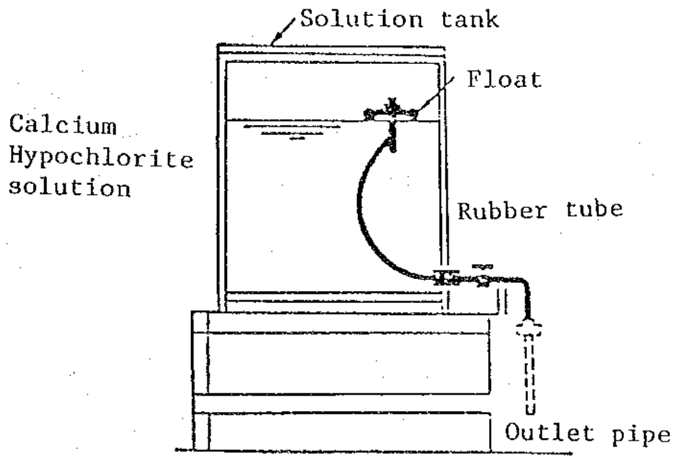
A - 4 WATER SUPPLY FACILITIES

o. Disinfecting Facilities

In case of heavy contamination of groundwater is arised and disinfecting meaterials are easily possible to purchase, it is recommendable to install the simple injector to apply Calcium Hypochlorite $Ca(Ocl)2$ solution for the domestic water as shown in the following figure:



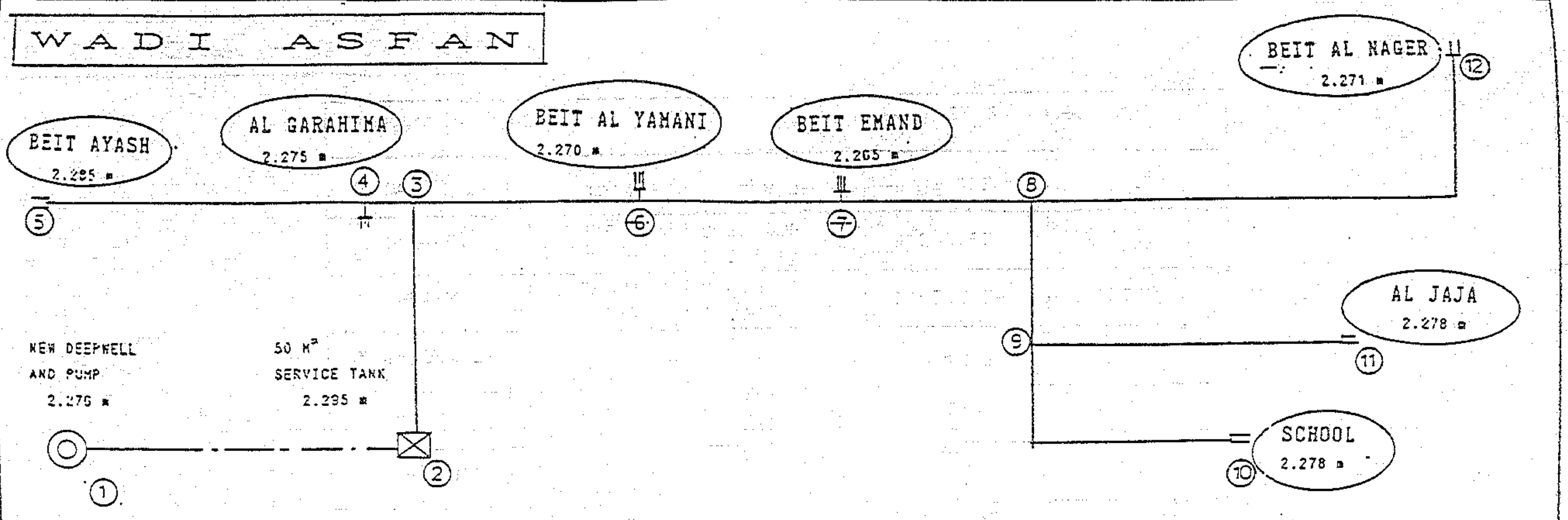
Simple Injector

p. Considerations on Pipelines

p-1 Pipe Diameter

The economic flow velocity concept which is derived from the economic correlation between construction costs and operation/maintenance costs of pumping facilities and pipelines is basically adopted for the determination of pipe diameters for this project. Velocities of 0.7 to 1.0 m/sec recommended for pipes having diameters of 75 to 100 mm are standard. However, for lengthy distribution pipelines, a part of the lines are designed to have larger sizes than those based upon economic velocities due to the necessity of keeping a head of more than 5 m at the taps of the farthest public fountain. Furthermore, since the transportation pipelines for Shihara and Al Rajam are particularly lengthy with their total heads reaching very high, water hammer actions are feared. As a preventive measure for this situation, lower velocities leading to larger sizes of pipes are adopted.

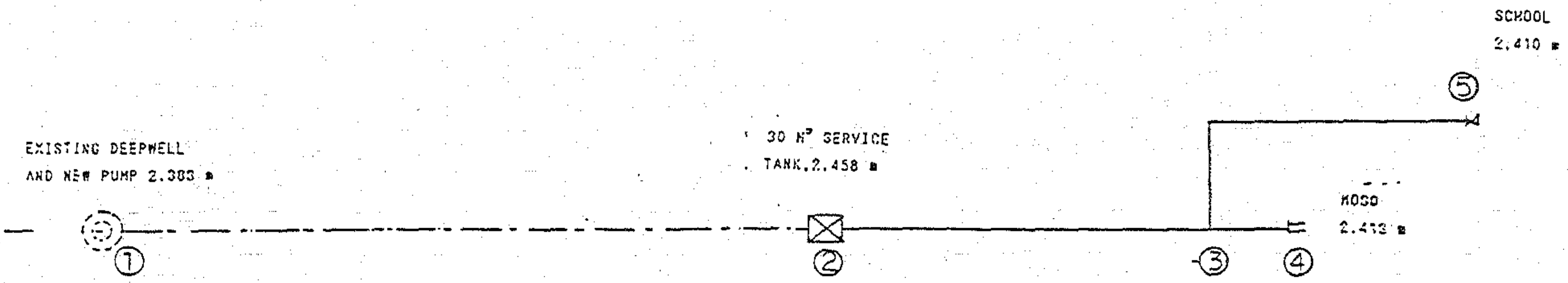
WADI ASFAN



SECTION	1—2	2—3	3—4	4—5	5—6	6—7	7—8	8—9	9—10	9—11	8—12
D (m/m)	50	75	40	40	50	50	50	50	40	50	50
l (m)	475	430	87	538	230	180	150	173	265	327	775
Q (lit/min)	150	32.5	29.2	12.1	53.8	44.8	35.8	14.8	12	2.8	21
I (mAq/m)	0.03783	0.003253	0.006018	0.001248	0.0060627	0.0043721	0.00293	0.000605	0.00123	0.000031	0.00113
V (m/sec)	1.2729	0.314248	0.387174	0.16044	0.456548	0.38017	0.3038	0.124493	0.149113	0.024	0.178207
h (m)	18.1	1.4	0.5	0.7	1.4	0.8	0.5	0.1	0.4	0.	0.9
Available head			(4) 18.1	(5) 7.4	(6) 22.2	(7) 26.4			(10) 12.4	(11) 12.7	(12) 19

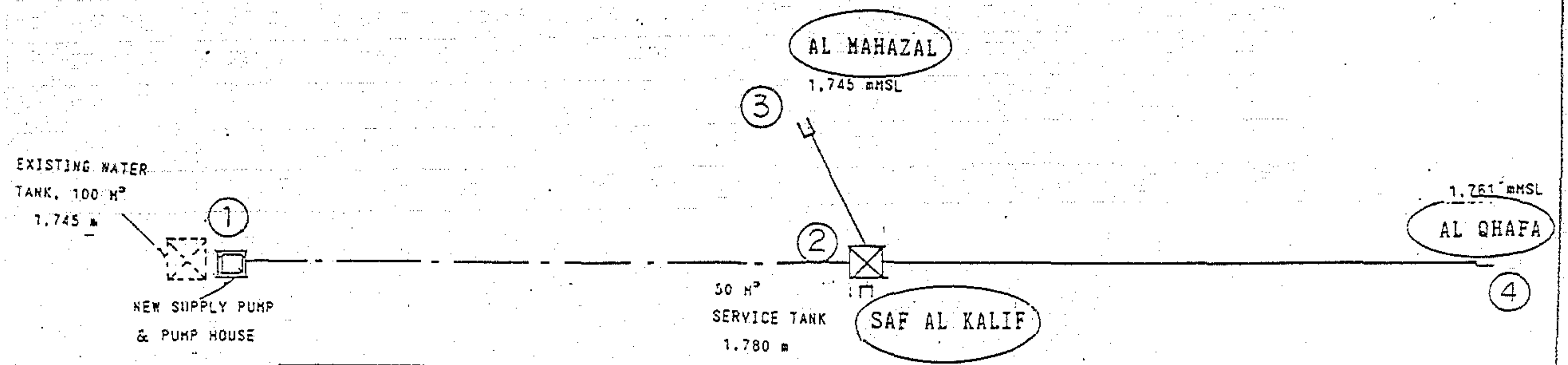
D: Diameter, l: Length of Pipeline, Q: Dischrge, I: Hydraulic Gradient, V: Verocity, h: Loss Head

AL KHASHNA



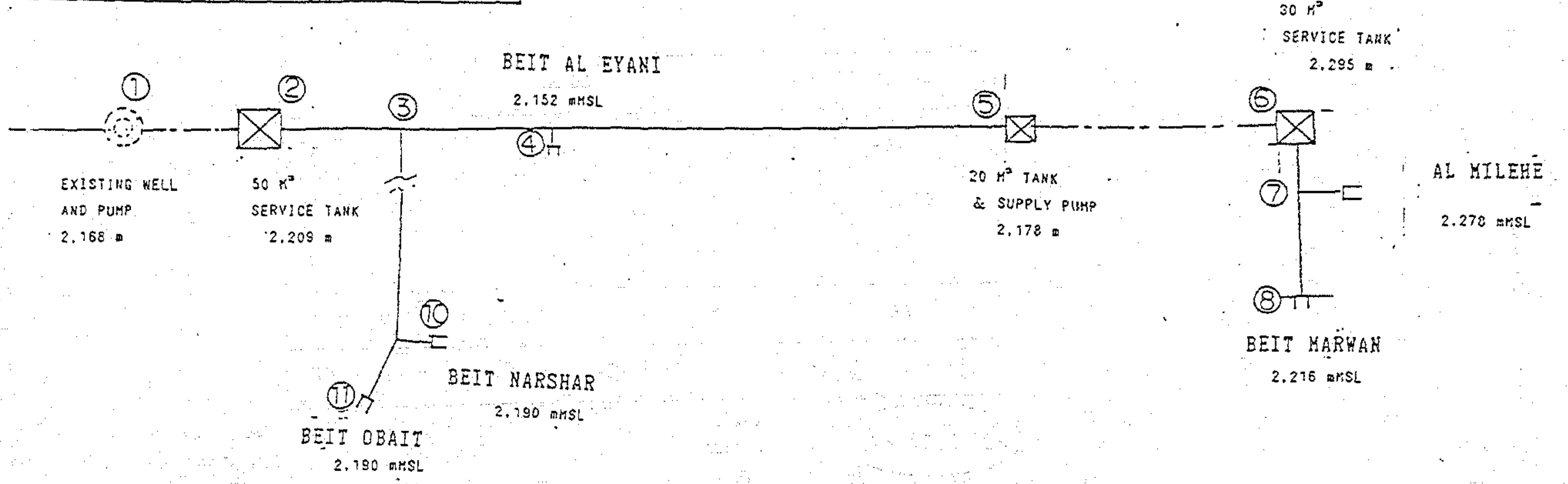
SECTION	①—②	②—③	③—④	③—⑤
D (m/m)	50 65	50 40	40	32
l (m)	130 780	50 311	139	350
Q (lit/min)	150	54	48.5	6
I (mAq/m)	0.0378321 0.0019739	0.006103 0.018041	0.0148916	0.001054
V (m/sec)	1.2729 0.76068	0.018041 0.716006	0.643081	0.124307
h (m)	15.4	8.7	2.1	0.4
Available head (m)			④ 34.2	⑤ 38.9

