Report

On

WATER QUALITY ANALYSIS

For

SEVEN TOWNS IN DEBUB REGION

Fikremariam Kahsai
Department of water resources
Asmara, Eritrea
Oct.24,1997

Introduction

As per request of Japan international co-operation agency (JICA) study team, the laboratory of WRD has conducted water quality analysis for seven target towns in the southern region of the country. These towns are, Debarwa, Mendefera, Adi-Quala, Dekemhare, Segeneiti, Adi-Keyih, and Senafe. The study encompasses chemical, bacteriological and physical assessment of water samples. To accomplish the task, ten sampling points were chosen from each town.

Water source intended for drinking should fulfil requirements which are essential for the well being of the consumer. It should be safe, as well aesthetically acceptable. The basic aspect of water quality which should be examined are:

1. Chemical quality: Chemically, water for public supply should hold optimum concentration of ions and trace metals.
2. Bacteriological quality: It should be free from pathogenic micro-organisms.
3. Physical quality: Aesthetically it should be acceptable to consumers. Meaning, its taste should be palatable, its color and odor acceptable.

The bacteriological and physical examination of water points was carried out in the field, and the technique used for the enumeration of coliforms was membrane filtration. Concerning chemical analysis, water samples were brought to the WRD water laboratory in Asmara and analysed

The analytical results and location of of the sampling points (in UTM coordinates) are annexed within this report.

Evaluation of analytical data

Water for public water supply should be free from any pathogens, chemically safe for human consumption and aesthetically acceptable.

To meet the intended purpose some countries set their own drinking water standards which comply with their own specific conditions. Most countries in the world follow WHO guidelines. Inspite of this, there are no measure differences between standards of some developed countries and that of WHO.
For practical purposes of this report, all references and evaluations of analytical data are given on WHO guidelines.

1. Physio-Chemical characteristics:

A. Electrical conductivity (EC)

EC is a measure of the ability of salts in solution to carry an electric current. The EC value rises with the rise in the degree of mineralisation or salinity.
Potable water should consist optimum concentration of dissolved substances, to serve as feasible source. Consideration of EC value as water quality is mainly due to its effect on taste. WHO has not set a standard for EC value, but the guideline value for TDS(total dissolved solids) which is directly related to EC (TDS = kEC, Where k ranges 0.55 to 0.7 for natural waters) is 1000ppm.
Among the seventy samples analysed from the seven towns, a borehole in Adiquala (AD-06), a well in (SG-09), borehole and a well in Dekemhare (DK-04), (DK-10), have electrical conductivity value greater than 1200 μs/cm to impart disagreeable taste.

B. pH Value

The pH value which is a measure of the concentration of the hydrogen ion is used as indicator of either acidic or basic pollution. The pH value of all the waters in the towns lie within the range of 6.5-8.5 units, which is a recommended limit for drinking.

C. Turbidity

Clarity is an important water quality parameter of water supply. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. If the turbidity exceeds 5NTU, then it is clearly visible in a glass of water and usually rejected by consumer on aesthetic grounds.

Turbidity higher than the recommended value was registered in Segeneyti, Kilowlie(Mendefera),Sememo(Adiquala), and Adi-Keyih dams. This is mainly caused by silt and clay materials transported with the flowing water during raining.
The other sources which are mainly ground water, have value less than 5NTU which meets the standard of WHO.

D. Total Hardness

Total hardness is the sum of calcium and magnesium concentrations, both expressed as calcium carbonate, in milligrams per litre. The hardness or softness of water varies from place to place and reflects the nature of the geology of the area with which the water has been in contact. In general, surface waters are softer than ground waters. Hard waters are associated with chalk and limestone catchment areas, whereas soft waters are associated with impermeable rocks such as grinite.

Very hard water, greater than 350 mg/l as CaCO3, causes scale deposition in pipelines and scum formation in boilers. Soft Waters, less than 75 mg/l as CaCO3 causes leaching of metals and corrosion.
The dams in Adi-Keyih(AK-09), Adi-Quala(AD-01), and Mendefera (Kilowlie)(MN-01) has 62, 54, and 48 mg/l total hardness as Calcium Carbonate, hence classified as soft water. Whereas, nine sampling points which are coded as SN-02, SN-08, AD-06, MN-06, MN-08, DB-06, SG-09, DK-04 and DK-10 has registered hardness value ranging 350 to 743 mg/l as Calcium Carbonate. Therefore, classified as very hard waters.

E. Nitrogenous Compounds

The chemical compounds nitrate, nitrite, and ammonia play a major role in evaluation of water quality. Three of them are interconnected by nitrogen cycle, hence one is a precursor of the other. oxidation of ammonia gives rise to nitrite and further to nitrate. The main concern of nitrate presence in excess is that it is linked to a condition known as blue baby syndrome or infant methaemoglobinemia. Due to its toxicity effect on human body, an upper limit value of 45mg/l has been set.

As the analytical results show, boreholes in Adi-Keyih (AK-10), Adi-Quala (AD-06), and Dubarwa (DB-05), a borehole(DK-04) and a well (DK-10) in Dekemhare, registered 45.2, 89.5, 64.2, 97.4, and 51.8 mg/l nitrate respectively.
Besides, in Senafe at consumer's tap (SN-06), the levels of nitrite was 5.16mg/l . This is exceedingly high in relation to WHO guideline value, which is 3mg/l as nitrite. This could be due to old pipeline system which permits intrusion of contaminants.
The possible source of nitrate contamination is organic matter broken down by bacteria in the soil.

F. Chloride

Chloride is widely distributed in nature in the form of varied salts. Its presence in natural waters can be attributed to dissolution of salt deposits, sewage discharges and sea water intrusion in coastal areas.
The taste threshold for chloride in drinking water is dependent upon the associated cation, but is usually within the range 200-300mg/l. WHO recommends a guideline value of 250mg/l .
Among the seventy samples analysed, with the exception of a bore hole in Dekemhare (DK-04) which was found 260mg/l, all were found to contain less than 250mg/l, hence in the desired limit.

G. Sulphate

High sulphate concentrations in water may contribute to the corrosion of metals in the distribution system. Due to the cathartic effect of sulphate, a guideline value of 400mg/l is set.

The sulphate content of all the analysed samples is far less than the recommended guideline value, therefore there will not be any sulphate related problem with the water supplies.

H. Sodium

The recommended guideline value is 200mg/l which is based on taste thresholds. With the exception of a borehole in Dekemhare (DK-04) which is found to be 215mg/l, all the analysed samples showed a sodium level in the range of acceptable quantity.

I. Iron and Manganese

Both chemical elements are related with staining of laundry and sanitary ware. For this reason a guideline value of 0.3mg/l and 0.1mg/l is set for iron and manganese respectively. For health related reasons a 0.5mg/l guideline value is set for manganese.
Among the analysed samples, a borehole in Senafe (SN-10), a dam in Mendefera (MN-01), and a well in Segeneyti (SG-07) were found to contain 0.39mg/l, 0.41mg/l and 0.61mg/l of iron. The rest samples are free from iron which can cause staining.
Furthermore, four water sources are found to consist 0.2mg/l of manganese. These are, a spring and a hand dug well in Dubarwa (DB-09, DB-10), a well in Segeneyti (SG-07) and a borehole in Dekemhare (DK-05). The rest are found to be free from manganese induced staining problems.

J. Fluoride

Fluoride levels in excess of 1.5mg/l lead to an increase in the occurrence and severity of dental fluorosis (teeth become mottled and brittle). Normally, 1 to 2mg/l fluoride is mentained in public drinking water supplies for the prevention of dental carries in children. All the analysed samples of water showed that the sources contain optimum concentration of fluoride.

K. Copper

As Debarwa was a copper mining site, analysis of water points for copper was done to evaluate the water chemistry of the town.
The guidelines value for copper for health related considerations is 2mg/l.
All the samples analysed contain copper in the limits of the recommended value.

Conclusion Concerning Pysio-Chemical Characteristics

Generally the physio-chemical characteristics of water sources in the seven towns is evaluated as good . The few exceptions being a borehole in Adiquala (AD-06), a well in Segeneyti (SG-09), borehole and a well in Dekemhare (DK-04), (DK-10), which have electrical conductivity value greater than 1200 μs/cm to impart disagreeable taste.

