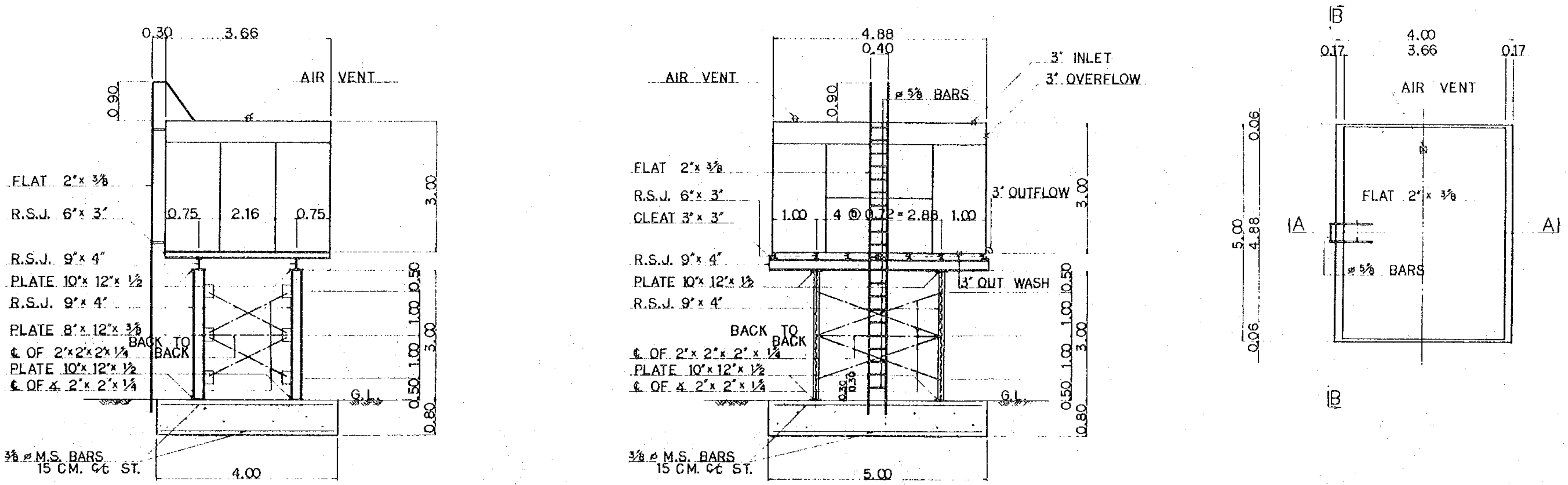
STANDARD DESIGN OF ELEVATED TANK

DATE FEB. '86 | SCALE NON-SCALE | DWG. No. 4

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

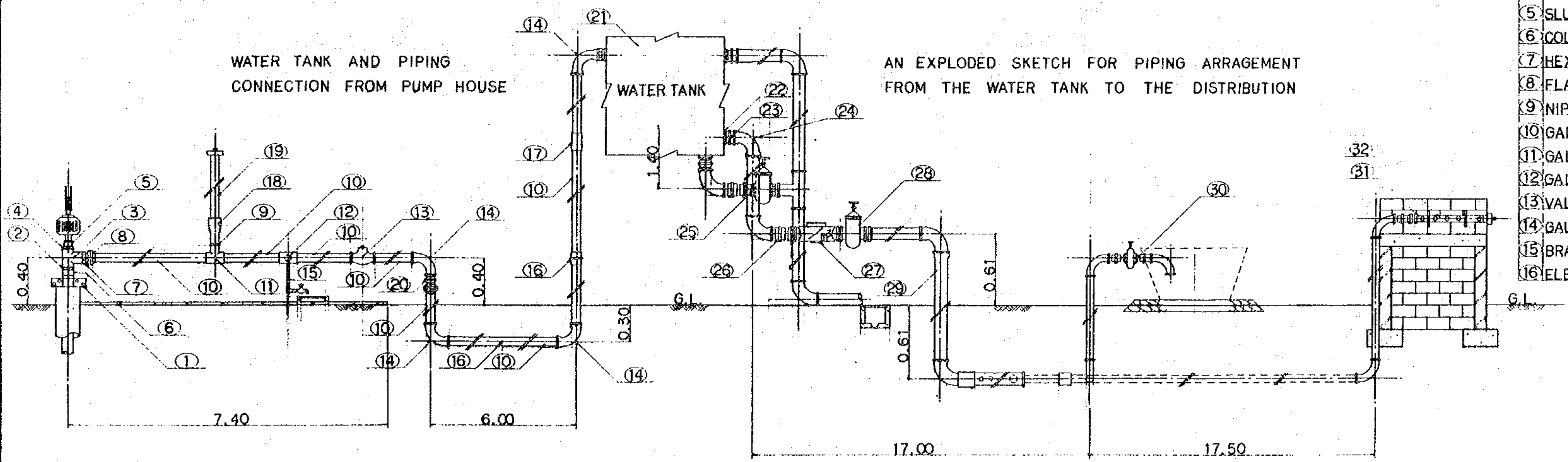
INDICATIVE DRAWING

SCALE 1:50



SECTION OF PIPING

SCALE 1:20



1	COLUMN PIPE CLAMP 4"	17	GALU. SOCKET 3"
2	HEXAGONAL NIPPLE 4"	18	REDUCING SOCKET 4"x3"
3	GALU. TEE 4"	19	HEXAGONAL NIPPLE 3"
4	REDUCING BUSH 4"x3"	20	NIPPLE 3"
5	SLUTTING BOX 3"	21	WATER TANK
6	COLUMN PIPE 4"	22	NIPPLE 4"
7	HEXAGONAL NIPPLE 3"	23	FLANGE 4"
8	FLANGE 3"	24	BEND 4"
9	NIPPLE 3"	25	GALU. PIPE 4"
10	GALU. PIPE 3"	26	NIPPLE 4"
11	GALU. TEE 3"x 3"	27	WATER METER 4"x 3"
12	GALU. TEE 3"x 2"	28	VALVE 4"
13	VALVE 3"	29	PIPE 4"
14	GALU. BEND 3"	30	NIPPLE 2"
15	BRASS BIPCOCK 1"	31	TEE 2"x 1"
16	ELBOW 3"	32	GALU. PIPE 2"