A L Z A K I R A

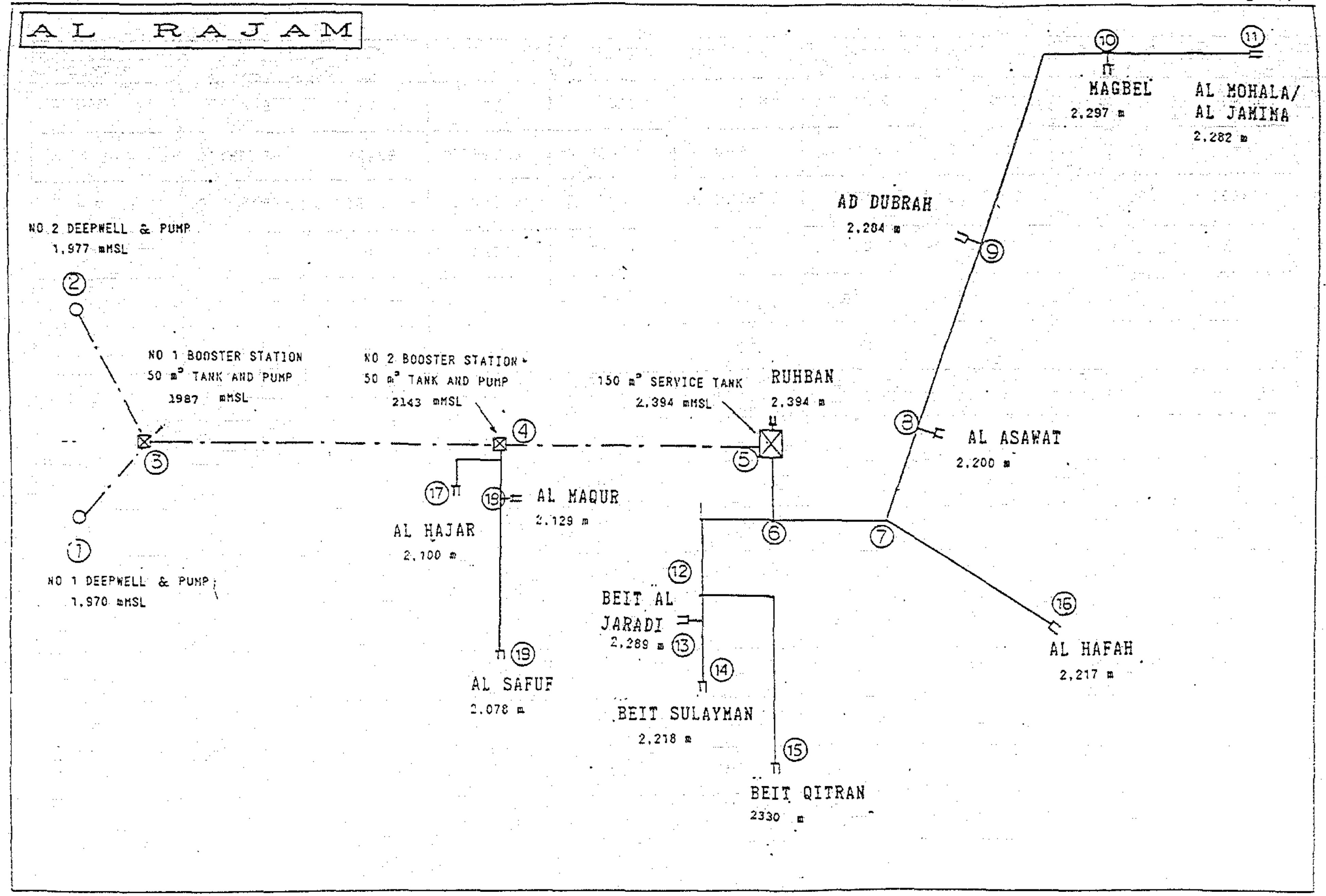


Section	① — ②	② — ③	② — ④
D (m/m)	50	40	50
l (m)	1,460	180	1,550
Q (lit/min)	120	37.9	62.3
I (mAq/m)	0.0254	0.0096	0.0079
V (m/sec)	1.0183	0.5025	0.5287
h (m)	37	1.8	12.3
Available head (m)		③ 33.2	④ 6.7

AL KHEISEN

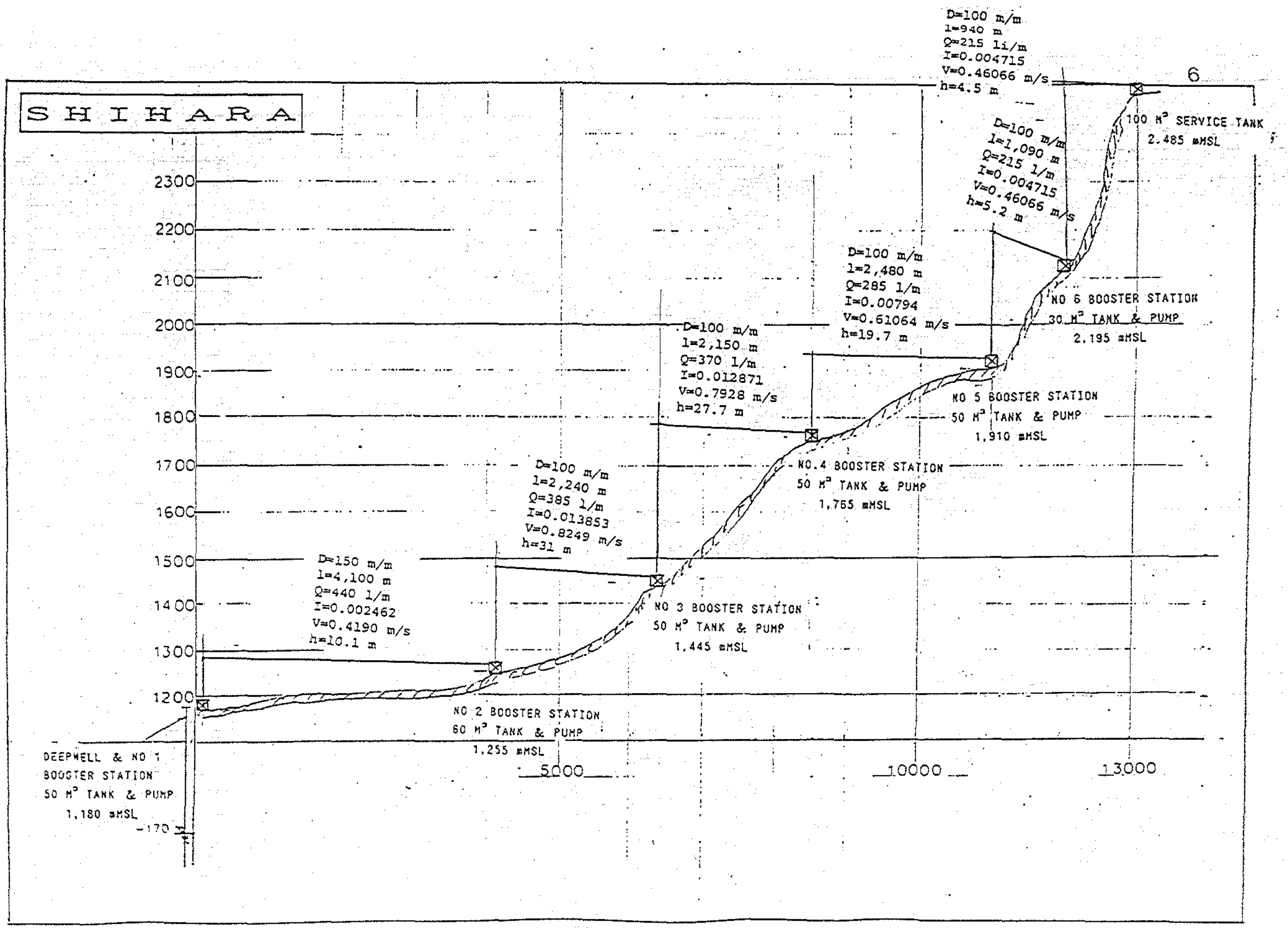


SECTION	(1)-(2)	(2)-(3)	(3)-(4)	(4)-(5)	(5)-(6)	(6)-(7)	(7)-(8)	(3)-(10)	(10)-(11)
D (m/m)	75	75	65	65	50	50	40	75	50
l (m)	200	350	390	1,750	780	200	350	1,200	50
Q (lit/min)	190	249	138	95.6	100	95.6	52.1	111	80
I (mAq/m)	0.0152	0.0251	0.0169	0.00857	0.01834	0.01692	0.01692	0.00564	0.012589
V (m/sec)	0.7237	0.9485	0.6998	0.4848	0.8486	0.8113	0.6908	0.4228	0.6874
h (m)	3.0	8.8	6.6	15	14.3	3.4	6.0	6.8	0.7
Available head (m)			(4) 41.6			(7) 21.6	(8) 69.6	(10) 12.2	(11) 11.5

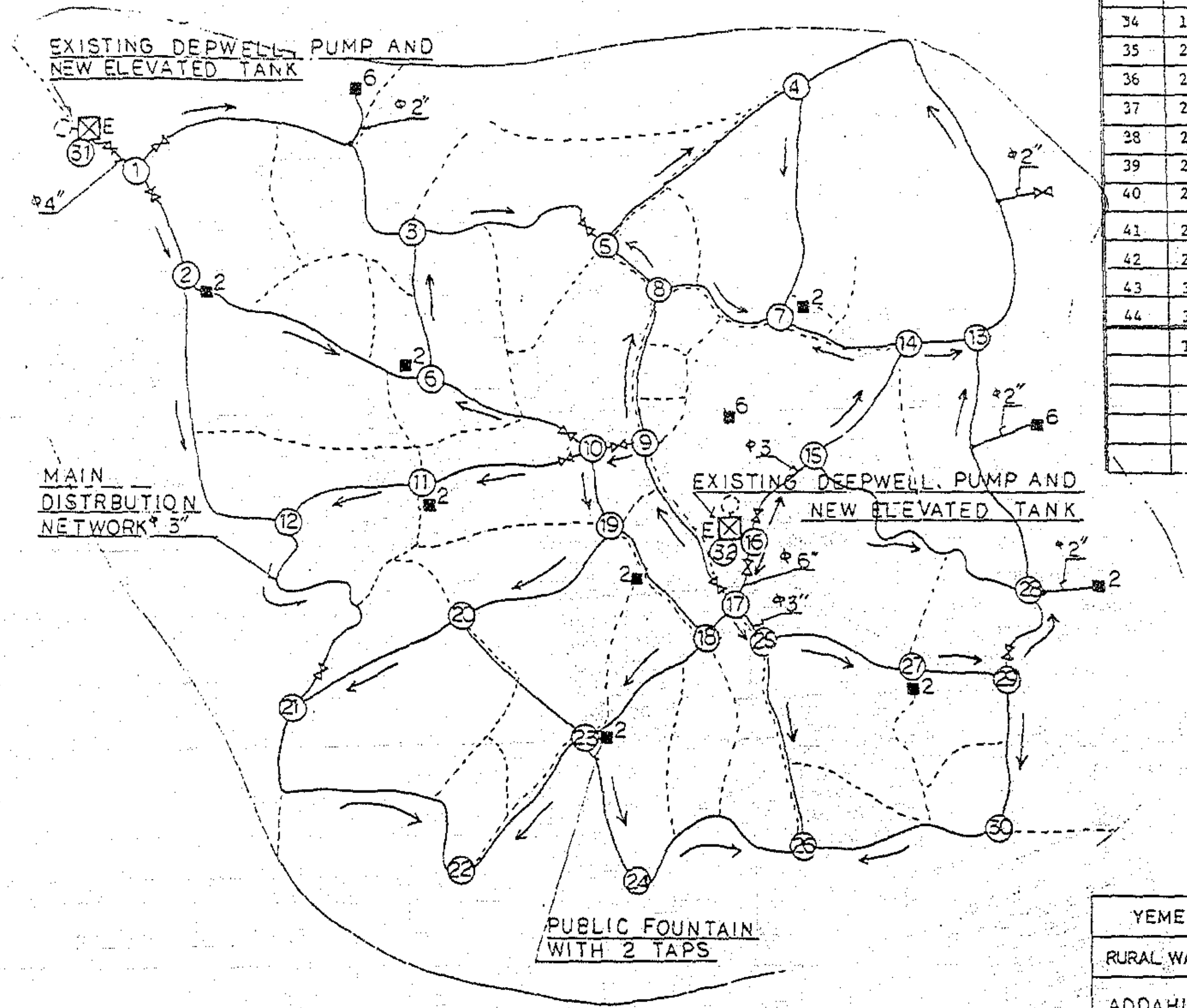

AL RAJAM
NO 2 DEEPWELL & PUMP
1,977 mMSL
NO 1 DEEPWELL & PUMP
1,970 mMSL
NO 1 BOOSTER STATION
50 m³ TANK AND PUMP
1987 mMSL
NO 2 BOOSTER STATION
50 m³ TANK AND PUMP
2143 mMSL
150 m³ SERVICE TANK
2,394 mMSL
RUHBAN
2,394 m
AL HAJAR
2,100 m
AL MAQUR
2,129 m
AL SAFUF
2,078 m
BEIT AL
JARADI
2,289 m
BEIT SULAYMAN
2,218 m
BEIT QITRAN
2330 m
AD DUBRAH
2,284 m
AL ASAWAT
2,200 m
AL HAFAH
2,217 m
MAGBEL
2,297 m
AL MOHALA/
AL JAMINA
2,282 m
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