In addition, boreholes in Adi-Keyih (AK-10), Adi-Quala (AD-06), and Dubarwa (DB-05), a borehole(DK-04) and a well (DK-10) in Dekemhare, were found to contain 45.2, 89.5, 64.2, 97.4, and 51.8 mg/l nitrate respectively, which could be potentially health hazard to consumers.

2. Bacteriological Characteristics

The basic requirement for any water source to be considered as an acceptable source for drinking is that it should be freed from bacteria, virus and protozoan.

In evaluation of bacteriological safety of water, routinely testes are done to identify for organisms indicators of pollution. The coliform group of bacteria which are found in sewage, animal and human excrement are the accepted indicators of pathogenic micro-organisms.

WHO standard recommends drinking water must not contain faecal coliform bacteria. Otherwise, it is unsafe for human consumption.

Out of seventy samples analysed from the seven towns, 29 were found to be contaminated with bacteria which are faecal in origin. This shows that the sanitary conditions of the water sources and reservoirs is not well mentained. The most probable source of contamination is human and animal waste which adds up to dams, ground water sources and pipeline systems with run off, percolation and infiltration respectively.

Total coliform bacteria should not occur repeatedly in water samples in regular water quality monitoring programme. Thier presence in a single analysis, as in the case of this study, does not necessarly imply the water sources are unsafe.

Conclusion Concerning Bacteriological Characteristics

As twenty nine of the seventy sampling points were found to be bacteriologically contaminated, it can be concluded that some of the people in these towns is getting unsafe water. However, it is noteworthy to mention that high rate of contamination may be due to unusual rainfall in the area before sampling which may helped to carry/percolate human and animal waste to the sources.
To improve the situation:

- The sanitary condition of the surroundings of the water points should be improved.
- Open wells should be covered with slab and a pump installed.
- Supplies from surface water should be treated before distribution.
- Regular water quality monitoring programme should be introduced.
- Public awareness on hygiene and sanitation should be increased.

Table-4 Water Quality In Dekemhare

I. Physical Quality

Date Sampled 21/10/97

Date Analysed 22/10/97

Well Ident	Description	EC us/cm	pH	Temp °c	Odor	Taste	Turb. NTU	Color
DK-01	BH,Motorized,Bloko	876	7.1	23.0	agreeable	agreeable	<5	clear
DK-02	BH,Motorized,Asali	980	7.0	21.3	agreeable	agreeable	<5	clear
DK-03	Main reservoir 340cu.m	926	7.0	22.2	agreeable	agreeable	<5	clear
DK-04	BH,Erdi-Awet School	1980	6.9	24.4	agreeable	salty	<5	clear
DK-05	BH,Ruba Adi Harm	684	6.6	24.3	agreeable	agreeable	<5	clear
DK-06	BH,Adi golgol	635	7.0	21.2	agreeable	agreeable	<5	clear
DK-07	HDW,Private,Hadamu	477	6.8	21.1	agreeable	agreeable	<5	clear
DK-08	Consumer's Tap	898	7.1	19.7	agreeable	agreeable	<5	clear
DK-09	Consumer's Tap	922	7.1	22.5	agreeable	agreeable	<5	clear
DK-10	HDW, miss.school	1290	6.8	24.5	agreeable	salty	<5	clear

II. Bacteriological Quality

T.C.B = Total Coliform Bacteria

F.C.B = Faecal Coliform bacteria

Well Ident	T.C.B count/100ml,35°c	F.C.B count/100ml,44.5°c	Remarks
DK-01	0	0	Safe
DK-02	0	0	Safe
DK-03	0	0	Safe
DK-04	0	0	Safe
DK-05	0	0	Safe
DK-06	10	4	contaminated
DK-07	0	0	Safe
DK-08	0	0	Safe
DK-09	0	0	Safe
DK-10	0	0	Safe

III. Chemical Quality

Date Sampled 21/10/97

Date Analysed 07/11/97

Well Ident	Description	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Fe mg/l	Mn mg/l	HCO3 mg/l	SO4 mg/l	Cl mg/l	NO3 mg/l	N-NH3 mg/l	NO2 mg/l	F mg/l	Hard. *G.d.h
DK-01	BH,Motorized,Bloko	72	27	87	2.6	0.06	0.1	342	67	84	5.8	0.25	0.04	0.98	16.3
DK-02	BH,Motorized,Asali	94	9	99	2.2	0.22	0.1	332	72	148	22.1	0.20	0.03	0.98	15.2
DK-03	Main reservoir 340cu.m	104	4	84	2.2	0.01	0.0	317	61	124	19.9	0.27	0.02	0.93	15.4
DK-04	BH,Erdi-Awet School	96	55	215	3.1	0.02	0.0	405	140	260	97.4	0.85	0.07	0.46	26.1
DK-05	BH,Ruba Adi Harm	75	0	61	2.2	0.00	0.2	300	30	66	0.0	0.13	0.01	0.61	10.5
DK-06	BH,Adi golgol	48	27	78	1.3	0.10	0.1	273	33	56	14.6	0.09	0.14	0.90	13.0
DK-07	HDW,Private,Hadamu	49	22	24	1.8	0.03	0.0	185	25	20	25.2	0.06	0.81	0.67	11.9
DK-08	Consumer's Tap	102	8	89	1.8	0.04	0.1	332	59	104	21.3	0.11	0.04	0.88	16.1
DK-09	Consumer's Tap	99	13	88	2.6	0.02	0.0	322	68	120	43.0	0.20	0.02	1.06	16.8
DK-10	HDW, miss.school	109	23	127	3.1	0.05	0.0	322	71	132	51.8	0.40	0.03	1.41	20.6