REPUBLIC OF THE SUDAN
COMMISSIONER FOR REFUGEES (COR)
MINISTRY OF INTERIOR AFFAIRS

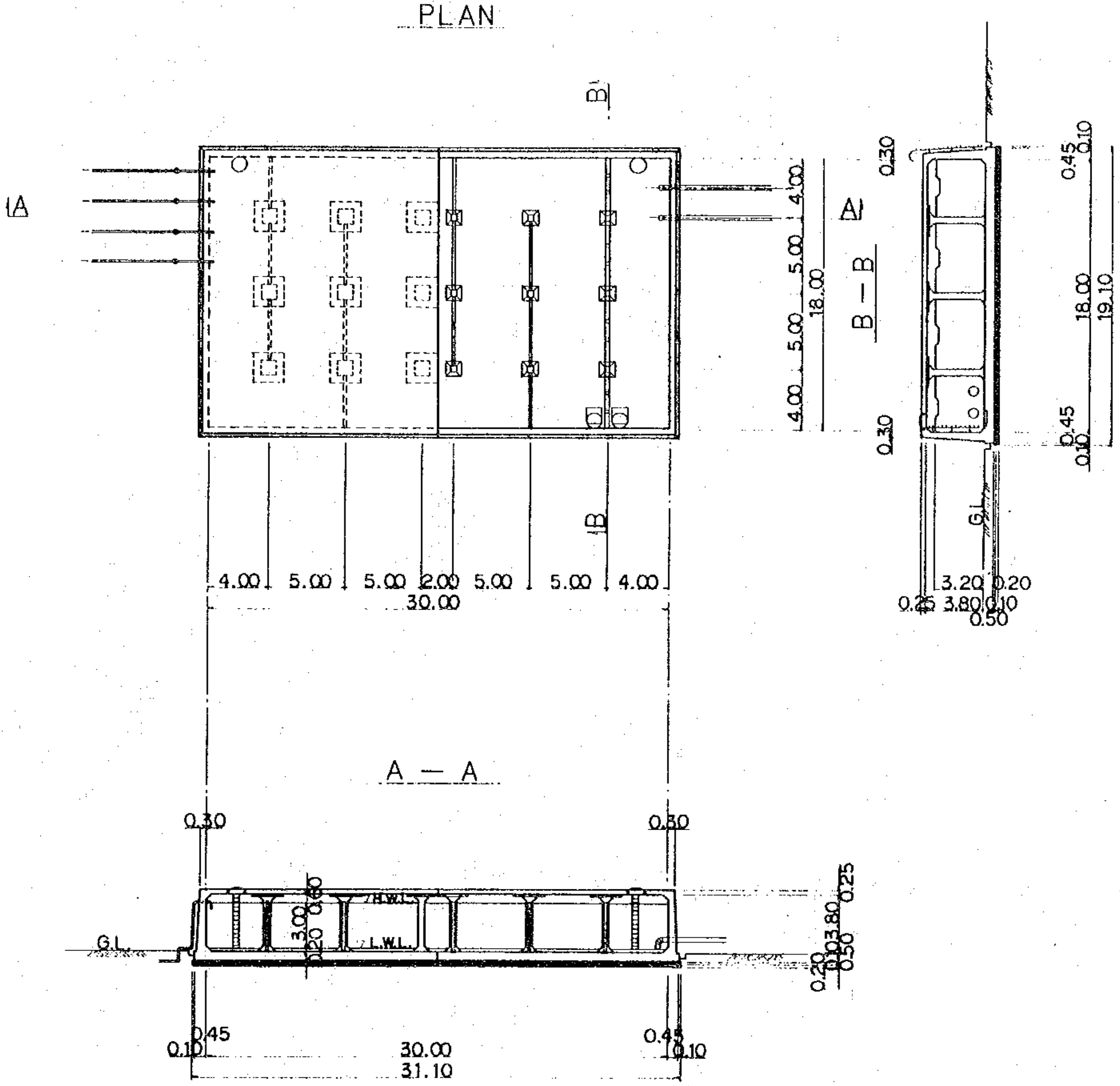
WATER SUPPLY PROJECT RELATED TO ICARA II