SECTION	1—3	2—3	3—4	4—5	5—6	6—7	7—8	8—9	9—10
D (m/m)	65 (well) 75 (surface)	65 (well) 75 (surface)	100	100	100	100	75	65	65
l (m)	170 410	170 560	2,090	1,440	335	500	615	543	881
Q (lit/min)	280	280	560	460	677	424.5	320.5	238.2	133.7
I (mAq/m)	0.06263 0.03120	0.06263 0.03120	0.0277	0.01925	0.03936	0.0166	0.04016	0.04644	0.01595
V (m/sec)	1.41995 1.06654	1.41995 1.06654	1.19986	0.9856	1.45054	0.9095	1.22081	1.22081	1.20797
h (m)	10.7 12.8 23.5	10.7 17.5 28.2	57.9	27.8	13.2	8.3	24.7	25.2	14.1
Available head (m)							8 147.8	9 38.6	10 11.5

SECTION	16—11	7—16	6—12	12—13	13—14	12—15	4—17	4—18	18—19
D (m/m)	50	50	75	65	50	50	50	75	65
l (m)	414	711	394	155	445	934	411	244	866
Q (lit/min)	57.3	104	252.5	170.2	82.3	82.3	89.3	100.6	82.3
I (mAq/m)	0.006785	0.01967	0.02577	0.02494	0.012952	0.012952	0.01498	0.004695	0.06502
V (m/sec)	0.486249	0.882546	0.96179	0.86313	0.6984	0.6984	0.7578	0.383192	0.41736
h (m)	2.8	14.0	10.2	3.9	5.8	12.1	6.2	1.2	56.3
Available head (m)		16 141.5		13 77.7	14 142.9	15 28.5	17 36.8	18 12.8	19 7.5


SHIHARA
6
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
-170
5000
10000
13000
DEEPWELL & NO 1
BOOSTER STATION
50 M³ TANK & PUMP
1,180 mMSL
D=150 m/m
l=4,100 m
Q=440 l/m
I=0.002462
V=0.4190 m/s
h=10.1 m
NO 2 BOOSTER STATION
60 M³ TANK & PUMP
1,255 mMSL
D=100 m/m
l=2,240 m
Q=385 l/m
I=0.013853
V=0.8249 m/s
h=31 m
NO 3 BOOSTER STATION
50 M³ TANK & PUMP
1,445 mMSL
D=100 m/m
l=2,150 m
Q=370 l/m
I=0.012871
V=0.7928 m/s
h=27.7 m
NO.4 BOOSTER STATION
50 M³ TANK & PUMP
1,765 mMSL
D=100 m/m
l=2,480 m
Q=285 l/m
I=0.00794
V=0.61064 m/s
h=19.7 m
NO 5 BOOSTER STATION
50 M³ TANK & PUMP
1,910 mMSL
D=100 m/m
l=1,090 m
Q=215 l/m
I=0.004715
V=0.46066 m/s
h=5.2 m
NO 6 BOOSTER STATION
30 M³ TANK & PUMP
2,195 mMSL
D=100 m/m
l=940 m
Q=215 li/m
I=0.004715
V=0.46066 m/s
h=4.5 m
100 M³ SERVICE TANK
2.485 mMSL

No.	SECTION	DISTANCE (m)
1	1 - 2	105
2	1 - 3	300
3	2 - 12	276
4	2 - 6	225
5	3 - 6	115
6	3 - 5	170
7	5 - 4	230
8	12 - 21	235
9	11 - 12	90
10	10 - 11	160
11	6 - 10	155
12	10 - 19	53
13	9 - 10	46
14	8 - 9	150
15	5 - 8	70
16	8 - 7	110
17	4 - 7	195
18	4 - 13	370
19	21 - 22	210
20	20 - 21	115
21	19 - 20	168
22	20 - 23	160
23	18 - 19	155
24	17 - 9	160
25	15 - 16	125
26	16 - 17	30
27	15 - 14	115
28	14 - 7	100
29	14 - 13	70
30	13 - 28	230
31	15 - 28	230
32	17 - 25	30
33	17 - 18	26



No.	SECTION	DISTANCE (m)
34	18 - 23	155
35	23 - 22	185
36	23 - 24	145
37	24 - 26	170
38	25 - 27	110
39	26 - 30	195
40	27 - 29	90
41	29 - 30	126
42	28 - 29	75
43	31 - 1	70
44	32 - 16	20
	Total	6,320 (m)

YEMEN ARAB REPUBLIC

RURAL WATER SUPPLY PROJECT

ADDAHI SUPPLY SYSTEM PLANNING

DATE: FEB. 1987 | SCALE | DWG. No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

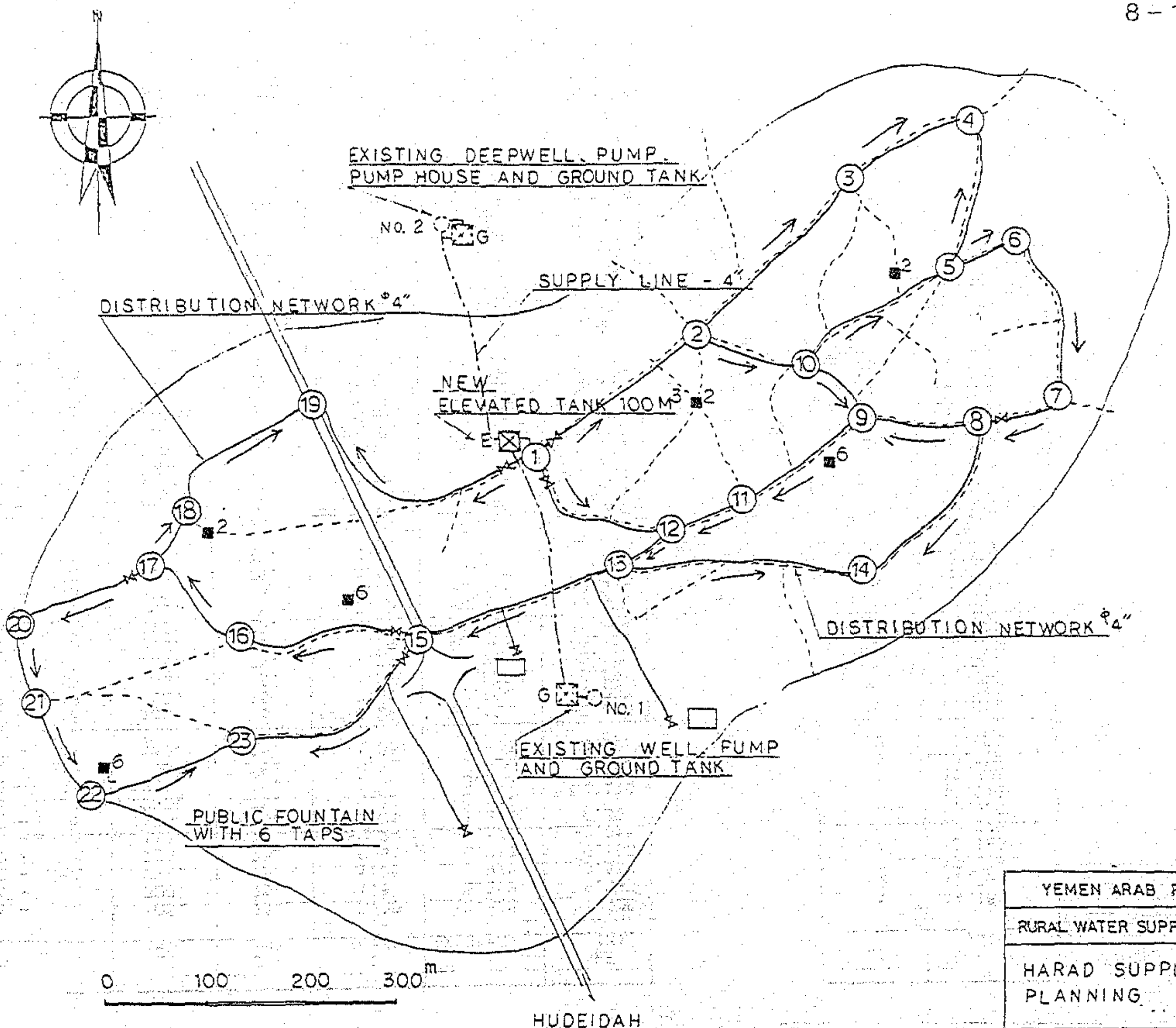
ADDAHI PIPELINE (1 – 44) / 44

NO	FROM	TO	L (M)	D (MM)	Q (L/S)	I (X10**3)	HF (M)
1	1	2	105.	75.	3.00	13.525	1.420
2	1	3	300.	75.	1.81	5.318	1.595
3	2	12	276.	75.	1.05	1.928	0.532
4	2	6	225.	75.	0.61	0.713	0.160
5	3	6	115.	75.	-0.24	-0.128	-0.015
6	3	5	170.	75.	1.01	1.816	0.309
7	5	4	230.	75.	0.50	0.494	0.114
8	12	21	235.	75.	0.44	0.393	0.092
9	11	12	90.	75.	0.71	0.929	0.084
10	10	11	160.	75.	1.05	1.923	0.308
11	6	10	155.	75.	-0.24	-0.126	-0.020
12	10	19	53.	75.	-0.61	-0.702	-0.037
13	9	10	46.	75.	1.08	2.037	0.094
14	8	9	150.	75.	-1.27	-2.769	-0.415
15	5	8	70.	75.	-0.39	-0.306	-0.021
16	8	7	110.	75.	0.51	0.501	0.055
17	4	7	195.	75.	-0.45	-0.410	-0.080
18	4	13	370.	75.	-0.23	-0.119	-0.044
19	21	22	210.	75.	0.13	0.039	0.008
20	20	21	115.	75.	0.75	1.048	0.121
21	19	20	168.	75.	1.17	2.383	0.400
22	20	23	160.	75.	0.04	0.005	0.001
23	18	19	155.	75.	2.01	6.454	1.000
24	17	9	160.	75.	2.69	11.077	1.772
25	15	16	125.	75.	-3.29	-16.069	-2.009
26	16	17	30.	125.	10.65	11.730	0.352
27	15	14	115.	75.	1.69	4.688	0.539
28	14	7	100.	75.	0.49	0.469	0.047
29	14	13	70.	75.	0.80	1.182	0.083
30	13	28	230.	75.	-0.52	-0.524	-0.121
31	15	28	230.	75.	1.12	2.180	0.501
32	17	25	30.	75.	2.95	13.089	0.393
33	17	18	26.	75.	4.77	31.866	0.829
34	18	23	155.	75.	2.41	9.041	1.401
35	23	22	185.	75.	0.60	0.692	0.128
36	23	24	145.	75.	1.00	1.775	0.257
37	24	26	170.	75.	0.37	0.283	0.048
38	25	27	110.	75.	2.51	9.703	1.067
39	26	30	195.	75.	-0.54	-0.561	-0.109
40	27	29	90.	75.	2.19	7.535	0.678
41	29	30	126.	75.	1.15	2.284	0.288
42	28	29	75.	75.	-0.36	-0.266	-0.020
43	31	1	70.	100.	5.91	11.702	0.819
44	32	16	20.	150.	14.09	8.110	0.162