*G.d.h = German degree of hardness,1G.d.h = 17.9mg/l hardness as CaCO3

* Note: HDW = hand dug well
BH = Borehole

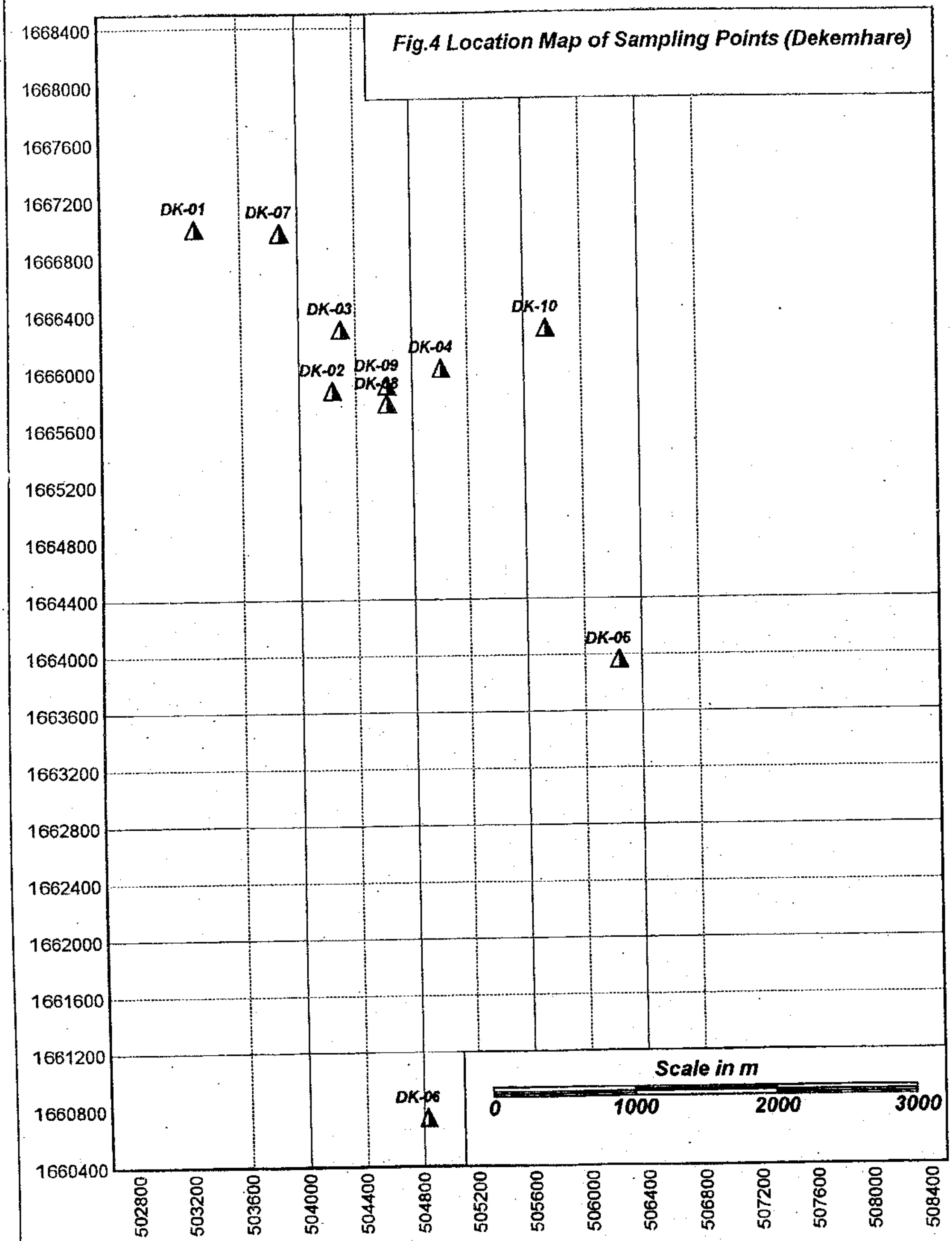


Fig.4 Location Map of Sampling Points (Dekemhare)
1668400
1668000
1667600
1667200
1666800
1666400
1666000
1665600
1665200
1664800
1664400
1664000
1663600
1663200
1662800
1662400
1662000
1661600
1661200
1660800
1660400
502800
503200
503600
504000
504400
504800
505200
505600
506000
506400
506800
507200
507600
508000
508400
DK-01
DK-07
DK-03
DK-10
DK-04
DK-02
DK-09
DK-06
DK-05
Scale in m
0
1000
2000
3000

Report

on

WATER QUALITY ANALYSIS

JICA TESTING BOREHOLES IN DEBUB REGION

Fikremariam Kahsai
Water Resources Department
Asmara, Eritrea
Feb. 19, 1998

Water Quality Evaluation of testing boreholes drilled in Debub region of JICA project

1. Mendefera :

Borehole No1 of Adimongoti is of acceptable with respect to chemical and bacteriological quality. Though manganese is present in significant concentration, it has not exceeded the WHO guidelines to cause any staining problems and, as the water is very soft it will be corrosive to pipelines. Besides, the pH is high (8.66) to make the water tastes alkaline.

2. Dubarwa :

This borehole has chemically and bacteriologically acceptable water quality although slightly hard due to calciumbicarbonate.

3. Segeneyti (SEG-01):

The water quality of this borehole is bacteriologically safe and based on the amount of total dissolved solids it is chemically acceptable for drinking. But, the concentration of manganese which is 0.4mg/l exceeds the WHO guidelines of 0.1 mg/l, therefore it will cause staining problem. The amount of ammonia though in the limits of WHO guidelines is considerable to show that there is domestic organic contamination. Furthermore it is slightly hard water which will consume considerable amount of soap for lathering.

4. Segeneyti (SEG-03) :

The source is bacteriologically safe for domestic water supply. Chemically the water quality is fairly good. The electrical conductivity value indicates that the dissolved solids are within the limits of WHO guidelines. Hence good quality with respect to dissolved solids. But, the source is slightly hard water and with manganese concentration exceeding the WHO guideline value to cause staining problem.

5. Adikeyih/ Tekondae (ADK-01):

The source is bacteriologically acceptable for drinking. The amount of dissolved solids indicated by the electrical conductivity value is considerable though in the limits of WHO guidelines.

The amount of ammonia is high showing sewage or organic pollution. Furthermore, the concentration of manganese is higher than WHO guideline value. The degree of clarity of the water is not satisfactory which is measured 5 NTU. Besides, it is very hard water due to calciumbicarbonate.

The source can be used as source of water supply only if no better alternative source is available.

6. Adi-Keyih/ Adiwegera (ADK-02):

The source is bacteriologically acceptable for drinking. Chemically the water quality is fairly good . The dissolved minerals is considerable though in the range of WHO guidelines and the concentration of manganese is high to cause staining in laundry and utensils. The amount of calcium is high to make the source hard water. The amount of ammonia though not exceeding WHO guidelines it indicates occurrence of organic contamination.

7. Senafe (SEN-02):

The borehole is found to contain bacteria indicators of faecal pollution. Therefore the source is bacteriologically unsafe for human consumption. Chemically, the source has good composition except for manganese (0.3mg/l) which is exceeding the WHO guidelines of 0.1mg/l for reasons of aesthetic.

8. Dekemhare : DEK-01 and DEK-02

These sources are found to be free from bacteriological contamination. Therefore bacteriologically safe for drinking. Chemically, though safe from health point of view, there are high concentration of calcium and magnesium to make the sources very hard water.

Table 1. Water Quality of JICA testing wells in Zoba Debub

I. Physical Quality

Date Sampled 05.01.98 - 30.01.98

Date Analysed 13.01.98 - 06.02.98

II. Bacteriological Quality

T.C.B = Total Coliform Bacteria

F.C.B = Faecal Coliform Bacteria

Well Idnt	Sub-Zoba	EC	pH	Temp	Odor	Taste	Turb	Color	T.C.B	F.C.B	Remarks
		us/cm		°c			NTU		count/100ml,35°c	count/100ml,44.5°c	
MEN-01	Mendefera	468	8.66	22.1	agreeable	agreeable	0	clear	0	0	safe
DUB-01	Dubarwa	762	7.46	22.2	agreeable	agreeable	0	clear	0	0	safe
SEG-01	Segeneyti	832	6.95	24.0	agreeable	agreeable	0	clear	0	0	safe
SEG-03	Segeneyti	791	6.74	22.5	agreeable	agreeable	0	clear	0	0	safe
ADK-01	Adi-Keyih	1051	6.85	21.4	agreeable	agreeable	5	muddy	0	0	safe
ADK-02	Adi-Keyih	948	6.77	20.7	agreeable	agreeable	0	clear	0	0	safe
SEN-01	Senafe	734	6.68	21.5	agreeable	agreeable	0	clear	many	30	contaminated
DEK-01	Dekemhare	1247	7.10	22.7	agreeable	agreeable	0	clear	0	0	safe
DEK-02	Dekemhare	1184	6.91	22.6	agreeable	agreeable	0	clear	0	0	safe

III. Chemical Quality

Date Sampled 05.01.98 - 12.02.98

Date Analysed 13.01.98 - 18.02.98

Well Idnt	Sub-Zoba	Ca	Mg	Na	K	Fe	Mn	HCO3	SO4	Cl	NO3	N-NH3	NO2	F	Hardness
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	*G.d.h
MEN-01	Mendefera	2.9	0.7	92.4	0.7	0.02	0.1	122.0	34.0	60.0	4.9	0.01	0.004	0.26	0.56
DUB-01	Dubarwa	86.0	32.8	30.8	0.5	0.04	0.0	427.0	32.0	30.0	10.6	0.02	0.340	0.18	19.55
SEG-01	Segeneyti	96.0	37.7	42.9	7.6	0.05	0.4	420.9	68.0	45.0	1.3	0.54	0.000	1.22	22.06
SEG-03	Segeneyti	102.0	32.8	35.2	0.6	0.07	0.4	555.1	34.0	40.0	7.1	0.26	0.049	0.42	19.83
ADK-01	Adi-Keyih	124.0	47.4	51.2	0.6	0.02	0.2	542.9	135.0	32.5	2.7	1.11	0.009	0.62	28.21
ADK-02	Adi-Keyih	110.0	30.4	56.1	0.4	0.02	0.4	488.0	75.0	50.0	1.8	0.60	0.007	0.38	22.35
SEN-01	Senafe	82.0	7.3	40.7	4.5	0.03	0.3	268.4	39.0	30.0	2.7	0.40	0.013	1.05	13.13
DEK-01	Dekemhare	141.2	27.2	75.0	0.9	0.09	0.1	402.6	70.0	155.0	6.2	0.52	0.007	0.52	25.98
DEK-02	Dekemhare	120.0	24.3	98.0	1.2	0.02	0.1	323.3	75.0	170.0	36.3	0.34	0.290	0.44	22.35

*G.d.h = German degree of hardness, 1G.d.h = 17.9 mg/lhardness as CaCO3

Groundwater monitoring data
DEKEMHARE at 6:00 a.m.