INDICATIVE DRAWING OF ELEVATED TANK

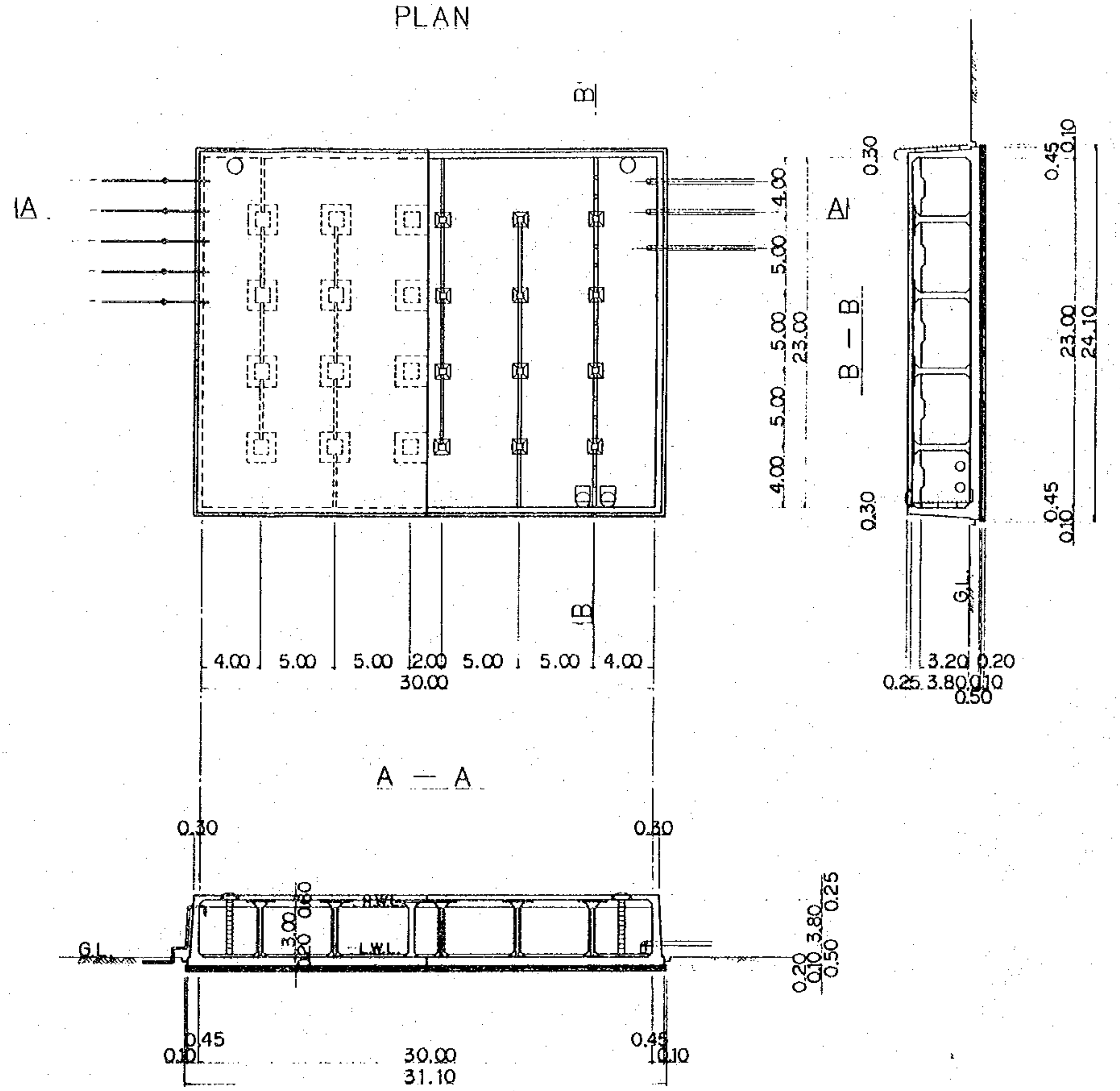
DATE	SCALE	DWG No.
FEB. '86	1:50, 1:20	5