(1 – 32) / 32

NO	H (M)
1	14.181
2	12.761
3	12.586
4	12.163
5	12.277
6	12.600
7	12.243
8	12.298
9	12.714
10	12.620
11	12.312
12	12.229
13	12.207
14	12.290
15	12.829
16	14.838
17	14.486
18	13.657
19	12.657
20	12.257
21	12.136
22	12.128
23	12.256
24	11.999
25	14.093
26	11.951
27	13.026
28	12.328
29	12.348
30	12.060
31	15.000
32	15.000

No.	SECTION	DISTANCE(m)
1	1 - 2	240
2	1 - 12	170
3	1 - 19	370
4	2 - 3	265
5	2 - 10	100
6	3 - 4	115
7	4 - 5	200
8	5 - 6	80
9	5 - 10	230
10	6 - 7	200
11	7 - 8	90
12	8 - 9	75
13	8 - 14	230
14	9 - 10	135
15	9 - 11	210
16	11 - 12	115
17	12 - 13	50
18	13 - 14	310
19	13 - 15	300
20	15 - 16	200
21	15 - 23	250
22	16 - 17	150
23	17 - 18	90
24	17 - 20	190
25	18 - 19	230
26	20 - 21	115
27	21 - 22	115
28	22 - 23	210
	Total	5,035 m



YEMEN ARAB REPUBLIC		
RURAL WATER SUPPLY PROJECT		
HARAD SUPPLY SYSEM PLANNING		
DATE: FEB. 1987	SCALE	DWG. No.
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)		

HARAD PIPELINE (1 - 28) / 28

NO	FROM	TO	L (M)	D (MM)	Q (L/S)	I (X10**3)	HF (M)
1	1 -	2	240.	100.	4.63	7.435	1.784
2	1 -	12	170.	100.	5.63	10.677	1.815
3	1 -	19	370.	100.	3.65	4.780	1.768
4	2 -	3	265.	100.	1.45	0.869	0.230
5	2 -	10	100.	100.	2.18	1.838	0.184
6	3 -	4	115.	100.	0.78	0.276	0.032
7	4 -	5	200.	100.	0.34	0.060	0.012
8	5 -	6	80.	100.	0.71	0.229	0.018
9	5 -	10	230.	100.	-0.94	-0.392	-0.090
10	6 -	7	200.	100.	0.17	0.016	0.003
11	7 -	8	90.	100.	-0.38	-0.074	-0.007
12	8 -	9	75.	100.	-1.45	-0.869	-0.065
13	8 -	14	230.	100.	0.50	0.120	0.028
14	9 -	10	135.	100.	-0.81	-0.296	-0.040
15	9 -	11	210.	100.	-1.06	-0.486	-0.102
16	11 -	12	115.	100.	-1.38	-0.792	-0.091
17	12 -	13	50.	100.	3.92	5.457	0.273
18	13 -	14	310.	100.	0.28	0.042	0.013
19	13 -	15	300.	100.	2.28	2.011	0.603
20	15 -	16	200.	100.	-0.41	-0.082	-0.016
21	15 -	23	250.	100.	0.85	0.322	0.080
22	16 -	17	150.	100.	-0.90	-0.362	-0.054
23	17 -	18	90.	100.	-2.34	-2.096	-0.189
24	17 -	20	190.	100.	1.03	0.461	0.088
25	18 -	19	230.	100.	-2.78	-2.885	-0.664
26	20 -	21	115.	100.	0.81	0.295	0.034
27	21 -	22	115.	100.	0.68	0.214	0.025
28	22 -	23	210.	100.	0.21	0.024	0.005

(1 - 23) / 23

NO	H (M)
1	15.000
2	13.216
3	12.985
4	12.954
5	12.942
6	12.923
7	12.920
8	12.927
9	12.992
10	13.032
11	13.094
12	13.185
13	12.912
14	12.899
15	12.309
16	12.325
17	12.379
18	12.568
19	13.232
20	12.292
21	12.258
22	12.233
23	12.228

p -2 Type of Pipe

The types of pipes to be considered are as follows.

i) Galvanized steel pipe
ii) Carbon steel pipe for pressure service
iii) Ductile cast iron pipe
iv) PVC pipe

Of these, i) and ii) are being used in rural water supply projects.

Ductile cast iron pipes are most commonly used for ordinary water supply systems in Japan. However in YAR, these are used only for water supply systems in large urban centers such as Sana'a (which were designed and constructed by EC countries). Considering the various factors encountered in rural water supply constructions, such as installation conditions (higher head-loss requirements and exposed installation on ground), diameter ranges (generally, diameters only up to 100 mm) and costs, the galvanized steel pipes are most appropriate and widely used for rural water supply projects in YAR.

PVC pipes are not suitable for exposed installation on rugged terrains in this country and presently they are used only for domestic drainage purposes.

Therefore, for this project, based on the following standards, galvanized steel or carbon steel pipes are selected.

i) Galvanized Steel Pipe for Water Service - equivalent to JIS G-3442. In principle, this is to be used for pipelines having standard head requirements of less than 100 m, and for general transportation and service pipelines.

ii) Carbon Steel Pipe for Pressure Service - equivalent to JIS G-3454. This is to be used for high pressure services to withstand head requirements exceeding that for ordinary galvanized steel pipes.

p-3 *Appurtenances*

The main appurtenances for pipelines are valves. The fundamental policy on basic design of appurtenances are described below.

a. Gate valves and check valves which correspond to the pump pressures are installed at the discharge outlets of pumps along transportation pipelines. Since a function of check valves is to prevent water hammer pressures when pumps are turned off, quick-closing type check valves will be selected and swing type check valves will be avoided. Further, since the pump pressures for Shihara and Al Rajam are from 20 to 40 kg/cm^2, pressure-resistant type cast iron gate valves must be used.

b. At an appropriate depressed area along the supply pipeline (near the pump house as much as possible), a drain valve box needs to be constructed. This must be capable to discharg mud water which may generate at the start of initial pumping at the well and during restarting operation after temporary stopping.

c. For distribution pipelines, a gate valve is installed at each outlet of distribution tanks to adjust service flow rates. Moreover, when branchings are designed along lengthy pipelines, gate valves should be installed on the branch lines in order to minimize the water suspension area during emergency periods.

d. Gate valves for water services (JIS B-2062) will be installed on the underground pipelines of the two sites in the coastal plain. Since the pipeline is to be installed along narrow town roads, this type of valve is judged to be suitable for valve box installations and for opening and closing of the valves. Both sites form a square about 1 km long in all directions. To minimize the water suspension areas during construction or repair works of the network the whole area will be divided into 3 sections and the locations of valves will be approximately determined so that these works can be done by sections.

e. Air-release valves will be located at upraised sections of pipelines with consideration on preventing water flow obstructions.

q. Considerations on Water Tanks

1 Tank Type

The following 3 types of tanks are considered in this project.

a. Distribution tank
b. Distribution/booster tank
c. Booster tank

2 Tank Structure

Steel panel tanks are selected in previous projects, for their simplicity in assembling and superior durability they are also chosen for this project. Panel tanks are made from 1 m square steel panels flanged on all sides which are bolted together with gasket to form a cube tank. The panels are coated (epoxy glazed, nylon coated, etc.) on both faces for anti-corrosion.

The assembled tanks are bolted onto steel frame stands. Ground tanks are installed on concrete foundations and elevated tanks are placed on steel towers.

3 Tank Capacity

a. Group A: Small- and Medium-sized Sites in Mountainous Areas

For the 4 sites included in this group, the daily peak service rate or 1.5 times the daily average service rate will be used to determine the tank capacity. WHO standards also recommends that, for rural villages, a day's amount of water should be reserved in case repairs are needed in the supply system, which can often take several days. With larger tanks in these small villages, the system can be stopped once in a while and the burden on operators can be reduced.

b. Group B: Village Complex in Mountainous Areas

The environmental conditions are similar to those of Group A, but the larger scale systems of this group require larger number of operators for operation and maintenance. Consequently, problems are treated relatively faster than that for Group A. Furthermore, even if the supply stops, the multiple number of tanks in the system increases the chances for finding emergency water. From this viewpoint, the effective capacity corresponding to the served population as is described in the Japanese standards for rural water supply systems will be adopted, based upon the daily peak service rate of each served area to determine the design capacity, so that the facilities will not be over-specified.

The table below indicates the effective storage capacities for distribution tanks into served population as described in the Japanese standards for rural water supply systems. However, since fire hydrants will not be installed in mountainous areas, fire-fighting water will be excluded.

Design Served Population	Effective Capacity of Distribution Tank
Over 4,999	8 hr's supply of daily peak service rate + 1 hr use of hydrant
3,000 - 4,999	9 "
2,000 - 2,999	10 "
1,000 - 1,999	12 "
500 - 999	14 "
300 - 499	16 "
100 - 299	18 "
Under 100	20 "

Furthermore, some of the distribution tanks of this group can also be used as booster tanks to transport water to elevated locations. Therefore, in principle, the service/booster tanks are designed with an amount needed for the discharge of 1 to 2 hours' detention time of the transportation rate added to the service capacity.

c. Group C: Small Urban Towns in Plains Areas

The sites in this group are judged to have potential for development and high population growth. Therefore, reevaluation of the development trend and redesigning of the system after about 10 years should be carried out. With these considerations, this project will adopt the same standards for rural water supply systems used in Group B as the design service rate projected for 10 years.

4 Calcultion of Design Tank Capacity for Each Site

The calculations on the tank capacities for each project site are explained hereafter. As the final decision on the tank capacities, with consideration on standardization of tank construction and reference to the capacity standards of RWSD, five sizes of 20, 30, 50, 100 and 150 m^3 were selected.

The determining factors for distribution tank capacities are tabulated in the following pages.

Calculation Table for Tank Capacity

(a) Small- and Medium-sized Villages in Mountainous Areas

Site Name	Tank Type	Name of Served Village	Daily Ave. Service Rate (m^3/day)	Daily Peak Service Rate (m^3/day)	Design Tank Capacity (m^3)
Wadi Asfan	Service	Beit Ayash Al Galahime Beit Al Yamani Bait Emand Beit Al Nager Al Jaja	6.8 9.6 4.8 4.8 12.0 1.6	10.2 14.4 7.2 7.2 18.0 2.4	
		Total	39.6	59.4	50
Al Zakira	Service	Al Mahazal Safi Al Kalit Al Qhafah	5.6 13.6 13.6	8.4 20.4 20.4	
		Total	32.8	49.2	50
Al Khashna	Service		19.6	29.4	30
Al Kheisen	1st Service	BeitObait Beit Narshar Beit Al Eyani	2.4 20.4 6.8	3.6 30.6 10.2	
		Total	29.6	44.4	50
	Booster	(Transport Rate 100 liter/min) x 120 min = 12 m^3/day			
	2nd Service	Al Milehe Beit Marwam	10.0 7.2	15.0 10.8	
		Total	17.2	25.8	30

(b) Village Complex in Mountainous Areas

Al Rajam

Tank Type	Service Rate: Served Village Name	Service Rate: Daily Ave. Service Rate (m³/day)	Service Rate: Daily Peak Service Rate (m³/day)	Service Rate: Detention Time (hr)	Service Rate: Calculated Capacity (m³)	Booster Rate: Transport Rate (ℓ/min)	Booster Rate: Detention Time (min)	Booster Rate: Calculated Capacity (m³)	Service/Booster Capacity (m³)	Design Tank Capacity (m³)
Booster						560	90	50.4	50.4	50
Service/Booster	Al Hajar	25.2	37.8	14	22					
	Al Maqur	4.4	6.6	18	5					
	Al Safuf	14.8	22.2	16	14.8					
	Total	44.4	66.6		41.8	460	30	13.8	55.6	50
Service	Ruhban	20.0	30.0	14	17.5					
	Bait Qitran	20.8	31.2	14	18.2					
	Bait Al Jaradi	22.8	34.2	14	19.9					
	Bait Sulayman	20.8	31.2	14	18.2					
	Al Hafah	31.2	46.8	14	27.3					
	Al Aswat	20.8	31.2	14	18.2					
	Ad Dubrah	30.4	45.6	14	26.6					
	Magbal	18.8	28.2	16	18.8					
	Al Mohala/ Al Jamima	12.8	19.2	16	12.8					
	Total	198.4	297.6		177.5				177.5	150