Date	Reading	from G.L
(10:40)3/11	13m60.0	-13.600
1998/3/12	13m60.0	-13.600
1998/3/13	13m60.2	-13.602
1998/3/14	13m60.2	-13.602
1998/3/15	13m60.2	-13.602
1998/3/16	13m60.3	-13.603
1998/3/17	13m60.8	-13.608
1998/3/18	13m61.1	-13.611
1998/3/19	13m61.2	-13.612
1998/3/20	13m61.6	-13.616
1998/3/21	13m61.8	-13.618
1998/3/22	13m61.9	-13.619
1998/3/23	13m62.0	-13.620
1998/3/24	13m62.2	-13.622
1998/3/25	13m62.7	-13.627
1998/3/26	13m62.8	-13.628
1998/3/27	13m63.2	-13.632
1998/3/28	13m63.2	-13.632
1998/3/29	13m63.0	-13.630
1998/3/30	13m63.2	-13.632
1998/3/31	13m63.2	-13.632
1998/4/1	13m63.9	-13.639
1998/4/2	13m64.0	-13.640
1998/4/3	13m64.0	-13.640
1998/4/4	13m64.0	-13.640
1998/4/5	13m64.0	-13.640
1998/4/6	13m64.2	-13.642
1998/4/7	13m64.3	-13.643
1998/4/8	13m64.8	-13.648
1998/4/9	13m64.8	-13.648
1998/4/10	13m65.0	-13.650
1998/4/11	13m65.0	-13.650
1998/4/12	13m65.2	-13.652
1998/4/13	13m65.6	-13.656
1998/4/14	13m66.0	-13.660
1998/4/15	13m66.0	-13.660
1998/4/16	13m66.1	-13.661
1998/4/17	13m66.1	-13.661
1998/4/18	13m66.2	-13.662
1998/4/19	13m66.2	-13.662
1998/4/20	13m66.5	-13.665
1998/4/21	13m66.9	-13.669
1998/4/22	13m67.0	-13.670
1998/4/23	13m67.0	-13.670
1998/4/24	13m67.3	-13.673
1998/4/25	13m67.4	-13.674
1998/4/26	13m67.6	-13.676
1998/4/27	13m68.1	-13.681
1998/4/28	13m68.1	-13.681
1998/4/29	13m68.2	-13.682
1998/4/30	13m68.4	-13.684
1998/5/1	13m68.8	-13.688
1998/5/2	13m68.9	-13.689
1998/5/3	13m69.0	-13.690
1998/5/4	13m69.3	-13.693
1998/5/5	13m69.5	-13.695
1998/5/6	13m69.6	-13.696
1998/5/7	13m69.7	-13.697
1998/5/8	13m69.8	-13.698
1998/5/9	13m69.8	-13.698
1998/5/10	13m69.6	-13.696
1998/5/11	13m69.6	-13.696
1998/5/12	13m69.6	-13.696
1998/5/13	13m69.6	-13.696
1998/5/14	13m69.6	-13.696
1998/5/15	13m69.6	-13.696
1998/5/16	13m70.0	-13.700
1998/5/17	13m70.0	-13.700
1998/5/18	13m70.0	-13.700
1998/5/19	13m70.0	-13.700
1998/5/20	13m70.1	-13.701
1998/5/21	13m70.2	-13.702
1998/5/22	13m70.2	-13.702
1998/5/23	13m70.7	-13.707
1998/5/24	13m71.0	-13.710
1998/5/25	13m71.0	-13.710
1998/5/26	13m71.1	-13.711
1998/5/27	13m71.0	-13.710
1998/5/28	13m71.2	-13.712
1998/5/29	13m71.6	-13.716
1998/5/30	13m72.0	-13.720
1998/5/31	13m72.1	-13.721
1998/6/1	13m72.1	-13.721
1998/6/2	13m72.1	-13.721
1998/6/3	13m72.3	-13.723
1998/6/4	13m72.5	-13.725
1998/6/5	13m72.7	-13.727
1998/6/6	13m72.8	-13.728
1998/6/7	13m73.0	-13.730
1998/6/8	13m73.0	-13.730
1998/6/9	13m73.5	-13.735
1998/6/10	13m73.6	-13.736
1998/6/11	13m73.9	-13.739
(17:35)6/11	13m74.0	-13.740

Appendix C-7 Well Inventory Study

C-7.1 Well Inventory

Table -.-.4 Well Inventory 4 -1 DEKEMHARE

<Well Ident>	<Location>	<Altitute> (m)	<Latitude: deg	min	sec	<Longi.> deg	min	sec	<Wateruse>	<Constr. year>	<Depth> (m)	<Diameter (m)	<Water level(m)>	<Yield> (l/min)	EC(micro S/cm)	<pH>	<Pump system>	<Pump status>	<Remarks>	<Well ident. of WRD>
BH-1	Revolution Boarding School	2030	15	5	7	39	1	36	Domestic	Ethiopian period	47	0.1524	16.03		869	7.09	Motor (KUBOTA)	Functional	11 to 12 hrs/day	
BH-2	Brocho(Asmara)	2029	15	4	56	39	1	48	Out of use	1983	50	0.1524	10.35				Motor (LISTER)	Out of use		
BH-3	Brocho(Asmara)	2029	15	4	49	39	1	53	Out of use	1992	70	0.2032						Out of use		
BH-4	Brocho(Asmara)	2029	14	4	45	39	1	55	Public W/S Dekemhare	1992	60	0.2032			876	7.47	Motor (1.43 *l/sec*)		10 to 12 hrs/day	
BH-5	Brocho(Asmara)	2029	14	4	45	39	1	55	Capped	1937		0.3048					Motor (OSNO)			
BH-6	Brocho(Asmara)	2029	14	4	45	39	1	55	Capped	1988	60	0.1524								
BH-7	Brocho(Asmara)	2029	14	4	45	39	1	54	Capped	1937		0.3048								
BH-8	Asali	2010	15	4	13	39	2	26	Public W/S Dekemhare	1993	48	0.2032			1091	7.51	Motor(MONOLIFT)	Functional		
BH-9	Asali	2010	15	4	13	39	2	26	Capped	1993		0.2032								
BH-10	Asali	2009	15	4	12	39	2	33	Public W/S Dekemhare	1987	60	0.2032	14.84					Urgent use(extremely few water)		
DW-11	Asali	2010	15	4	12	39	2	32	Dry					dry						
BH-12	Elementary school	2010	15	4	9	39	2	52	Domestic	1993	46	0.2032			2240	6.74	Submersible (HELIOS solar)	Functional		
BH-13	In front of Paradise hotel	2010	15	4	6	39	2	59		Italian period		0.1524								
BH-14	Adi Golgol	1950	15	1	19	39	2	44	Public W/S Dekemhare	1994	50.75	0.2032	7	480			Motor (CAPRARI, 5.5 *l/sec*)	Functional	Water tanker	

(continue)

4 -2 (Dekemhare)

<Well Ident>	<Location>	<Altitute> (m)	<Latitude> deg	min	sec	<Longi.> deg	min	sec	<Wateruse>	<Constr. year>	<Depth> (m)	<Diameter> (m)	<Water level(m)>	<Yield> (l/min)	EC(micro S/cm)	<pH>	<Pump system>	<Pump status>	<Remarks>	<Well ident. of WRD>
DW-15	Adi Golgol(near 14BH)	1950	15	1	18	39	2	43												
BH-16	Adi Golgol	1980	15	2	11	39	2	45	Capped	1997	49	0.3048		dry					The Sector Study	
BH-17	Adi Golgol	1990	15	2	27	39	2	57	Out of use	1994	80	0.3048							WRD	
BH-18	Adi Golgol	1990	15	2	35	39	2	40	Out of use			0.2032							American base camp	
BH-19	Adi Harum	1990	15	3	8	39	3	27	Public W/S Dekemhare	1994	42	0.2032			816	5.45	Motor (DEUTZ, 5.7 l/sec)		Water tanker	
BH-20	Adi Harum	1980	15	3	5	39	3	27	Out of use	1993	72	0.2032								
BH-21	Secondary school	2020	15	3	52	39	2	57	Domestic	1992		0.2032					Hand (India Mark II)	Not functional		
BH-22	Mt. Tseghay's residence	2020	15	4	3	39	3	5	Domestic & irrigation	1994	45	0.254			3240	5.24	Submersible	Functional		
BH-23	Faith mission	2030	15	4	18	39	3	10	Domestic			0.2032			1522	5.42	Hand (India Mark II)	Functional		
BH-24	Catholic church for girls(Daniel COMBONI)	2030	15	4	5	39	2	56	Domestic		52	0.2032	19.05				Hand (India Mark II)	Repairing		
DW-25	Catholic church for boys(COMBONI)	2040	15	4	18	39	2	48	Domestic (not for drinking)	1935	16.7	2.3 x 2.25			2160	4.92	Motor			
BH-26	Public park	2030	15	3	58	39	2	51	Domestic			0.2032			2810	4.92	Hand (India Mark II)	Functional		
BH-27	Adi Amhara	2000	15	3	37	39	2	8	Domestic								Hand (India Mark II)	Functional		
DW-28	Adi Amhara	2000	15	6	30	39	2	13	Domestic											