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

1 500 m^3 WATER RESERVOIR SCALE 1:200



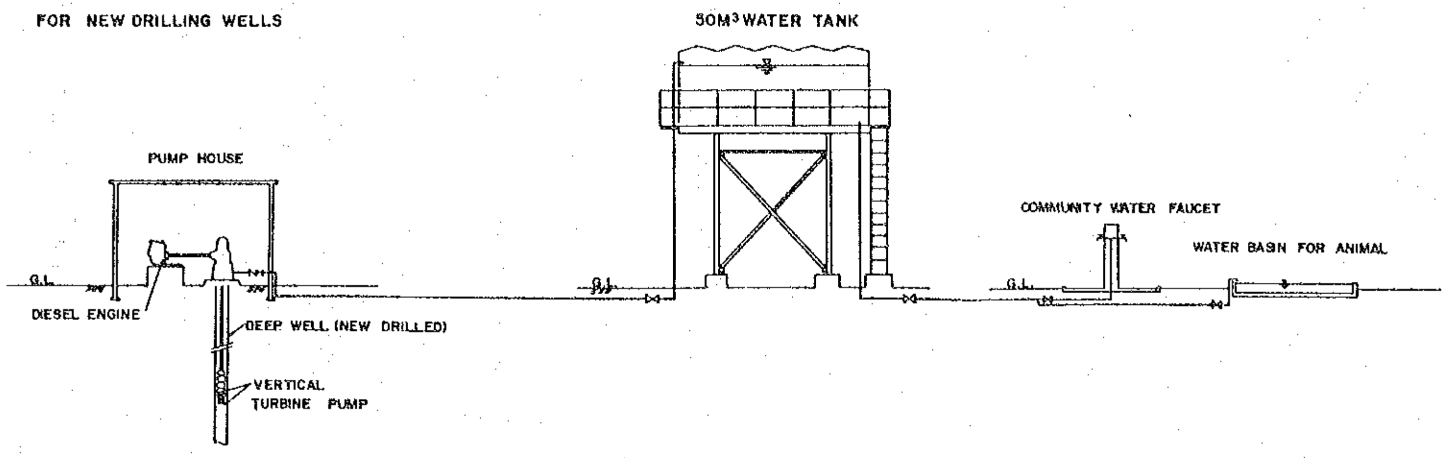
2 000 m^3 WATER RESERVOIR SCALE 1:200



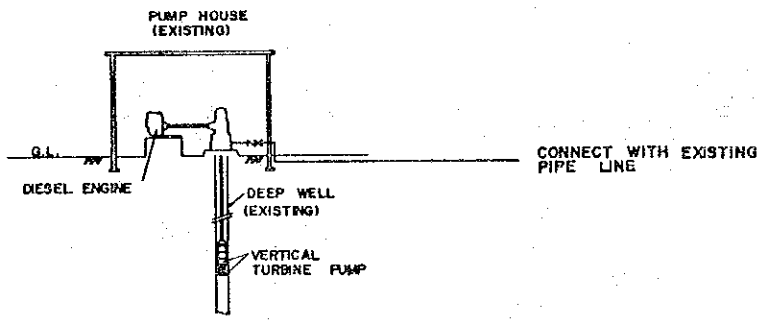
REPUBLIC OF THE SUDAN COMMISSIONER FOR REFUGEES (COR) MINISTRY OF INTERIOR AFFAIRS		
WATER SUPPLY PROJECT RELATED TO ICARA II		
BASIC DESIGN OF STORAGE TANK		
DATE FEB. '86	SCALE 1:200	DWG. No. 6
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)		