Shihara

Tank Type	Service Rate: Served Village Name	Service Rate: Daily Ave. Service Rate (m³/day)	Service Rate: Daily Peak Service Rate (m³/day)	Service Rate: (Served Pop.) Det. Time (hr)	Service Rate: Calculated Capacity (m³)	Booster Rate: Transport Rate (ℓ/min)	Booster Rate: Detention Time (min)	Booster Rate: Calculated Capacity (m³)	Service/Booster Capacity (m³)	Design Tank Capacity (m³)
1st B.S. Booster						440	120	52.8	52.8	50
2nd B.S. Service/Booster	Suq Al Qabain									
	Al Qabain			(1,130)						
	Al Saye									
	Al Qwashe									
	Total	45.2	67.8	12	33.9	385	60	23.1	57.0	50
3rd B.S. Service/Booster	Al Jehada			(310)						
	Al Koresh									
	Total	12.4	18.6	16	12.4	370	30	11.1	23.5	30
4th B.S. Service/Booster	Al Magrobah									
	Beni Habshah									
	Beni Waden			(1,590)						
	Al Mahama									
	Al Habs									
	Mohebah									
	Total	63.6	95.4	12	47.7	285	30	25.5	73.2	50
5th B.S. Service/Booster	Al Jamyma									
	Al Rahabah									
	Beit Al Qazaiy			(1,230)						
	Al Beyadah									
	Al Qashiba									
	Al Shamakh	49.2	73.8	12	36.9					
				(110)						
	A Quar	4.4	6.6	16	4.4					
	Total	53.6	80.4		41.3	215	30	6.5	47.8	50
6th B.S. Booster						215	120	25.8	25.8	30
Mountain top Service				(3,490)						
	Shihara	139.6	209.4	9	78.5					
	Al Majd	23.2	34.8	14	20.3					
	Total	162.8	244.2		98.8				98.8	100

Note: B.S. = booster station.
The 3rd booster station has reserve capacity, while the 4th one is insufficient, but nearby villages can receive water from either tank depending on the approach, so the total capacity of both stations will meet the requirements for these villages.

(c) Urban Towns in Coastal Plains

Site Name	Daily Ave. Service Rate (m^3/day)	Daily Peak Service Rate (m^3/day)	Served Pop. (pers)	Detention Time (hr)	Calculated Capacity (m^3)	Design Capacity (m^3)
Ad Dahi	474.5	711.0	6,779	8	237	200 ——— 100 m^3 elevated tank x 2
Harad	363.9	545.8	5,198	8	182	200 ——— 100 m^3 elevated tank x 1 + 100 m^3 ground booster tank x 1 (existing)

r. Study on Pumping Facilities

1) Type

The following types of pumps are used for this project.

a. Deep well pump: Submersible motor pumps (driven by generators) and borehole pumps (driven by belt-drive or angle-gear/shaft drive diesel engines, of which the latter is more popular in YAR)

b. Booster pump: Horizontal multi-stage pumps directly coupled to electric motors or connected to diesel engines. The former type is powered by a generator.

In this country, borehole pumps have been and are employed much more frequently than submersible motor pumps, because of their relative simplicity in maintenance and handling. However, recently,at the construction of the improved water supply systems, the submersible pumps, which can send water up directly to service tanks at higher locations, are adopted gradualy. At present, the selection of either type depends upon the required head; submersible motor pumps of lifting water more than 200 m high and borehole pumps for less lifting capacity. In this project, this principle is followed, with the specifications of the respective deep well pumps as listed hereunder.

Name of Site	Type of Pump	Head	Remarks
Wadi Asfan	Submersible motor pump	200 m	Newly-provided
Al Khashna	Submersible motor pump	200 m	Newly-provided
Al Zakira	Submersible motor pump	245 m	Existing (in service)

(continue)

(continued)

Name of Site	Type of Pump	Head	Remarks
Al Kheisen	Borehole pump	315 m	Existing (in service)
Shihara	Submersible motor pump	184 m	Newly-provided
Al Rajam	Submersible motor pump	200 m	Newly-provided (2 units)
Ad Dahi	Borehole pump	80 m	Newly-provided (1 unit)
		60 m	Existing new unit (to replace old one)
Harad	Borehole pump	50 m	Newly-provided (to replace old one)
	Submersible motor pump	70 m	Existing

As booster pumping facilities, those of a small size are planned for two sites of Al Zakira and Al Kheisen, and those of a large scale, for Shihara and Al Rajam. The type of pump is multistage turbine pump to meet requirements of high lifting. Pumps of this type smaller in discharge and head are planned to be directly connected to diesel engines, while those of a larger size should be of type directly coupled to an electric motor driven with a diesel generator in order to assure constantly stabilized running.

2) Capacity

a. Pumping rate

Pumping rates of deep well pumps are determined, based upon safe yields at the respective water sources, with daily total intake depending upon daily peak demands. Daily pumping duration, therefore, can be calculated by the daily peak demand (m^3/d) divided by safe yield (m^3/min).

Since the water sources are deep wells, a daily operation needs a certain period of suspension of running for the recovery of groundwater level. The Rural Water Supply Department has a criteria that the operation duration should be less than 20 hours a day, adding that the shorter, the better. This measure is also recommendable in view of conservation of groundwater resources and the operation and maintenance of wells. With such consideration, the shorter duration is preferred in this country, selecting a pumping rate in a larger range. The minimum pumping rate shall be 100 lit/min, which is the lower limit of judging a successful well by the Department, and the upper rate, 70 to 80% of maximum potential in order to plan a shorter pumping duration.

The pumping rates at the respective sites are listed in the following table (Note: For the project sites where pumping rates can not be confirmed, design pumping rates are determined through hydrogeological study and data of existing wells in and around drilling sites).

Name of Site	Max Potential	Design Pumping Rate	Pumping Duration at Design Rate
Wadi Asfan	(300 1/m)	150 1/m	6.6 hrs
Al Khashan	(250 1/m)	150 1/m	3.3 hrs
Al Zakira	(300 1/m)	250 1/m	(3.3 hrs)*
Al Kheisen	(300 1/m)	190 1/m	6.2 hrs
Al Rajam	(400 1/m)	280 1/m (2 wells)	each 10.9 hrs
Shihara	(600 1/m)	450 1/m	10.8 hrs
Ad Dahi	(800 1/m)	600 1/m (2 wells)	each 13.2 hrs
Harad	500 1/m	400 1/m (2 wells	each 15.3 hrs

Pumping rates of booster pumps are as follows:

(1) Booster pumps at the first stage ....
Design pumping rates (l/min)

(2) Booster pumps at the second and further stages ....
Required water transportation rates (l/min) which is calculated by decreasing service rates at the respective stations from the preceding pumping rates, and dividing it by pumping duration.

b. Head

Required heads for pumps are calculated in accordance with the following formula:

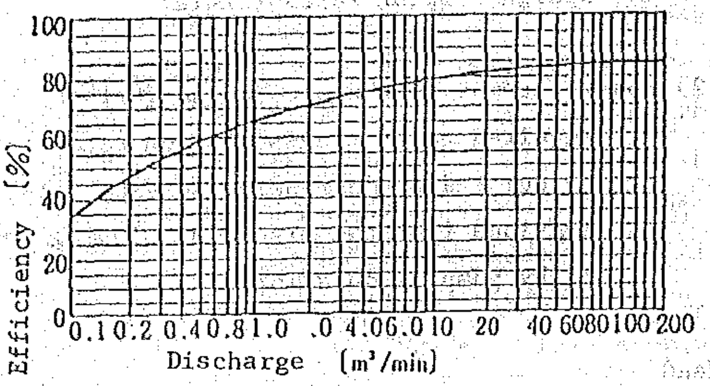
Total head = Actual head + Pipeline head loss

The results of the head calculation with the respective pumps employed in this project are presented in the table of pump capacities calculation attached herewith. In addition, details of pipeline head losses are shown in Appendix A-4-q.

For the calculation, the low water levels at the deep wells during pumping are assumed as follows:

Well Depth	L.W.L. (Site Name)
200 m	170 m (Wadi Asfan, Al Rajam, Shihara)
150 m	130 m (Al Khashna)
80 m	60 m (Ad Dahi No. 2 well)
60 m	50 m (Ad Dahi No. 1 well)
50 m	40 m (Harad, existing shallow well)

Document 1 Standard Efficiency of General Pump
(from Standards for Water Supply Systems)



Document 2 Allowance Rate of Power Units

Power Unit		Allowance Rate
Small Motor	(under 37 kW)	0.15 - 025
Medium and Large Motor	(over 37 kW)	0.10 - 0.20
Small Engine	(under 50 PS)	0.20 - 0.30
Medium and Large Engine	(over 50 PS)	0.15 - 0.25

Document 3 Transmission Efficiency

Transmitting Method		Transmission Efficiency t
Direct Coupling		1.0
Gear Drive	Parallel Gear	0.97 - 0.07
	Angle Gear	0.94 - 0.96
	Mesh Gear	0.95 - 0.98
Fluid Coupling		0.95 - 0.97
Flat Belt		0.90 - 0.93
V-Belt		0.93 - 0.95

3) Water Hammer

One of possible troubles with regard to pumping equipment and pipelines is water hammering particularly to be encountered at time of sudden power supply suspension. This is a phenomenon in which pressure in pipeline changes transiently, rising or dropping, due to rapid change in flow velocity at a time of start or stop of the pump, in extreme cases resulting in the breakdown of sections of lines, valves and/or the pump. High pressure and lengthy pipelines are particularly vulnerable to this phenomenon. In this project, Al Rajam and Shihara are the case, and the measures are considered for safeguarding against this possible trouble as follows:

a. Quick closing valve

The check valve at the end of pumps should be of a quick-closing type in place of ordinary swing check valve so that the reverse flow occurring at a time of pump stop can be shut off before the pressure change at pump delivery does not amount to so much.

b. Flywheel

The booster pump is provided with a fly wheel with a high inertia at a coupling so that the revolution of the pump can not suddenly drop at a time of pump stop.

c. Enlarged pipe diameter

Pipelines shall be designed to have larger diameters to make flow velocity less so that change in velocity can be minimized at a time of pump stop.

Inventory of Calculation Data for Pumping Facilities

1. Intake Pump

Site Name	Flow Rate (l/m)	Pipe Dia. (mm)	Pipe Length (m)	Pipeline Head Loss (m)	Actual Head (m)	Loss at Station (m)	Total Head (m)	Motor/ Engine Output	Generator Output (KVA)	Comments
Wadi Asfan	150	50 50	170 305	18.1	170 19	4	212	11 KW	30	Newly installed pump (submersible pump)
Al Khashna	150	50 65	130 780	4.9 15.4	130 75	4	230	11 KW	30	Newly installed pump (submersible pump)
Al Rajam No. 1 well	280	65 80	170 410	10.7 12.8	170 17	4	215	18.5 KW	(Central controlled operation)	
Al Rajam No. 2 well	280	65 80	170 560	10.7 17.5	170 10	4	209	18.5 KW	(Central controlled operation)	
Shihara	450	80	190	10.5	170	4	184	30 KW	175	Newly installed pump (submersible pump)
Ad Dahi No. 1 well	600	100	60 40	1.9 1.3	77.5	4	84	20 HP		Newly installed pump (borehole pump)
Ad Dahi No. 2 well	600	100	40 40	1.3 1.3	40 17.5	4	64	(23 HP)		Replaced pump Existing borehole pump
Harad	400	100	40 360	0.6 5.4	40 17.5	4	67	13 HP		Newly installed pump (borehole pump)

Since Al Zakira and Al Kheisen have existing pumps in operation, these are not listed.