Date surveyed : mainly 31 Oct., 1997

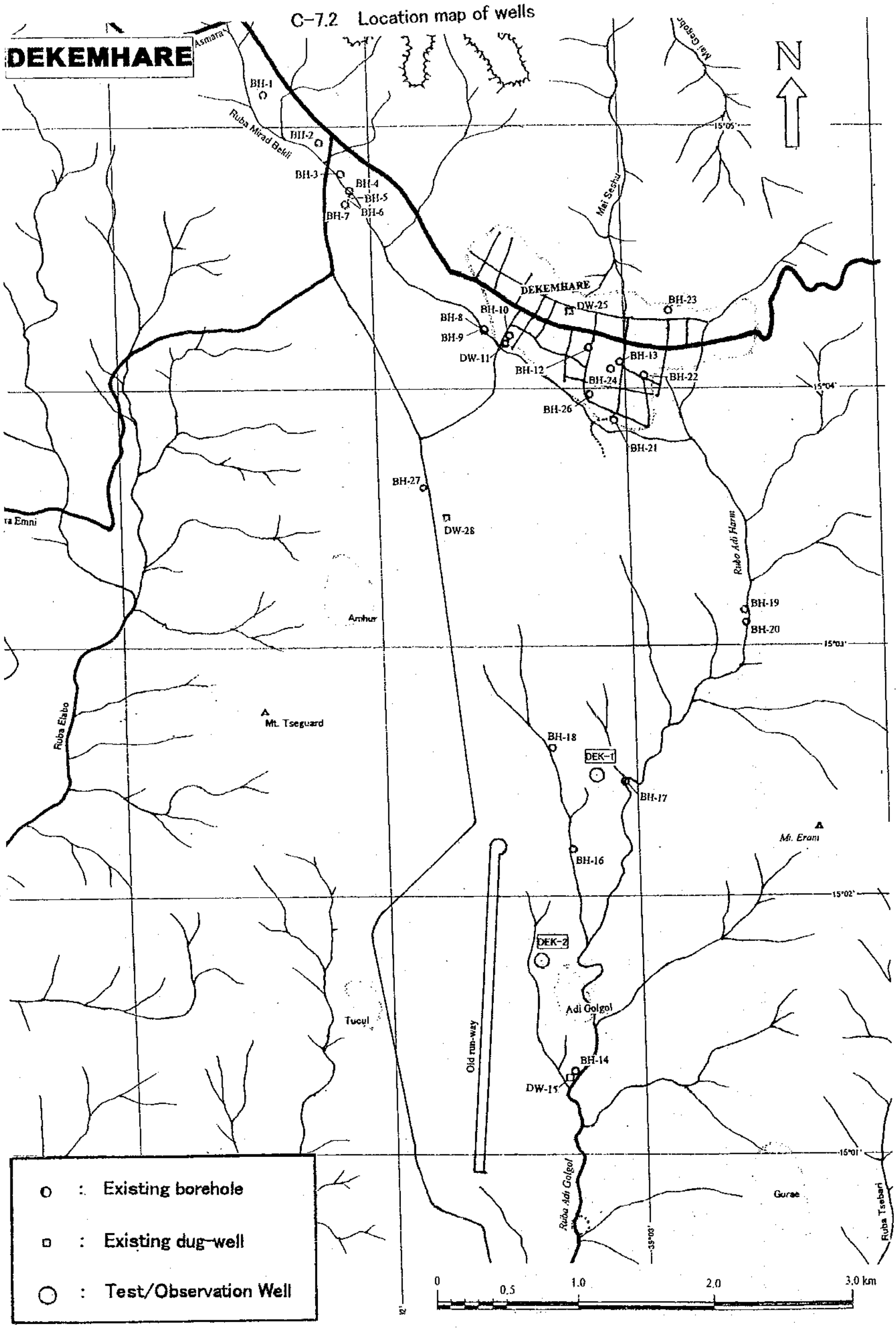
Well ident. : BH:Borehole, DW:Dug well, R:Reservoir

Bracket of construction year : year of repair

Bracket of Wpt. Diameter : inside diameter

Bracket of pump system : pump type and capacity

C-7.2 Location map of wells



Appendix C-8 Technical Specification of Production Well

1. SCOPE OF WORKS

1.1. OBJECTIVES OF WORKS

The objectives of works are to establish production well(s) for one of the water sources of _____ town. The detail of specifications will be mutually adjusted between the Engineer and the Contractor during the course of work.

1.2. CONTENTS OF WORKS

The content of works under this Contract consists of as below:

(1) Mobilization and Demobilization to/from the survey area, inclusive of moving from the Site to Site, and Site preparation. .

(2) Production Well Drilling;
Drilling works, inclusive of a drilling, borehole logging, casing installation, gravel-packing, grout-sealing, development, head works, etc.

(3) Pumping Test, composed of Preliminary, Step-drawdown, Constant discharge, and Recovery tests, inclusive of water sampling and water quality analysis.

(4) Reporting, inclusive of daily drilling records, borehole and lithological logs, pumping test records, photographs, sketches, and so forth.

1.3. MEASUREMENT AND PAYMENT

The measurement and payment for the works carried out by the Contractor shall be made in accordance with the quantity actually worked out by the Contractor and confirmed by the Engineer's (Consultant's supervisor) measurement; and the unit or lump sum price specified in the Bill of Quantities, APPENDIX-__ of the Contract.

The unit or lump sum price specified in the Bill of Quantities shall be deemed to involve every costs necessary for the appropriate item of work inclusive of personnel, machinery amortization, consumable and permanently installed materials, overhead, profit, tax, duties and so forth. No extra payment shall be made for the lump sum price in case the quantities of works specified in the Bill of Quantities may be increased or decreased.

2. LOCATION OF WORKS

The works under this Contract are to be carried out in and around the six (6) towns as shown in the Figure-A "Location Map of the Drilling Works" attached.

The exact well drilling sites are to be indicated in-situ to the Contractor by the Engineer prior to the mobilization of drilling equipment.

3. EQUIPMENT, TOOLS, DEVICES AND MATERIALS TO BE EMPLOYED

3.1. GENERAL

The equipment, sampler, tools, measuring devices, and materials to be employed to the works under this Contract shall be provided by the Contractor, excepting water sampler for water quality analysis, and water quality meters for in-situ water quality test which are to be provided by the Study Team.

The Contractor shall submit, prior to the mobilization to the area, a list of equipment, samplers, and major tools, describing the model, type, capacity, specification, quantities to the Engineer for his approval.

3.2. SCREEN AND BLANC CASING

Blank casing pipes for the wells shall be made of PVC with inner-diameter of 6 inches.

Screen pipes to be installed in the wells shall also be made of PVC with 6 inches diameter and of open ratio of more than ten percent (10%).

3.3. CENTRALIZER AND BOTTOM PLUG

Centralizer and bottom plug shall be of the same material and diameter of above mentioned pipes.

4. WORKS

4.1. MOBILIZATION AND DEMOBILIZATION

The Contractor shall mobilize and demobilize the personnel, equipment, tools, devices, and materials necessary for the works under this Contract to/from the work area under the Project from/to the Contractor's base within Eritrea.

The Contractor shall prepare the drilling sites to suite for the erection of equipment, working space, and others.

Further, the Contractor shall make moving the drilling equipment and others from a site to another site.

4.2. DRILLING OF WELLS

4.2.1. DRILLING

(1) Drilling Site

The exact site of well to be drilled is indicated in-situ to the Contractor by the Engineer prior to the mobilization to the area.

Upon the Engineer's indication, the Contractor shall mark out the point by means of wooden or stone stake with the Well Number.