TYPICAL DIAGRAM OF WATER SUPPLY SYSTEM

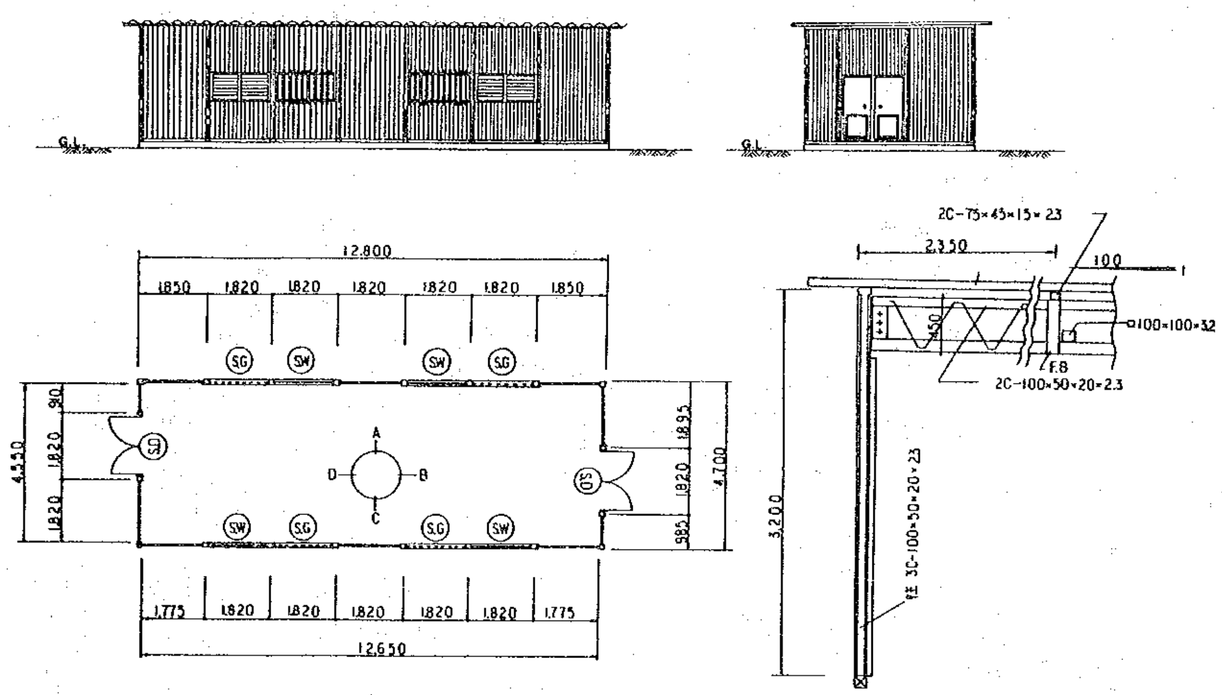
FOR NEW DRILLING WELLS



FOR REHABILITATING WELLS

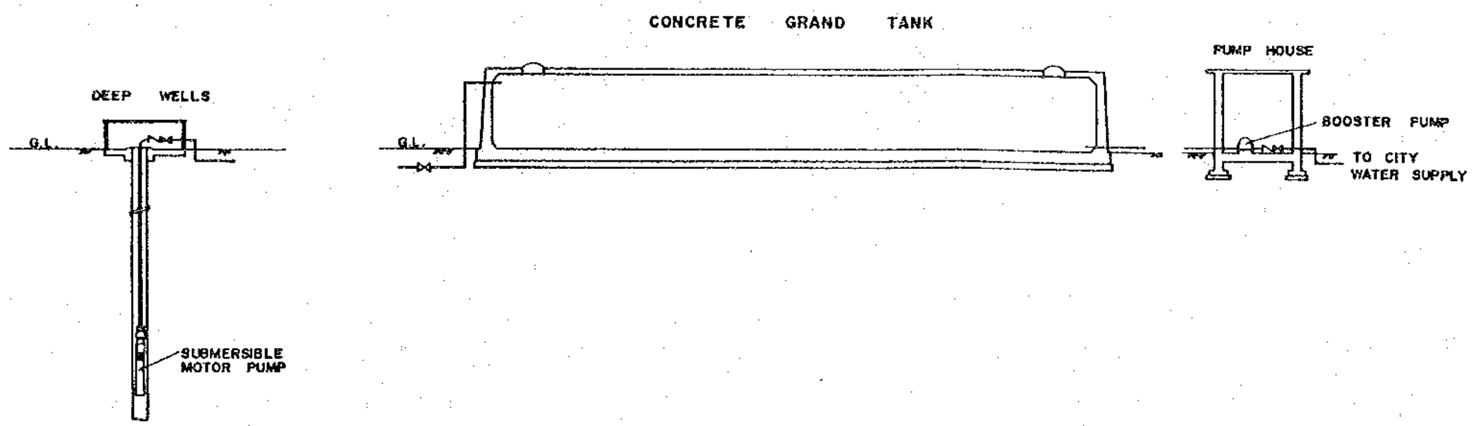


PUMP HOUSE FOR BOOSTER PUMP



TYPICAL DIAGRAM OF WATER SUPPLY SYSTEM

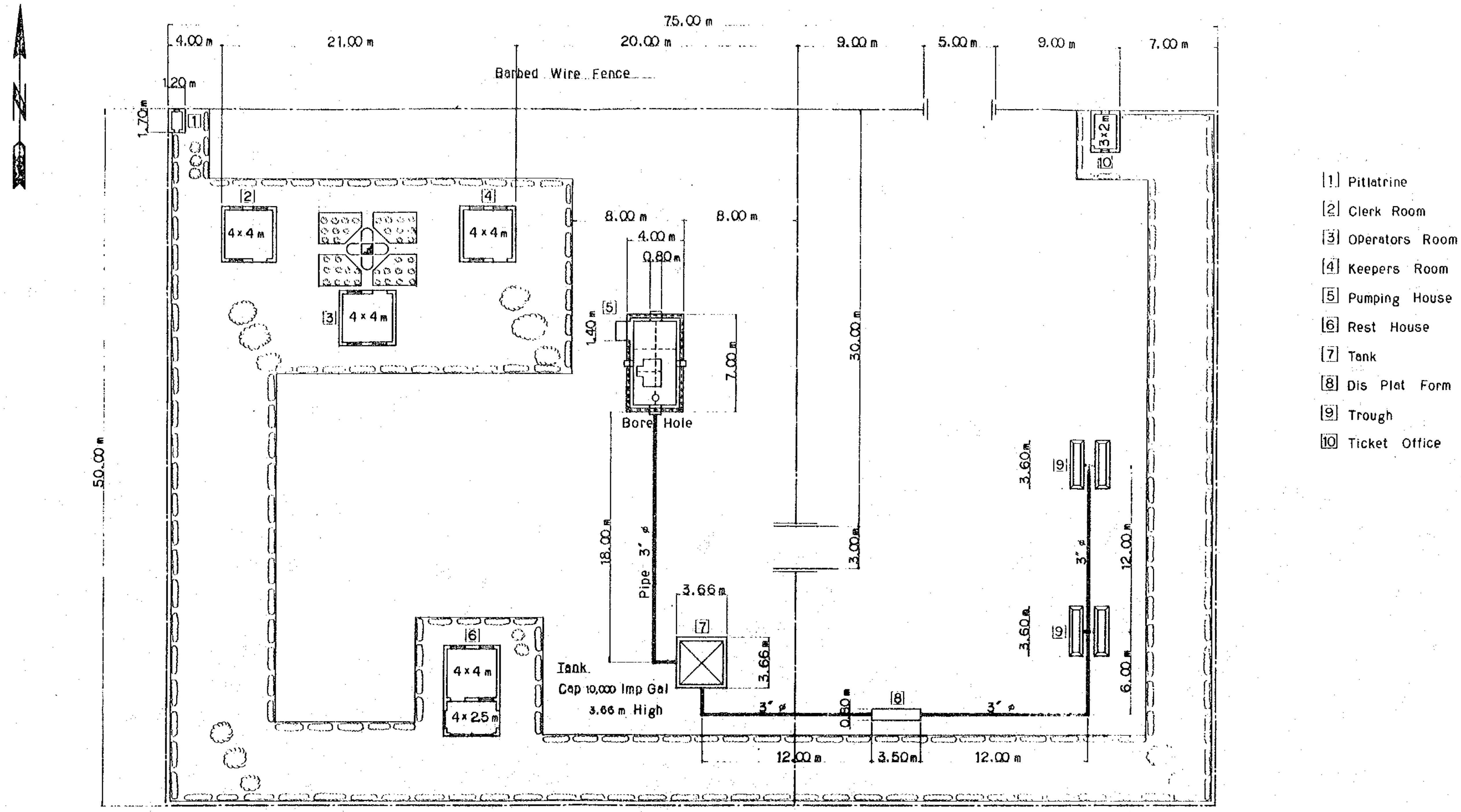
(FOR KASSALA CITY)



REPUBLIC OF THE SUDAN COMMISSIONER FOR REFUGEES (COR) MINISTRY OF INTERIO AFFAIRS		
WATER SUPPLY PROJECT RELATED TO ICARA II		
BOOSTER PUMP AND TYIPICAL DIAGRAM OF WATER SUPPLY SYSTEM		
DATE FEB, '86	SCALE NON - SCALE	DWG. No. 7
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)		

TYPE — A

SCALE 1:150



REPUBLIC OF THE SUDAN
COMMISSIONER FOR REFUGEES (COR)
MINISTRY OF INTERIO AFFAIRS

WATER SUPPLY PROJECT RELATED TO ICARA II

STANDARD DESIGN OF FENCE (A)