2. Booster Pump (1)

Site Name	Flow Rate (1/m)	Pipe Dia. (mm)	Pipe Length (m)	Pipeline Head Loss (m)	Actual Head (m)	Loss at Station (m)	Total Head (m)	Motor/ Engine Output	Generator Output (KVA)	Comments
Al Zakira	120	50	1,460	37	35	4	76	10 PS		
Al Kheisen	100	50	780	14.3	117	4	135.3	12 PS		
Harad	400	100	300	4.5	17.5	4	26	5.5 KW	(15 KVA)	Operated by existing 45 KVA pump

3. Booster Pump (2)
(Al Rajam)

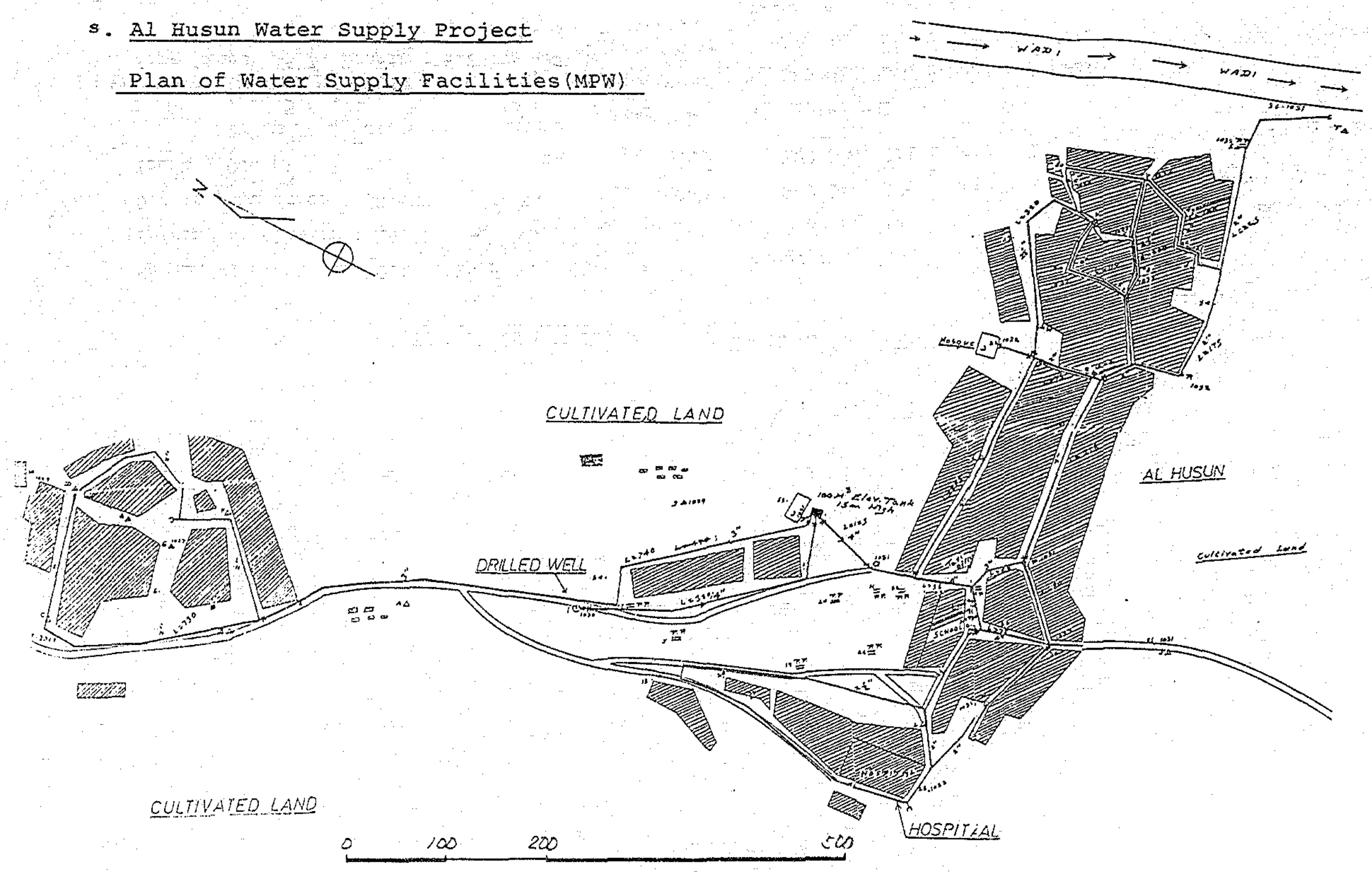
Site Name	Flow Rate (1/m)	Pipe Dia. (mm)	Pipe Length (m)	Pipeline Head Loss (m)	Actual Head (m)	Loss at Station (m)	Total Head (m)	Motor/ Engine Output	Generator Output (KVA)	
Al Rajam 1st Booster Station	560	100	2,090	57.9	156	4	218	37 KW	2 intake pumps and (central control)	200 KVA
Al Rajam 2nd Booster Station	460	1200	1,440	27.8	251	4	283	45 KW		175 KVA

4. Booster Pump (3)
(Shihara)

Site Name	Flow Rate (1/m)	Pipe Dia. (mm)	Pipe Length (m)	Pipeline Head Loss (m)	Actual Head (m)	Loss at Station (m)	Total Head (m)	Motor/ Engine Output	Generator Output (KVA)	Comments
1st Booster Station	440	150	4,100	10.1	75	4	89	15	175	Also used as intake pump
2nd Booster Station	385	100	2,240	31.0	190	4	225	30	100	
3rd Booster Station	370	100	2,150	27.7	320	4	352	45	175	
4th Booster Station	285	100	2,480	19.7	145	4	165	22	70	
5th Booster Station	215	100	1,090	5.2	285	4	295	30	200	(Central controlled operation)
6th Booster Station	215	100	940	4.5	290	4	299	30		

s. Al Husun Water Supply Project

Plan of Water Supply Facilities (MPW)

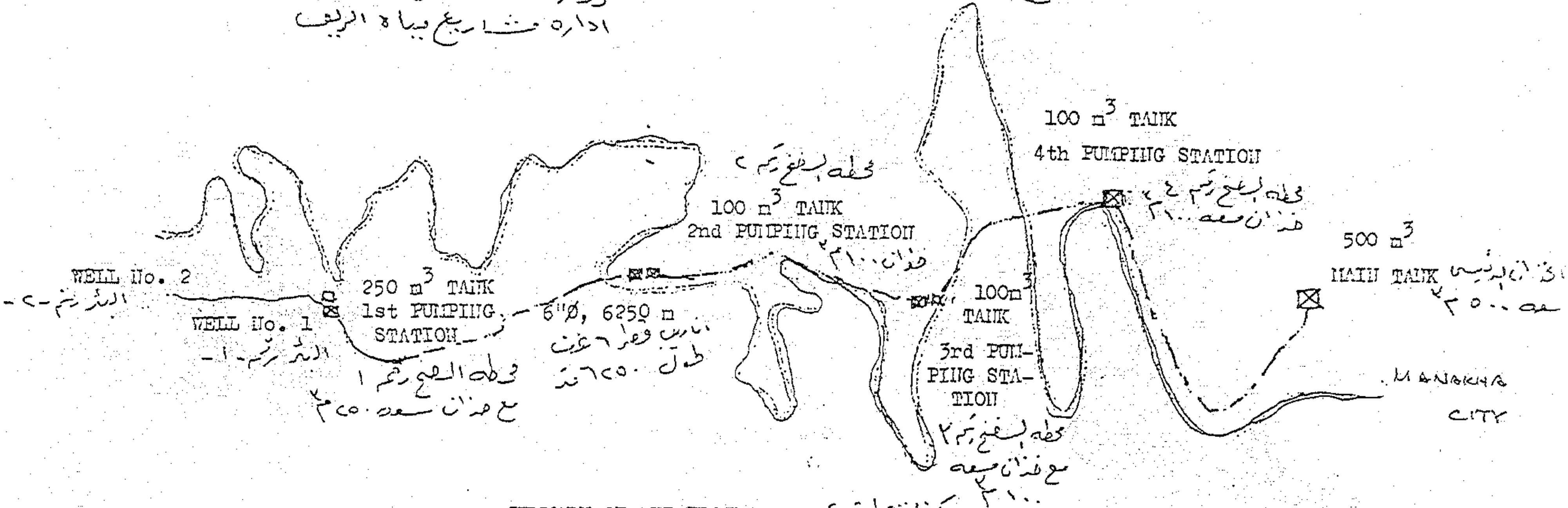


t. Existing Large Scale Water Supply Project by MPW

(1/3)

MINISTRY OF PUBLIC WORKS
RURAL WATER SUPPLY DEPARTMENT
وزارة الأشغال العامة
ادارة مشاريع مياه الريف

MANAKHAH WATER SUPPLY PROJECT
مشروع تزويد المياه لمدينة مناخة



SUMMARY OF THE PROJECT مكونات المشروع

Estimated cost : YR 10.1 million

Present population : 15,000

Design population : 30,000

Tanks : 500 m3 - 1 No.
250 m3 - 1 No.
100 m3 - 3 Nos.

Pipe lines : 6"Ø, Length : 6.25 km

Pumps : 14 Nos.

a) Submersible

100 GPM, 205 m head : 1 No.

120 GPM, 211 m head : 1 No.

b) Horizontal

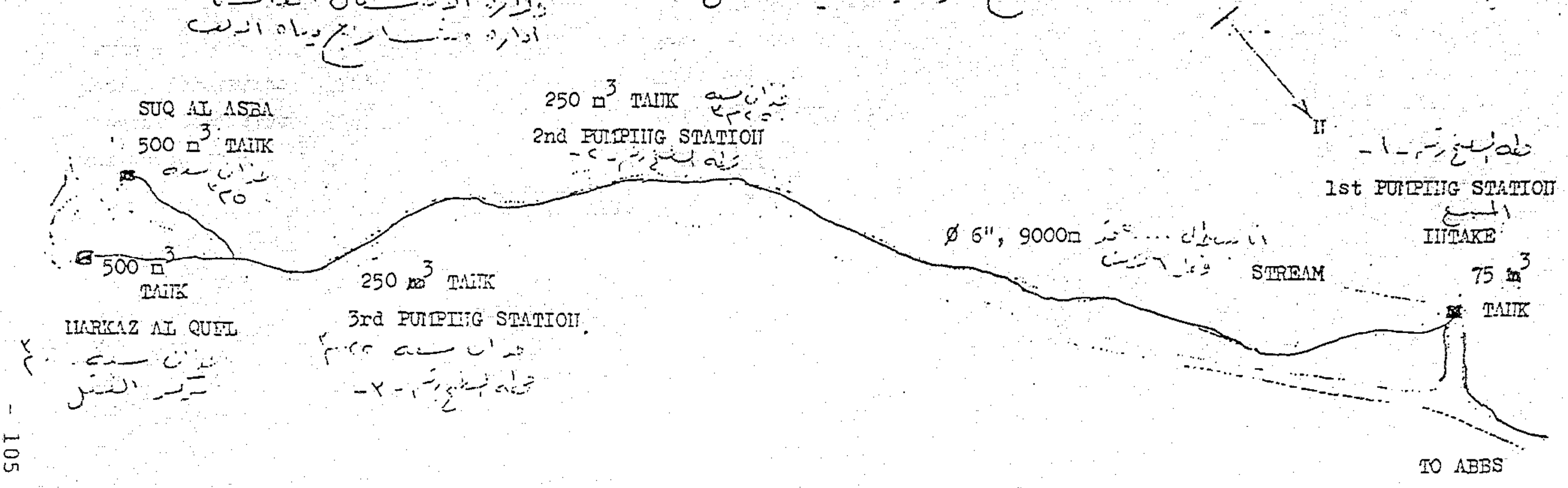
220 GPM, 286 m head : 9 Nos.