(2) Type of Well

The standard type of well is shown as the Figure-__ "Standard Well Structure", and explained as follows:

The well shall consist of blank casing, slotted screen, and bottom plug of PVC pipes in 150 mm (6 inches) diameter.

The drilling diameters, the bit size, shall be good enough for the casing and gravel-packing, and be not less than 240 mm (9-5/8 inches) except surface casing portion which required to drill by 317 mm (12-1/2 inches) or more larger size bit.

The depth of the well shall be just covering the aquifer portion and as instructed by the Engineer.

(3) Quantities of Drilling Works

The work quantities in the initial plan are as shown in the Table-__ "Summary of the Works" and Table-__ "Drilling Site and Plan" attached. The depth of each well and the total quantities are to be modified on the course of works in accordance with the Engineer's instruction.

The unit and lump sum prices in the related items of the Bill of Quantities (APPENDIX-__ of the Contract) shall never be revised even if the said modification may take place.

(4) Drilling Works

The drilling of well shall be carried out by fluid-circulating direct rotary and/or the down-the-hole method or other method approved by the Engineer. The circulating fluid shall be as thin as possible except under an artesian condition.

The surface casing pipe at the top six (6) meter portion of all wells shall be installed to control sloughing and to ensure good condition to make the grout-sealing.

(5) Sampling

The drill-cut sampling about a half (0.5) kg in weight shall be collected at an interval of every one (1) meter and every change of formation encountered. The sample collected shall be put into a plastic bag together with a tag marked the Well Number and the depth collected.

The sample corrected shall be submitted to the Engineer for his inspection for casing program immediately after the completion of well drilling.

(6) Daily Drilling Record

The Contractor shall provide the daily drilling record in a form approved by the Engineer describing water level before and after the daily drilling work, drilling rate, characteristics of drill-cut, loss or increase of drilling fluid, and so forth. The record shall be submitted to the Engineer upon the completion of drilling of any well.

4.2.2. BOREHOLE LOGGING

Immediately after the completion of well drilling to the designated depth, the Contractor shall make borehole logging.

The logging items shall be of 1) resistivity (long and short) and 2) Spontaneous Potential (SP).

The borehole log thus measured shall be submitted to the Engineer, immediately after completion of the logging, for his examination and formulation of the casing program.

4.2.3. INSTALLATION OF CASING AND SCREEN PIPES

On the basis of the results obtained from lithological and borehole logs; and so forth, the casing program shall be finally decided by the Engineer. In accordance with the Engineer's instruction on casing program, the Contractor shall install, in the center of the borehole, bottom plug, screen and blank casing pipes into the drilled hole. The centralizer shall be attached to the said pipes at every twelve (12) meters interval from the bottom or as instructed by the Engineer.

4.2.4. GRAVEL-PCKING AND GROUT-SEALING

(1) Gravel-packing

Immediately after the casing installation is over, gravel-packing shall be carried out into the annular space between the pipes installed and the hole.

The packing gravel shall be composed of siliceous materials and selected gradation, approved by the Engineer prior to the installation work.

The most care shall be paid dropping gravel at equal rate and shaking the pipes to avoid sticking and bridging of gravel at the annular apace and/or the centralizer.

Upon the Engineer's instruction, drill-cut or impervious materials may be packed at the blank casing portion.

(2) Grout-sealing

The Contractor shall seal by means of cement or mortar grouting the annular space between the hole and casing pipes at the upper-most six (6) meters portion of the borehole.

4.2.5. DEVELOPMENT

Immediately after the gravel-packing is over, the borehole shall be developed by means of jetting, surging by water or air, and water lifting by air or other appropriate manners. Borehole development shall be lasted when the lifted water is judged to be free from mud, sand, and other suspensions, and otherwise instructed by the Engineer, but for at least 24 hours.

4.2.6. PUMPING TEST

(1) Equipment and devices

The Contractor shall provide a proper pump and its attachment to be utilized for the pumping test. The type, name, capacity, and its specification shall be noticed to the Engineer for his approval prior to carry it to the site.

For measurement of discharge, the Contractor shall provide a calibrated wear, orifice or venture meter and/or accurate associated piezometer.

Water level in the well shall be measured by electric detective devices.

The pumped water shall be led and released at the position enough far from the teat well, not to disturb the test by re-infiltration, by proper conduit or through other suitable means.

(2) Preliminary Test

After setting of all equipment and devices, the pumping equipment shall be calibrated at various pumping rates in order to ensure that all the equipment are properly functioning and to select the pumping rate for the subsequent step-drawdown test, the drawdown and yield shall be presumed through the test.

The pumping rate shall be modified according to the drawdown at the pumping well, and the preliminary pumping shall be continued at least four (4) hours.

The static water level of both pumping and observatory well (if exist) shall be measured carefully before any pumping, and the tests described below shall be started after the water level recovered to the original water level.

(3) Step-drawdown Test

The borehole shall be pumped continuously at least three (3) increasing and two (2) decreasing discharge rates, maintaining each rate at a water level to be stable, but at least more than 180 minutes.

The pumping rate of each step shall be instructed by the Engineer based on the result of preliminary test.

For each pumping discharge, the water level at the borehole shall be measured and recorded in the manner shown below;

Period	*Interval of recording*
0 – 5 min.	30 sec.
5 – 15 min.	1 min.
15 – 30 min.	5 min.
30 – 90 min.	10 min.
after 360 min.	30 min.

(4) Constant Discharge Test and Recovery Test

Pumping shall be continued at least 48 hours without any interruption. The constant discharge rate shall be instructed by the Engineer.

Water level of the borehole shall be measured and recorded during full pumping and recovery period. The measurement of recovery can be stopped when the recovery attains to the static water level.

The water level shall be measured and recorded as following time interval;

Period	*Interval of recording*
0 – 5 min.	30 sec.
5 – 15 min.	1 min.
15 – 30 min.	5 min.
30 – 180 min.	15 min.
180 – 360 min.	30 min.
360 – 900 min.	60 min.
after 900 min.	120 min.

(5) Test Record

The Contractor shall submit the pumping test records, in a proper forms of hard-printed and floppy-disk-base approved by the Engineer, within three (3) days after the completion of any pumping test to the Engineer.

(6) In-situ Water Quality Analysis

The Contractor shall make a series of in-situ water quality test of water temperature, pH, EC, and so forth, and take water sample for laboratory water quality analysis, during the constant discharge test.

(7) Laboratory Water Quality Analysis

The Contractor shall send water samples to the laboratory of WRD, immediately after the sampling. The items to be analyzed are as follows, and the cost on the analysis shall be born by the Contractor.

Cations: Ca, Mg, Na, K, Fe

Anions: HCO_3; CO_3, SO_4, Cl, NO_3

Others: Mn, NO_2, PO_4, F, B, SiO_2, N-NH_3

Physical Properties: TDS, Hardness, Conductivity, pH

Bacteriologic properties: Total coliform bacteria, Faecal coliform bacteria

4.2.7. HEADWORK

Upon the completion of all the works specified above, the Contractor shall place the concrete pad and well-cap to the wells as the following manners;

(1) Concrete Pad

The dimension of concrete pad for the well shall be 1.00 m of wide, 1.00 m of long, both centered by the drilled well, and 0.50 m of deep, or otherwise instructed by the Engineer. The concrete mix of the Portland cement, fine and coarse aggregates, by volume ratio, shall be of 1:2:4 or as instructed by the Engineer.

(2) Well-cap

All the wells completed shall be covered by cap. The design, dimension, size and type of cap shall be approved by the Engineer prior to actual providing.

(3) Installation of Automatic water-level recorder

The Contractor shall install total ____ of automatic water-level recorders provided by WRD into ___ monitoring wells existing or drilled under this Contract. Details on hook, wire, method to set, etc., shall be proposed by the Contractor for Engineer's approval prior to the installation work.

4.2.8. SITE CLEARANCE

On the completion of all the works in the field, the Contractor shall remove all equipment and materials concerned, clean up the site as almost same as original states before the commencement of the works.