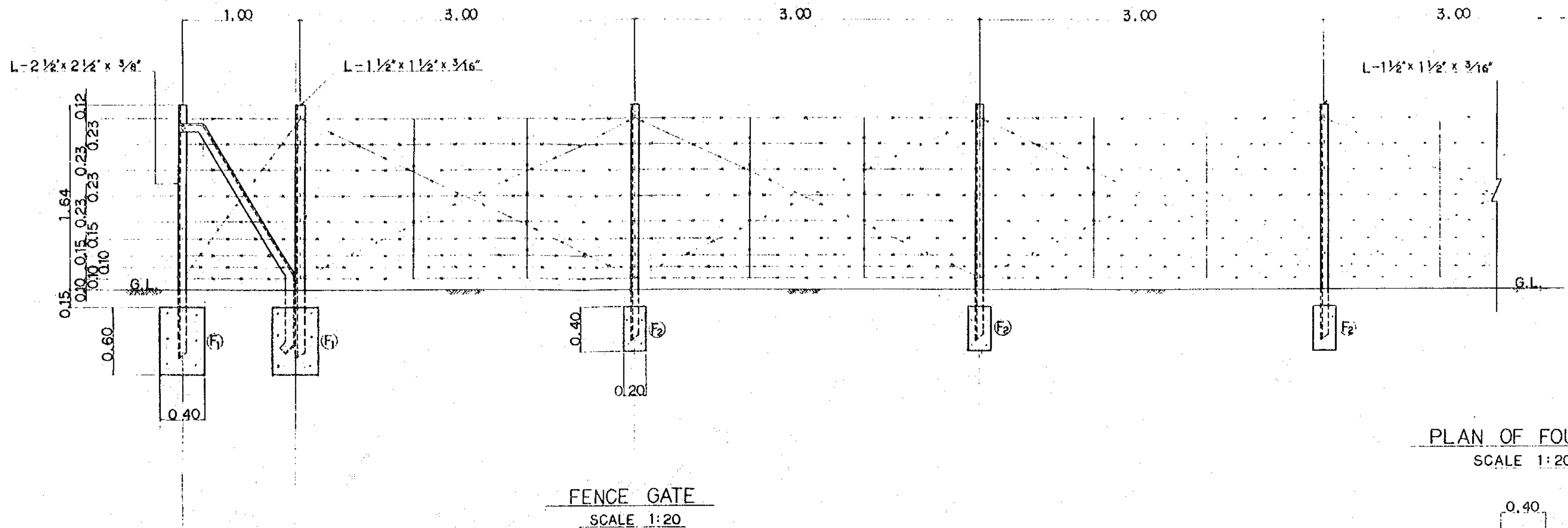
DATE	SCALE	DWG. No.
FEB. '86	1:150	8

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

WATER YARD FENCE

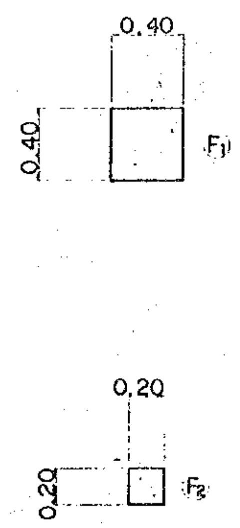
SCALE 1:20

TYPE - A



PLAN OF FOUNDATION

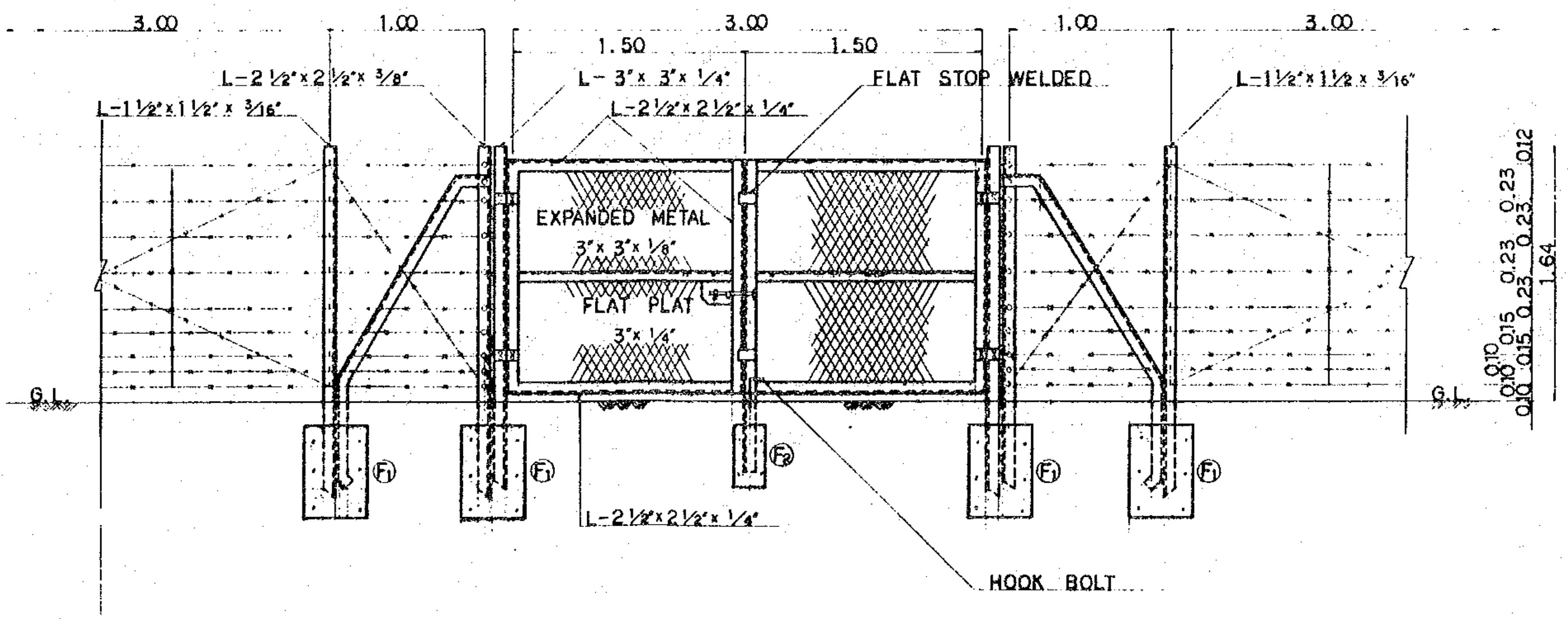
SCALE 1:20



FENCE GATE

SCALE 1:20

TYPE - A



REPUBLIC OF THE SUDAN

COMMISSIONER FOR REFUGEES (COR)
MINISTRY OF INTERIO AFFAIRS

WATER SUPPLY PROJECT RELATED TO ICARA II

STANDARD DESIGN OF FENCE (B)

DATE FEB. '86	SCALE 1:20	DWG. No. 9

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

5.4 Summary of Proposed Material

Different kinds of equipment, machinery and material are required for the project. Of these items proposed machinery and materials are summarized as below;

I. New Village Water Supply Facilities: 34 sites

Item	Specifications	Unit	Quantity
1. Material for New Boreholes: 34 sites			
1) Casing and Screen			
(1) Casing	12" x 5.5m	pcs	102
(2) Casing	6 5/8" x 6m	pcs	850
(3) Screen	6 5/8" x 6m	pcs	170
(4) Centralizer	6 5/8" x 9 5/8"	pcs	408
2) Mud Material			
(1) Bentnite		ton	100
(2) Chemicals		kg	1,000
3) Bits			
(1) Tricon Bit	14 3/4" S	pcs	17
(2) Tricon Bit	9 5/8"	pcs	17
(3) Tricon Bit	9 5/8" S	pcs	17
(4) Air Hammer Bit	9 5/8"	pcs	17
2. Related Facilities (34 holes)			
1) Vertical Turbine Pump	180lit/n x 100m	set	34
2) Spare Parts		set	34
3) Material for Pump House		set	34
4) Elevated Tank	$50m^3$, 3mH	set	34
5) Pipe Material		set	34

II. Rehabilitation of Existing Boreholes

Item	Specification	Units	Quantity
1. Material and Machinery (73 holes)			
1) Vertical Turbine Pump	180 lit/m x 100m	set	73
2) Spare Parts		set	73
3) Pipe Material	set	73	
2. Rehabilitation Chemical (73 holes)			
1) Well Cleaner	22,000	kg	1,100

III. Rehabilitationof Kassala Water Supply

Item	Specifications	Unit	Quantity
1. Water Source Machinery			
1) Submersible Motor Pump			