220 GPM, 230 m head : 3 Nos.

Total head : 1060 m

MINISTRY OF PUBLIC WORKS
RURAL WATER SUPPLY DEPARTMENT

AL-QUFL WATER SUPPLY PROJECT



SUMMARY OF THE PROJECT

Estimated cost : YR 5 million
Present Population : 11,300
Design population : 20,000

Tanks : 250 m^3 - 2Nos.
500 m^3 - 2Nos.
75 m^3 - 1No. (In take)

Pipe line : Ø 6", length : 9 km

Pumps : 6 Nos.
Discharge : 300 GPM
Head : 370 m
Power : 260 H.P
Total Head : 1100 m
Design Daily Consumption : 432,000 Gallons

MINISTRY OF PUBLIC WORKS

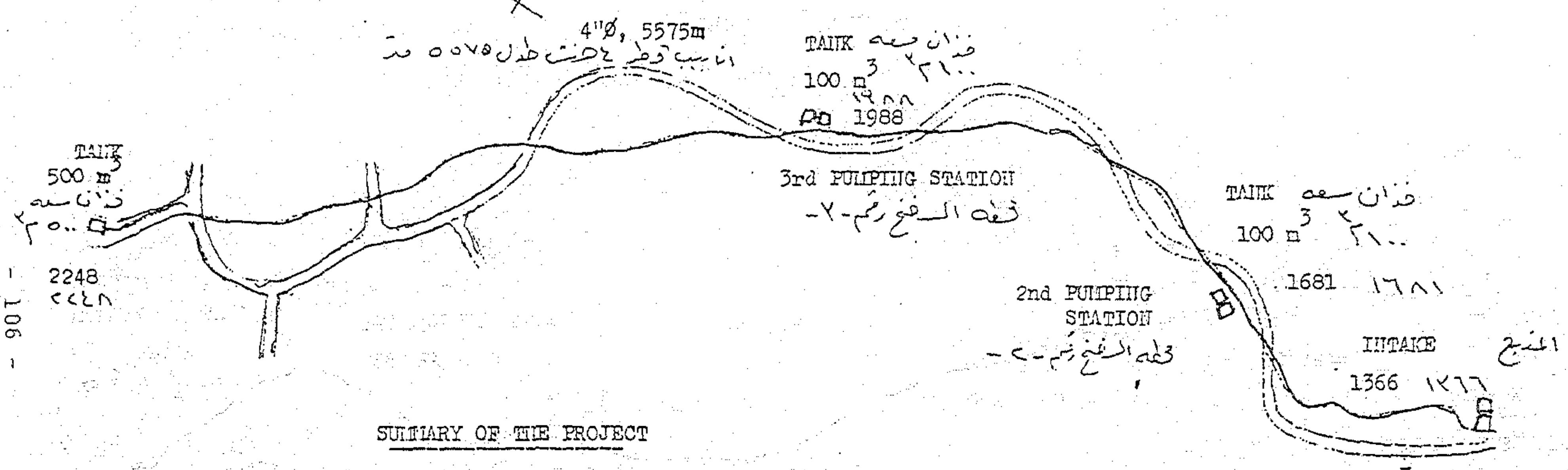
RURAL WATER SUPPLY DEPARTMENT

وزارة الاشغال العامة

ادارة مشاريع مياه الريف

AL-MAHWEET WATER SUPPLY PROJECT

مشروع تمديد المياه لمدينة المحويت



SUMMARY OF THE PROJECT

Estimated cost : YR 7.5 million

Present populaton : 6000

Design population : 12000

Tanks : 4 Nos.

500 m^3 : 1 No.

100 m^3 : 3 Nos.

Ø 4",Pipe line length : 5575 m

Pumps : 6 Nos.

Discharge : 184 GPM

Head : 370 m

Power : 140 H.P

Total Head : 882 m

Design Daily Consumption : 176,640 Gallon

A – 5 OPERATION AND MAINTENANCE

u. Operation and Maintenance Costs

1 Components of Operation and Maintenance Costs

1) Salaries of Operators

Operators are usually selected among inhabitants of the beneficiary village. Since the operating hours in small- and medium-sized villages are short, in most cases, the two designated operators work in shifts and usually without pay. However, villages inhabited by over 2,000 persons require salary payments to the operators. According to the field survey, the monthly salary is YR2,000-2,500/person, depending on factors such as age and experience.

2) Fuel Costs

Procurement of engine oil is relatively easy, where the present price is about ¥ 34/l. Also the oil exchange of pumps/engines becomes necessary, so an allowance of 10 % of the fuel cost should be counted.

3) Maintenance Costs

In this project, the required maintenance cost to maintain a stable and continuous operation of the completed facilities is calculated by the criteria indicated below.

a. Machinery house and storage tank: Since these are covered by the daily operation and maintenance by operators, the costs will not be considered.

b. Deep wells: The wells in the coastal plains areas have possibility of accumulating sand at the well bottom when pumping, and therefore, periodic well cleaning is essential. Ad Dahi and Harad have existing wells, and so well preservation needs to be considered. For these sites, judging from the present and past conditions, well cleaning is required about once every 5 years. The cost components are listed below.

i)	Well purging (same conditions as completion works)	¥276,000 (unit working price)
ii)	Pump installation	¥ 92,000 (")
iii)	Temporary works	¥540,000 (field survey)
iv)	Repairment	10 % of capital cost

Therefore, the cost for well rehabilitation works for Ad Dahi and Harad is estimated Y 1,403,000/2 wells/5 years.

c. Pumps and power units: Standby units and spare parts are included as a part of grant aid in this project, but the following operation and maintenance costs are required for each site.

i) Intake Pump

Newly installed submersible pump : Standby motors are included in spare parts, for the operation of 5 to 10 years depending on the operating hours, if the well remains normal. Therefore, in preparing for accidents, 5% of the annual average pump cost will be necessary.

Newly installed engine-powered borehole pump : As spare parts, 20 % is included which can allow maintenance for about 3 years. For maintenance after this period, annualy 20 % of capital cost/3 years and about 7 %/year deposit are needed.

Existing intake pump : Standby equipment and spare parts are not included for the existing pump. Using a similar priced pump as reference, annualy 7 % of capital cost is required for maintenance fee.

ii) Transportation Pump: Standby pumps and motors are including and so, an average of 5 % is necessary.

iii) Generator : Since 20 % spare parts is included, annualy 7 % of capital cost is needed.

iv) Control Panel : As spare parts, 20 % of capital cost is included and therefore, annualy a 7 % of capital cost is required.

As the basic costs for calculations on the above-listed equipment, including construction cost, unit working price + general maintenance cost (10 %) will be adopted.

d. Pipelines and valves: Annualy 0.5 % of the construction cost will be considered as the repair cost.

e. Public fountains: Replacement of frequently used fountains will probably be required once every 2 years.

2 Calculation Method

The operation and maintenance cost of each site and water fee charged to each household are indicated below. The criterion of 20 years when facilities become fully operated will be used for the calculation. The composition of one household is considered as one income-earning adult plus 4 others for a total of 5 persons and the income is assumed as YR4,000.

Site Name	Wadi Asfan	
1.Operator's salary	1 x 27,000 ¥/m	27,000 ¥/m
2.Fuel Cost	type/output / daily operating hours(hr) / unit consumption (lit/hr) / total consumption (lit) 30KVA/44PS / 6.6 / 4.6 / 30.4	30.4 x 34 ¥ =1,034 ¥ 1,034 x30days = 31,020 ¥/m Lubricants 10 % 3,102 ¥/m
3.Pump/ generator repair cost	submersible pump 3,463,463 x 1.1 = 3,809,810 generator 2,877,221 x 1.1 = 3,164,940 (total 34,336 ¥/m)	(3,809,810 x 0.05) ÷ 12 = 15,874 ¥/m (3,164,940 x 0.07) ÷12 = 18,462 ¥/m
4.Well rehabilitation cost		
5.Pipeline repair cost	15,748,000 x 1.1 = 17,323,000 (17,323,000 x 0.005)÷12 = 7,218	7,218 ¥/m
6.Faucets replacement cost	24,300 x 18pcs x 1.1 = 481,140 481,140 ÷ 24 = 20,048	20,048 ¥/m
Total operation/ maintenance cost		122,724 ¥/m (9,091 YR/m)
Water fee caluculation	design population: 990 nos. of household: 198 water fee = OM cost/household = 620 ¥/m(45.9YR/m) water fee ratio to household income: 1.1 %	
Note		

Site Name	Al Khashna	
1.Operator's salary	1 x 27,000 ¥/m	27,000 ¥/m
2.Fuel Cost	type/output: 30KVA/44PS daily operating hours(hr): 3.3 unit consumption (lit/hr): 4.6 total consumption (lit): 15.2	15.2 x 34 ¥ = 517 ¥ 517 x30days = 15,510 ¥/m Lubricants 10 % 1,551 ¥/m
3.Pump/ generator repair cost	submersible pump generator control panel 5,911,663 x 1.1 = 6,500,000	(6,500,000 x 0.05) ÷ 12 = 27,083 ¥/m
4.Well rehabilitation cost		
5.Pipeline repair cost	6,645,000 x 1.1 = 7,309,500 (7,309,500 x 0.005) ÷ 12 = 3,045	3,045 ¥/m
6.Faucets replacement cost	24,300 x 4 pcs x 1.1 = 106,920 106,920 ÷ 24 = 4,455	4,455 ¥/m
Total operation/ maintenance cost		78,644 ¥/m (5,825 YR/m)
Water fee caluculation	design population: 490 nos. of household: 98 water fee = OM cost/household = 802 ¥/m (59 YR/m) water fee ratio to household income: 1.49 %	
Note		

Site Name	Al Zakira				
1.Operator's salary	1 x 27,000 ¥/m				27,000 ¥/m
2.Fuel Cost	type/output	daily operating hours(hr)	unit consumption (lit/hr)	total consumption (lit)	
	10 PS	7	1.04	7.3	7.3 x 34 ¥ = 248 ¥ 248 x 30 days = 7,440 ¥/m Lubricants 10 % 744 ¥/m
3.Pump/ generator repair cost	booster pump 1,950,164 x 1.1 = 2,145,200				(2,145,200x0.5) ÷ 12 = 8,938¥/m
4.Well rehabilitation cost					
5.Pipeline repair cost	14,800,920 x 1.1 = 16,281,000 (16,281,000 x 0.005) ÷ 12 = 6,784				6,784 ¥/m
6.Faucets replacement cost	24,300 x 8 pcs x 1.1 = 213,840 213,840 ÷ 24 = 8,910				8,910 ¥/m
Total operation/ maintenance cost					59,816 ¥/m (4,431 YR/m)
Water fee caluculation	design population: 820 nos. of household: 164 water fee = OM cost/household = 365 ¥ (27 YR) water fee ratio to household income: 0.68 % (33 ÷ 4,000)				
Note					

Site Name	Al Kheisen	
1.Operator's salary	2 x 27,000 ¥/m	54,000 ¥/m
2.Fuel Cost	type/output / daily operating hours(hr) / unit consumption (lit/hr) / total consumption (lit) 40 PS / 6.2 / 4.14 / 25.7 (existing borehole pump) 12 PS / 4.3 / 1.24 / 5.3 (booster pump / new engine)	31.0 x 34 ¥ =1,054 ¥ 1,054 x30days = 31,620 ¥/m Lubricants 10 % 3,162 ¥/m
3.Pump/ generator repair cost	existing pump / engine price : 5,000,000 new booster pump /engine : 2,438,234 x 1.1 = 2,682,000 (total : 40,345 ¥/m)	(5,000,000 x 0.07) ÷ 12 = 29,170 ¥/m (2,682,000 x 0.05) ÷ 12 = 11,175 ¥/m
4.Well rehabilitation cost		
5.Pipeline repair cost	30,576,885 x 1.1 = 33,634,570 (33,634,570 x 0.005) ÷ 12 = 14,000	14,000 ¥/m
6.Faucets replacement cost	24,300 x 16pcs x 1.1 = 427,680 427,680 ÷ 24 = 17,820	17,820 ¥/m
Total operation/ maintenance cost		160,947 ¥/m (11,922 YR/m)
Water fee caluculation	design population: 1,170 nos. of household: 234 water fee = OM cost/household = 688 ¥/m (51 YR/m) water fee ratio to household income: 1.3 %	
Note		

Site Name	Al Rajam	
1.Operator's salary	5 x 27,000 ¥/m	135,000 ¥/m
2.Fuel Cost	type/output / daily operating hours(hr) / unit consumption (lit/hr) / total consumption (lit) 200KVA/260ps / 10.9 / 26.9 / 293 175KVA/220ps / 10.9 / 22.8 / 249	542 x 34 ¥ =18,428¥ 18,428x30days = 552,840 ¥/m Lubricants 10 % 55,284 ¥/m
3.Pump/ generator repair cost	submersible pump(6,581,435 x2 x 1.1) x 0.05 ÷ 12 booster pump (4,072,078 x 1.1)x 0.05 ÷ 12 booster pump (6,458,009 x 1.1)x 0.05 ÷ 12 200KVA generator (11,156,264 x 1.1)x 0.07÷12 175KVA generator (9,302,984 x 1.1) x 0.07 ÷12 central control panel (7,787,496 x 1.1) TOTAL	60,330 ¥/m 18,664 ¥/m 29,599 ¥/m 71,586 ¥/m 59,694 ¥/m 49,970 ¥/m 289,843 ¥/m
4.Well rehabilitation cost		
5.Pipeline repair cost	(106,800,000 x 1.1 x 0.005) ÷ 12 = 48,950	48,950 ¥/m
6.Faucets replacement cost	24,300 x 62pcs x 1.1 = 1,657,260 1,657,260 ÷ 24 = 69,052	69,052 ¥/m
Total operation/ maintenance cost		1,150,969¥/m (85,257 YR/m)
Water fee caluculation	design population: 6,070 nos. of household: 1,214 water fee = OM cost/household = 948 ¥/m (70 YR/m) water fee ratio to household income: 1.76 %	
Note		