4.2.9. REPORTING

The Contractor shall provide the following reports and records, and on all occasions submit them to the Engineer;

(1) Daily Reports

- Daily drilling record
- Daily work record

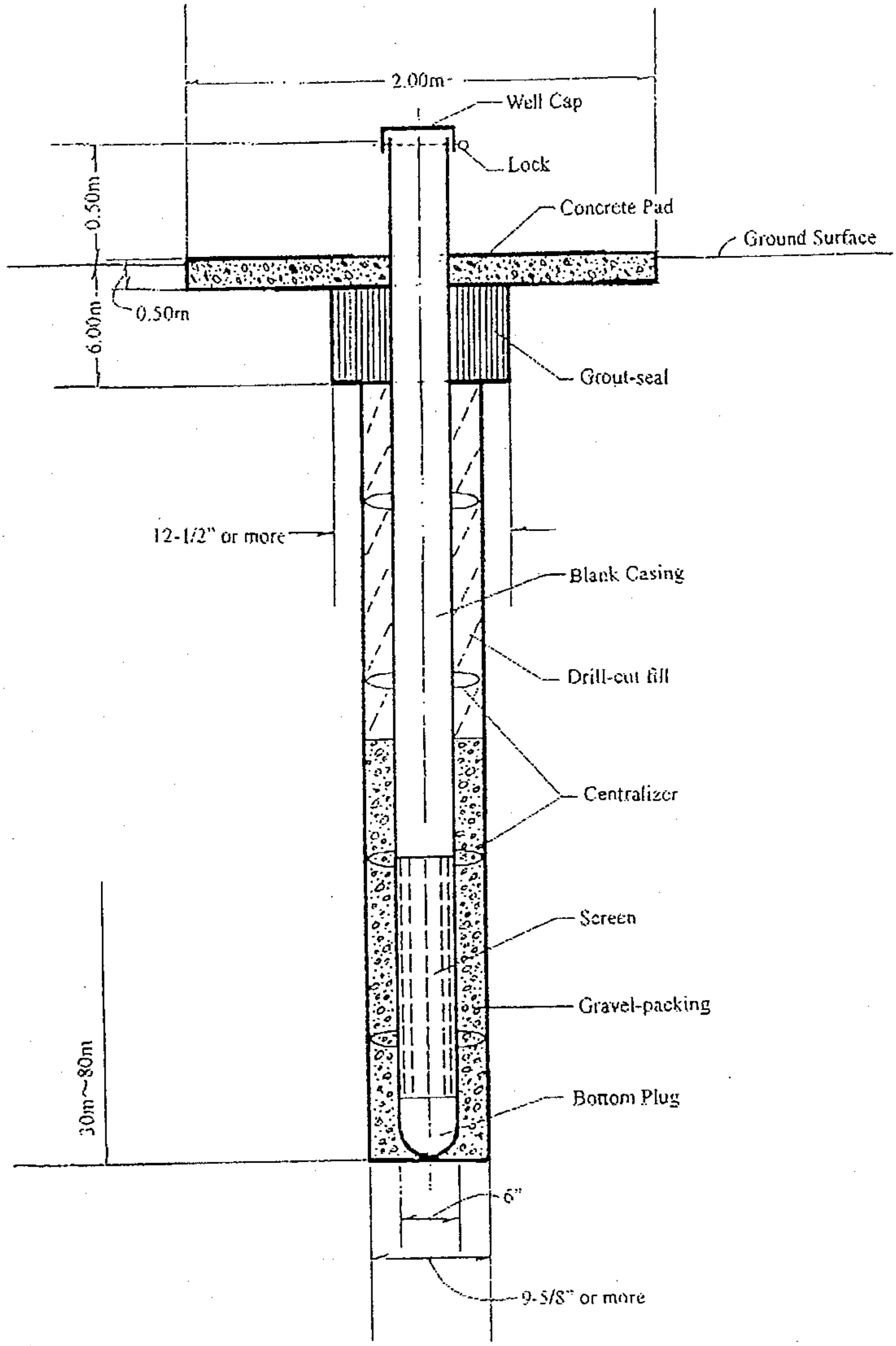
(2) Results

- Drilling logs
- Lithological logs
- Borehole logs
- Pumping tests

(3) Color photograph (or sketch by the instruction)

- Typical work operation
- Site views
- Equipment, measuring devices and materials
- Other related to the execution of the works and indicated by the Engineer.

Appendix C-9 Standard Design of Production Well



APPENDIX D

WATER SUPPLY

TABLE OF CONTENTS

1. Service Population

No.1

Debarwa

Year	1997	2005			2010			2015		
Zone,Village		Total Pop.	%	Supplied	Total Pop.	%	Supplied	Total Pop.	%	Supplied
Zone 1	1,884	3,701	0.90	3,331	5,078	1.00	5,078	6,719	1.00	6,719
Zone 2	1,551	3,047	0.90	2,742	4,180	1.00	4,180	5,532	1.00	5,532
Geza Lamza	1,396	2,742	0.70	1,920	3,762	0.85	3,198	4,979	1.00	4,979
Total	4,831	9,490	0.84	7,993	13,020	0.96	12,456	17,230	1.00	17,230
Projected Pop.		9,490			13,020			17,230		

Mendefera

Year	1997	2005			2010			2015		
Zone,Village		Total Pop.	%	Supplied	Total Pop.	%	Supplied	Total Pop.	%	Supplied
Western zone										
5	1,398	2,227	0.60	1,336	2,857	0.80	2,286	3,629	1.00	3,629
6	2,005	3,194	0.70	2,236	4,097	0.85	3,483	5,204	1.00	5,204
7	4,089	6,513	0.80	5,211	8,356	0.90	7,520	10,614	1.00	10,614
8	2,275	3,624	0.70	2,537	4,650	0.80	3,720	5,906	1.00	5,906
Eastern zone										
1	2,743	4,370	0.70	3,059	5,606	0.85	4,765	7,121	1.00	7,121
2	2,934	4,674	0.70	3,272	5,996	0.85	5,096	7,616	1.00	7,616
4	2,192	3,491	0.60	2,095	4,479	0.75	3,359	5,689	1.00	5,689
Adi Bari	1,488	2,370	0.00	0	3,041	1.00	3,041	3,863	1.00	3,863
Adi Wegri	708	1,128	0.00	0	1,447	0.00	0	1,838	1.00	1,838
Adi Hare	539	859	0.00	0	1,101	0.00	0	1,399	1.00	1,399
Total	20,371	32,450	0.61	19,745	41,630	0.80	33,270	52,880	1.00	52,880
Projected Pop.		32,450			41,630			52,880		

Adiquala

Year	1997	2005			2010			2015		
Zone,Village		Total Pop.	%	Supplied	Total Pop.	%	Supplied	Total Pop.	%	Supplied
Adiquala										
Zone 1	1,475	2,399	1.00	2,399	3,004	1.00	3,004	3,685	1.00	3,685
Zone 2	1,818	2,956	1.00	2,956	3,701	1.00	3,701	4,541	1.00	4,541
Zone 3	1,857	3,020	1.00	3,020	3,782	1.00	3,782	4,639	1.00	4,639
Zone 4	2,075	3,374	1.00	3,374	4,224	1.00	4,224	5,182	1.00	5,182
Geza Gebrai	335	545	0.00	0	682	1.00	682	837	1.00	837
Geza Azazi	334	543	0.00	0	680	1.00	680	834	1.00	834
Adi Arbaa	625	1,016	0.00	0	1,273	0.00	0	1,561	1.00	1,561
Geza Atat	87	141	0.00	0	177	1.00	177	217	1.00	217
Tekerakari	117	190	0.00	0	238	1.00	238	292	1.00	292
Adi Hihi	306	498	0.00	0	623	0.00	0	764	1.00	764
Adi Mini	201	327	0.00	0	409	0.00	0	502	1.00	502
Adi Shinfio	258	420	0.00	0	525	0.00	0	644	1.00	644
Total	9,488	15,430	0.76	11,750	19,320	0.85	16,490	23,700	1.00	23,700
Projected Pop.		15,430			19,320			23,700		