(1) Pump	40 m^3/h x 60m	set	10
(2) Spare Parts		set	10
2) Casing and Screen			
(1) Casing	16" x 5.5m	pcs	20
(2) Casing	10: x 5.5m	pcs	60
(3) Screen	10" x 6.0m	set	30
(4) Centralizer	10" x 14 3/4"	set	33
3) Bentnite		ton	15
4) Bits			
(1) Tricon Bit	20" S	pcs	2
(2) Tricon Bit	14 3/4" MH	pcs	5
(3) Tricon Bit	14 3/4" S	pcs	5
2. Storage Tank and Booster Pump Station			
1) Storage Tank			
(1) Generator	30 kVA	unit	10
(2) Spare Parts		set	10
(3) Pipe Material	ϕ125mm x 5.5m	pcs	1,820
(4) Accessory		pcs	1
(5) Piping Connection		pcs	2
2) Booster Pump			
(1) Pump House		unit	2
(2) Pumps	350m^3/h x 40m	set	3
(3) Spare Parts		set	3
(4) Pumps	150m^3/h x 40m	set	3
(5) Spare Parts		set	3

Item	Specifications	Unit	Quantity
3) Chlorination Equipment	500/h	set	8
4) Pipe and Valves			
(1) Pipes	ϕ100A x 50m	pcs	2,000
(2) Pipes	ϕ150A	pcs	1,600
(3) Pipes	ϕ200A	pcs	1,100
(4) Pipes	ϕ250A	pcs	700
(5) Stopper	100A	pcs	34
(6) Stopper	150A	pcs	27
(7) Stopper	200A	pcs	19
(8) Stopper	250A	pcs	12
(9) Air Valves	25mm	pcs	28
(10) Joints		set	1

5.5 Equipment

5.5.1 Introduction

It is proposed to provide equipment for drilling and rehabilitation of boreholes which will be utilized for further underground water development in the Region even after completion of the project.

For determination of the specification and the quantity of these eqipment, considerations were given to various aspects of the project; the guideline of the Grant Aid Cooperation, urgency of the project, necessary technology transfer, work volume required for the project and existing conditions in Sudan.

5.5.2 Equipment for Construction of New Boreholes

Drilling equipment has to be a complete unit of all necessary items including camping facility, pump test equipment and well logging apparatus.

For selection of the drilling equipment, type of aquifer and required depth and available construction period have to be taken into account.