Site Name	Shihara	
1.Operator's salary	7 x 27,000 ¥/m	189,000 ¥/m
2.Fuel Cost	type/output / daily operating hours(hr) / unit consumption (lit/hr) / total consumption (lit) 70KVA/95ps 18.8 hr/d 9.8 184 100KVA/130ps 18.8 13.5 254 175KVA/220ps 18.8 22.8 x 2 857 200KVA/260ps 18.8 26.9 506 total 1,801	1,801 x 34 ¥ = 61,234 ¥ 61,234x 30 day = 1,837,020¥/m Lubricants 10 % 183,702 ¥/m
3.Pump/ generator repair cost	submersible pump (6,546,443 x 1.1) x 0.05 ÷ 12 booster pump ((3,133,564 + 6,758,009 + 4,989,651 + 7,298,990 + 5,079,518 x 2) x 1.1) x 0.05÷12 generator ((3,329,640 + 3,923,040 + 9,302,784 + 11,156,264) x 1.1) x 1.1 x 0.07÷ 12 central control panel (6,707,496 x 1.1) x 0.07 ÷ 12 TOTAL	30,005 ¥/m 146,847 ¥/m 161,653 ¥/m 43,070 ¥/m 381,575 ¥/m
4.Well rehabilitation cost		
5.Pipeline repair cost	(205,379,000 x 1.1 x 0.05) 6÷12 = 94,132	94,132 ¥/m
6.Faucets replacement cost	24,300 x 42pcs x 1.1 = 1,122,660 1,122,660 ÷24 = 46,778	46,778 ¥/m
Total operation/ maintenance cost		2,732,207 ¥/m (202,386 YR/m)
Water fee caluculation	design population: 8440 nos. of household: 1688 water fee = OM cost/household=1,619 ¥/m (120 YR/m) water fee ratio to household income: 3.0 %	
Note		

Site Name	Ad Dahi	
1.Operator's salary	5 x 27,000 ¥/m	135,000 ¥/m
2.Fuel Cost	type/output / daily operating hours(hr) / unit consumption (lit/hr) / total consumption (lit) 20 PS / 13.2 / 2.1 / 27.7 27.7 x 2 nos = 55.4	55.4 x 34 ¥ =1,884 ¥ 1,884 x30days = 56,520 ¥/m Lubricants 10 % 5,652 ¥/m
3.Pump/ generator repair cost	6,423,992 x 2 nos x 1.1 = 14,132,782	(14,132,782 x 0.07) ÷12 = 82,440 ¥/m
4.Well rehabilitation cost	1,406,284 x 4 times ÷ 20years = 281,260	281,260 ÷ 12 = 23,438 ¥/m
5.Pipeline repair cost	80,430,255 x 1.1 = 88,473,280 (88,473,280 x 0.005) ÷12 = 36,864	36,864 ¥/m
6.Faucets replacement cost	24,300 x 28pcs x 1.1 = 748,440 748,440 ÷ 24 = 31,185	31,185 ¥/m
Total operation/ maintenance cost		371,099 ¥/m (24,489 YR/m)
Water fee caluculation	design population: 9,030 nos. of household: 1,806 water fee = OM cost/household = 205 ¥/m (15.2YR/m) water fee ratio to household income: 0.38 %	
Note	5 operators will be paid including subsitutes due to 2 shifts a day.	

Site Name	Harad	
1.Operator's salary	5 x 27,000 ¥/m	135,000 ¥/m
2.Fuel Cost	type/output / daily operating hours(hr) / unit consumption (lit/hr) / total consumption (lit) 13 PS (borehole pump engine) / 15.3 / 13.5 / 20.7 45KVA/57PS (generator for existing and new pumps) / 15.3 / 5.9 / 90.3	111 x 34 ¥ =3,774 ¥ 3,774 x30days =113,200 ¥/m Lubricants 10 % 11,320 ¥/m
3.Pump/ generator repair cost	(new borehole pump + supply pump + existing submersible pump) (5,517,912 + 1,465,661 + 7,000,000) x 1.1 = 13,983,573	(13,983,573 x 0.07) ÷ 12 = 81,571 ¥/m
4.Well rehabilitation cost	1,406,284 x 4 times ÷ 20years = 281,260	281,260 ÷ 12 = 23,438 ¥/m
5.Pipeline repair cost	76,119,889 x 1.1 = 83,731,878 (83,731,878 x 0.005)÷12 = 34,888	34,888 ¥/m
6.Faucets replacement cost	24,300 x 24pcs x 1.1 = 641,520 641,520 ÷ 24 = 26,730	26,730 ¥/m
Total operation/ maintenance cost		426,147 ¥/m (31,566 YR/m)
Water fee caluculation	design population: 6,920 nos. of household: 1,384 water fee = OM cost/household = 308 ¥/m (23 YR/m) water fee ratio to household income: 0.6 %	
Note		

v. Specification for the Equipment to be Supplied

Backhoe

Capacity of bucket	:	0.3 - 0.4 m^3
Max. drilling depth	:	more than 4m
Climbing capacity	:	more than 60%
Power	:	more than 75 ps
Total width	:	less than 2.6m
Total length	:	less than 4.0m

Truck for slope climbing

Loading capacity	:	more than 2.5 ton
Engine	:	4 cycle diesel engine
Max. power	:	more than 65 ps
Transmission	:	5-foreward, 5-rear, 4 x 4
Max. climbing capa.	:	30°
Total width	:	less than 2.5m
Total length	:	less than 5.5m

8 ton truck (equipped with crane)

Loading capacity	:	more than 8.0 ton
Engine	:	4 cycle diesel engine
Max. power	:	more than 180 ps
Transmission	:	4 x 4

Pick up

Total weight	:	more than 3,000 kg
Engine	:	4 cycle gasoline engine
Max. power	:	more than 120 ps
Transmission	:	4 x 4

A - 6 OTHERS

w. Design Criteria for Rural Water Supply Facilities of RWSD

YEMEN ARAB REPUBLIC

Rural Water Supply Department

Design Criteria for Rural Water Supplies

1. Population Present

Population statistic issued by the Central Planning Organization (CPO) show figures which appear to be on the lower side. Databank on Yemen's population issued in 1975 by the Swiss Technical Co-operation Service shows also figures lower than the actual population. Information provided by the local villages gives figures that are often exaggerated.

To obtain reasonable estimates of present population, the following steps should be followed:

a. Obtain COP figures: population, number of families and number of houses;

b. Obtain population estimate independently from more than one reliable source from the village;

c. Calculate population by:

- multiplying number of families by 7
- multiplying number of houses by 10;

d. Compare population estimates obtained from above a, b, and c, discarding doubtful figures, take the mean and then use it for design purposes;

e. Try and obtain from the village Sheikh population figure according to "FITRAH" (or religious taxes) which is probably the most accurate estimate although is usually indicates less figure than the actual population.

2. Population Future

It is pratically impossible to use population projection techniques as there exist no statistic prior to 1975 the overall growth rate is about 2.9% per annum; 2.5% for rural population and 8.5% for urban population. The growth rate in some urban towns may reach 16% and great care must therefore be exercised in establishing, as far as possible, how fast does a village or town expand by examining its economical and social conditions affecting such growth. In some cases, an idea of growth tendencies can be had by obtaining information on building permits granted ans population figures in the last few years.

The following table gives population projections for certain growth rates. Multiply present population by shown multiplier for the required design period.

Growth Rate %	Multiplier by 15 years	Multiplier by 20 years
2.5	1.41	1.60
3.0	1.51	1.75
3.5	1.62	1.92
4.0	1.75	2.11
4.5	1.85	2.31
5.0	1.98	2.53
5.5	2.12	2.77
6.0	2.26	3.03

However, it is suggested that the following projections be used;

a. For rural areas: 2 x present population;

b. For semi-urban centres: use an annual growth rate of 6% - or 3 x present population;

c. For urban centres: investigate each case separately.

3. Water Demand

a. 45 lit/person/day - using public fountains only with no house connections, especially when the source is not sufficient;

b. 80 - 100 lit/person/day - for general house connections with some public fountains. Use low figure for temperate climates and high figure for hot areas such as Tihama region;

c. Fire fighting demand - is not economically warranted for the rural areas.

4. Daily Operating Hours

Ideally, the shorter the daily operating hours the better, in order to facilitate operation and maintenance of the mechanical equipment and to provide flexibility in the operation of the system by enabling the operator to increase operation hours, if the need arises without putting too much load on the pumping unit.

Twenty-four hours operations is not desirable, as this leaves not time for necessary maintenance and would reduce the life of the pumping unit significantly. However, standby unit must be provided if 24 hours pumping is desired.

The following guidelines are proposed:

a. The design should aim at maximum daily operating hours of 8 - 20 hours at the end of the design period, if the source yield is adequate;

b. The daily operating hours should preferably not exceed 8 hours for human consumption if the same well is utilized to supply water for irrigation purpose;

c. If the yield of the available source is low, the daily operating hours at the end of the design period may have to be increased beyond 16 hours. In this case, the concerned authorities should be warned of the situation and advised to look for supplementary source. The period after which 16 hours daily pumping wil be necessary can be roughly calculated and noted.

5. Storage Tax (Storage Capacity)

a. For ground tanks storage capacity of the reservoir should be based on maximum daily demand at end of the design period. This is necessary in rural areas where repair of mechanical equipment may take a few days to be carried out. However, a maximum storage capacity of 250 m^3 or more may be used in larger villages.

If the designed storage capacity is more than 100 m^3 , then it is preferable to split the storage volume in phases according to the demand and local conditions and the availability of the funds.

b. For elevated tanks: about 25% of maximum daily demand at end of design period.

c. Use the following standard sizes for ground tanks:
25 - 50 - 100 - 150 - 200 - 250 m^3 .

d. Use the following standard sizes for elevated tanks: 40 - 60 - 100 m^3 .

6. Water Distribution Networks

a. For small water distribution systems with no fire hydrants, the minimum head at any point in the system should be 10 m for double-storey houses.

b. For water distribution systems with fire hydrants, the minimum head should be 20 m.

c. In case the fire fighting vehicles are equipped with pumping unit then the pressure may be reduced.

7. Public Fountains

a. Standard units are for 2-4 and 6 taps per unit.

b. The loading per tap should not exceed 200 persons.

c. Maximum walking distance to any public fountain should preferably not exceed 200 m.

8. Distribution Flow

The gravity flow in any pipe should be taken as 2 times the average daily flow. The average flow is the total demand divided by 24 hours (converted to litres per seconds or US gpm).

9. Arrangement of Valves

a. Immediately on the pump discharge line a non-return valve should be installed followed by sluice (or gate) valve.

b. Air-relief valves must be installed at high points on pipelines.

c. Drain valves (sluice or gates) must be installed at low points in pipelines.

d. Working pressure must be defined in the drawing.

10. Water Marker

In high pressure systems it is necessary to calculate the instantaneous rise in pressure at the pump upon closure of the non-return valve after stoppage of the pumping unit. This rise in the pressure should be added to the total manometric head and the summation constitutes the working pressure for the pipe.

11. Duration of Prime Movers

Engines must be derated for the altitude and maximum ambient temperature combined. Humidity has also an effect on the rating of electric motors.

12. How to Specify Pumps

Any pump must be specified by the following:

a. Discharge: (US gpm) or (lit/second)

b. Total manometric head - m

c. Internal size of well casing (if a deep well)

d. Installation depth (if a deep well). Consideration must be given in both horizontal and vertical pumps to the NPSH (Net Positive Suction Head) of the pumps in question.

e. Minimum rated output of prime mover which must be based on: Temperature and altitude duration and the maximum S.N.P. of the pump at rated speed (not the SNP at the rated Q and E). An allowance should be added for flexibility of operation and other factors such as type of drive (clutch or belt).

f. Multiplier of the power needed is 1.2 - 1.4.