Major types of aquifers in the project area are alluvial deposits and the Nubian Sandstone. Most of sites distribute in the area of the Nubian Sandstone and drilling depth required is 180m. Considering these conditions and urgency of the project it is proposed to provide for the rotary type drilling machine with the air hammer. The proposed specifications for the drilling equipment are summarized as below;

Type:	Track mounted rotary machine
Capacity:	4 1/2 inch x 250 m
Method:	Mud circulation and Air Hammer
Mast Load:	More than 40 ton
Mud Pump:	1,500 l/min, 20 kg/cm^2
Truck:	6 x 6
Spare Parts:	One set

Considering required period of purchasing the drilling equipment and duration of the rainy season, it takes approximately two years for the project period. The first year is for procurement of the drilling equipment and the dry season in the second year is for construction.

There are three factors to determine the required number of the drilling equipment; the drilling capacity of the equipment, the available time for the project and the necessary work volume to complete necessary technology transfer.

Since the major types of aquifers in the project area are alluvial deposits and Nubian Sandstones, construction of ten boreholes in each aquifer will be sufficient to transfer necessary technology to complete the remaining construction of 24 boreholes by Sudanese counterparts.

The necessary period for construction of one borehole is estimated considering the drilling capacity of the proposed equipment and the nature of aquifer;

Alluvial deposits; 23 days for 50m
Nubian Sandstones; 39 days for 180m

Assuming working days in a month are 25 days discarding Friday, total duration required for drilling is determined as below;

$$\frac{39\ \text{days}}{25\ \text{days}} \times 10\ \text{holes} + \frac{23\ \text{days}}{25\ \text{days}} \times 10\ \text{holes} = 24.8\ \text{months}$$

On the other hand, the available time for construction during the dry season is 8 months. Therefore, required units of the drilling equipment is determined as below;

$$\frac{24.8\ \text{months}}{8\ \text{months}} = 3.1\ \text{units}$$

Therefore it is proposed to provide 3 units of the drilling equipment.

5.5.3 Equipment for Rehabilitation of Existing Boreholes

The same considerations to determine the required number of the drilling equipment units are necessary to determine the number of the rehabilitation equipment. However,rehabilitation of existing borehole requires different kinds work depending on the required nature of rehabilitation. For this reason it is proposed to rehabilitate 36 holes for technology transfer.

Considering required work volume for rehabilitation of boreholes, 13 days will be required for rehabilitation of one borehole on an average.

Available time for rehabilitation is the same duration of construction of new boreholes; 8 months. Therefore, required number of rehabilitation equipment is determined as below;

$$\frac{13\ \text{days}}{25\ \text{days}} \times 36\ \text{holes} \div 8\ \text{months} = 2.3\ \text{units}$$

Therefore it is proposed to provide 2 units of rehabilitation equipment. The proposed specifications for rehabilitation equipment are summarized as below;

Type	:	Truck Mounted Cable Tool	
Main Drum	:	Single Line	5 ton
		Capacity	19mm x 240m
		Rope Speed	Max. 50 m/min
Sand Reel	:		25 ton
Mast Height	:		9 - 10 m
Mast Load	:		25 ton
Water Pump	:		500 l/min, 22 kg/cm^2
Truck :			4 x 4
Spare Parts	:		One set

5.5.4 Other Equipment

Since the construction work will be made by 6 working groups vehicles and communication facilities will be required. The working groups and required vehicles and wireless radio sets are summarized as below;

Working Group	8-ton Truck	Pick-up	Station Wagon	Wireless Radio
1. Head Office	2	1	2	1
2. Drilling Team				
R-1	1	1		1
R-2	1	1		1
R-3	1	1		1
3. Rehabilitation Team				
S-1	1	1		1
S-2	1	1		1
4. Construction Team for Village Water Supply				
C-1		1		1
C-2		1		
C-3		1		
5. Pipe Laying at Kassala				
T-1	1			
T-2		1		

... cont'd

Working Group	8-ton Truck	Pick-up	Station Wagon	Wireless Radio
6. Construction Team for Kassala Reservoir and Booster Pumps				
P-1	1			
P-2		1		
TOTAL	9	11	2	7

5.5.5 Summary of The Proposed Equipment

Item	Unit	Quantity
1. Drilling Equipment	set	3
1) Drilling Machine	set	3
2) Compressor	set	3
3) Test Apparstus	set	3
4) Camping Facility	set	3
2. Drilling Material		
1) Attachments	set	1
2) Cementing Tools	set	1
3) Measurement Apparatus	set	1
4) Completion Material	set	1
5) Water Tanks	set	1
6) Fuel Tanks	set	1
7) Electric Tools	set	1
8) Welder	set	1
9) Mechanical Tool	set	1
10) Earth Work Tools	set	1
11) Wires	set	1

Item		Unit	Quantity
3. Construction of Water Supply Facilities			
1) Machinery		set	1
2) Watr Tank		set	1
3) Fuel Tank		set	1
4) Welder		set	1
5) Mechanical Tool		set	1
6) Earth Work Tool		set	1
7) Frames		set	1
8) Wires		set	1
4. Rehabilitation Equipment			
1) Service Machine		set	2
2) Testing Apparatus		set	2
3) Camping Facility		set	2
5. Piping Material			
1) Measuring Apparatus		set	1
2) Water Tank		set	1
3) Fuel Tank		set	1
4) Electric Apparatus		set	1
5) Welder		set	1
6) Earth Work Tools		set	1
7) Piping Tools		set	1
6. Vehicle			
1) 8 ton truck	3 ton crane	unit	9
2) Spare Parts		set	9
3) Station Wagon		unit	2
4) Spare Parts		set	2
5) Pick Up		unit	11
6) Spare Parts		set	11
7. Wowkshop Tools		set	1

Item	Unit	Quantity
8. Communication		
1) Base Camp	set	2
2) Field Team	set	5