Dekemhare

No.2

Year	1997	2005			2010			2015		
Zone,Village		Total Pop.	%	Supplied	Total Pop.	%	Supplied	Total Pop.	%	Supplied
Zone 1										
1	3,163	5,016	0.60	3,009	6,425	0.80	5,140	8,155	1.00	8,155
2	3,168	5,024	0.90	4,522	6,436	1.00	6,436	8,168	1.00	8,168
3	1,746	2,768	0.70	1,938	3,546	0.85	3,015	4,501	1.00	4,501
4	1,024	1,623	0.90	1,461	2,080	1.00	2,080	2,639	1.00	2,639
5	776	1,230	1.00	1,230	1,576	1.00	1,576	2,000	1.00	2,000
Zone 2									–	
6	2,616	4,148	1.00	4,148	5,314	1.00	5,314	6,744	1.00	6,744
7	2,057	3,261	1.00	3,261	4,178	1.00	4,178	5,302	1.00	5,302
8	2,106	3,339	1.00	3,339	4,278	1.00	4,278	5,429	1.00	5,429
9	2,920	4,631	0.80	3,705	5,932	1.00	5,932	7,529	1.00	7,529
Hadamu	1,192	1,890	0.00	0	2,421	0.00	0	3,073	1.00	3,073
Metsalu	314	498	0.00	0	638	0.00	0	810	1.00	810
Amhare	593	940	0.00	0	1,205	0.00	0	1,529	1.00	1,529
Total	21,675	34,370	0.77	26,614	44,030	0.86	37,949	55,880	1.00	55,880
Projected Pop.		34,370			44,030			55,880		

Segeneiti

Year	1997	2005			2010			2015		
Zone,Village		Total Pop.	%	Supplied	Total Pop.	%	Supplied	Total Pop.	%	Supplied
1	2,477	4,304	0.80	3,443	5,513	0.90	4,962	6,851	1.00	6,851
2	3,669	6,376	0.60	3,826	8,167	0.80	6,534	10,149	1.00	10,149
Total	6,146	10,680	0.68	7,269	13,680	0.84	11,495	17,000	1.00	17,000
Projected Pop.		10,680			13,680			17,000		

Adi Keyih

Year	1997	2005			2010			2015		
Zone,Village		Total Pop.	%	Supplied	Total Pop.	%	Supplied	Total Pop.	%	Supplied
Zone 1	7,837	12,212	0.70	8,548	15,057	0.85	12,798	18,293	1.00	18,293
Zone 2	6,378	9,938	0.80	7,951	12,253	1.00	12,253	14,887	1.00	14,887
Total	14,215	22,150	0.74	16,499	27,310	0.92	25,052	33,180	1.00	33,180
Projected Pop.		22,150			27,310			33,180		

Senafe

Year	1997	2005			2010			2015		
Zone,Village		Total Pop.	%	Supplied	Total Pop.	%	Supplied	Total Pop.	%	Supplied
Zone 1										
1	730	1,147	0.90	1,033	1,419	1.00	1,419	1,728	1.00	1,728
2	1,022	1,606	0.80	1,285	1,986	1.00	1,986	2,419	1.00	2,419
3	876	1,377	0.80	1,102	1,703	1.00	1,703	2,073	1.00	2,073
Zone 2									–	
4	3,549	5,578	0.70	3,905	6,898	0.90	6,208	8,398	1.00	8,398
5	1,971	3,099	1.00	3,099	3,832	1.00	3,832	4,666	1.00	4,666
6	2,366	3,719	1.00	3,719	4,598	1.00	4,598	5,599	1.00	5,599
Metera	1,178	1,852	0.80	1,481	2,290	0.90	2,061	2,788	1.00	2,788
Awle	590	927	0.00	0	1,147	0.00	0	1,396	1.00	1,396
Hahahile	0	0	0.00	0	0	0.00	0	0	1.00	0
Tisha	652	1,025	0.00	0	1,267	0.00	0	1,543	1.00	1,543
Afema	0	0	0.00	0	0	0.00	0	0	1.00	0
Total	12,934	20,330	0.77	15,623	25,140	0.87	21,807	30,610	1.00	30,610
Projected Pop.		20,330			25,140			30,610		

Total

Target Year	1997	2005			2010			2015		
		Total Pop.	%	Supplied	Total Pop.	%	Supplied	Total Pop.	%	Supplied
Grand Tatal	89,660	144,900	0.73	105,491	184,130	0.86	158,518	230,480	1.00	230,480

2. Water Demand

Water Demand

Name of Town	Year	Population			Average Water Demand				(m3/d) Total	Daily Max. (m3/d)	Hourly (m3/h)
		Whole	Supply area	%	Domestic	Industry	Others	Loss	Total		
Debarwa	2005	9,490	7,990	84.2	150		141	51	342	411	25.7
	2010	13,020	12,460	95.7	247	81	206	94	629	754	47.2
	2015	17,230	17,230	100.0	390	271	272	165	1,098	1,318	82.3
Mendefera	2005	32,450	19,750	60.9	456		253	125	834	1,001	62.6
	2010	41,630	33,270	79.9	979	314	324	285	1,902	2,283	142.7
	2015	52,880	52,880	100.0	1,840	413	412	470	3,134	3,761	235.1
Adiquala	2005	15,430	11,750	76.2	241		136	66	443	532	33.2
	2010	19,320	16,490	85.4	389		170	99	658	789	49.3
	2015	23,700	23,700	100.0	728		208	165	1,102	1,322	82.6
Dekemhare	2005	34,370	26,610	77.4	615		320	165	1,100	1,320	82.5
	2010	44,030	37,950	86.2	1,117	210	410	307	2,044	2,452	153.3
	2015	55,880	55,880	100.0	1,945	1,050	520	620	4,135	4,962	310.1
Segeneiti	2005	10,680	7,270	68.1	136		107	43	287	344	21.5
	2010	13,680	11,500	84.1	228		138	65	431	517	32.3
	2015	17,000	17,000	100.0	385		171	98	654	785	49.0
Adi Keyih	2005	22,150	16,500	74.5	381		220	106	707	849	53.0
	2010	27,310	25,050	91.7	737		271	178	1,186	1,424	89.0
	2015	33,180	33,180	100.0	1,155		329	262	1,746	2,095	130.9
Senafe	2005	20,330	15,620	76.8	321		174	87	582	698	43.6
	2010	25,140	21,810	86.8	515		215	129	859	1,030	64.4
	2015	30,610	30,610	100.0	940		261	212	1,414	1,697	106.0
Total	2005	144,900	105,490	72.8	2,301		1,350	644	4,295	5,154	322.1
	2010	184,130	158,530	86.1	4,214	605	1,733	1,156	7,708	9,250	578.1
	2015	230,480	230,480	100.0	7,383	1,734	2,173	1,992	13,283	15,939	996.2

(1) Population

		Debarwa		Mendefera		Adiquala		Dekemhare		Segeneiti		Adi Keyih		Senafe	
Water consumption		%	l/c/d	%	l/c/d	%	l/c/d	%	l/c/d	%	l/c/d	%	l/c/d	%	l/c/d
1997	H.C.	1.25	25	10.94	24.11	13.86	20.45	5.67	25.59	3	28.73	4.95	11.66	7.78	10.3
	Y.C.			6.56	14.95	6.14	12.07	8.67	15.67	5	12.64	10.64	5.94	6.62	6.8
	C.W.P	41.7	8.56	29.2	10.13	63.6	14.31			90.5	16.45	13.94	8.79	83.8	8.04
Average			9.0		14.1		15.2		19.6		16.6		8.2		8.1
Population			4,831		20,371		9,488		21,675		6,146		14,215		12,934
Water Demand			44		287		144		425		102		117		105
2005	H.C.	17	28	29	35	23	29	29	35	17	28	29	35	23	29
	Y.C.	22	22	33	22	33	22	33	22	22	22	33	22	33	22
	C.W.P	61	15	38	15	44	15	38	15	61	15	38	15	44	15
Average			18.8		23.1		20.5		23.1		18.8		23.1		20.5
Population			7,990		19,750		11,750		26,610		7,270		16,500		15,620
Water Demand			150		456		241		615		136		381		321
2010	H.C.	19	30	34	40	27	34	34	40	19	30	34	40	27	34
	Y.C.	24	24	66	24	37	24	66	24	24	24	66	24	37	24
	C.W.P	56	15	0	15	37	15	0	15	56	15	0	15	37	15
Average			19.9		29.4		23.6		29.4		19.9		29.4		23.6
Population			12,460		33,270		16,490		37,950		11,500		25,050		21,810
Water Demand			247		979		389		1,117		228		737		515
2015	H.C.	22	35	39	47	31	39	39	47	22	35	39	47	31	39
	Y.C.	27	27	61	27	69	27	61	27	27	27	61	27	69	27
	C.W.P	51	15	0	15	0	15	0	15	51	15	0	15	0	15
Average			22.6		34.8		30.7		34.8		22.6		34.8		30.7
Population			17,230		52,880		23,700		55,880		17,000		33,180		30,610
Water Demand			390		1,840		728		1,945		385		1,155		940

(2) Industry

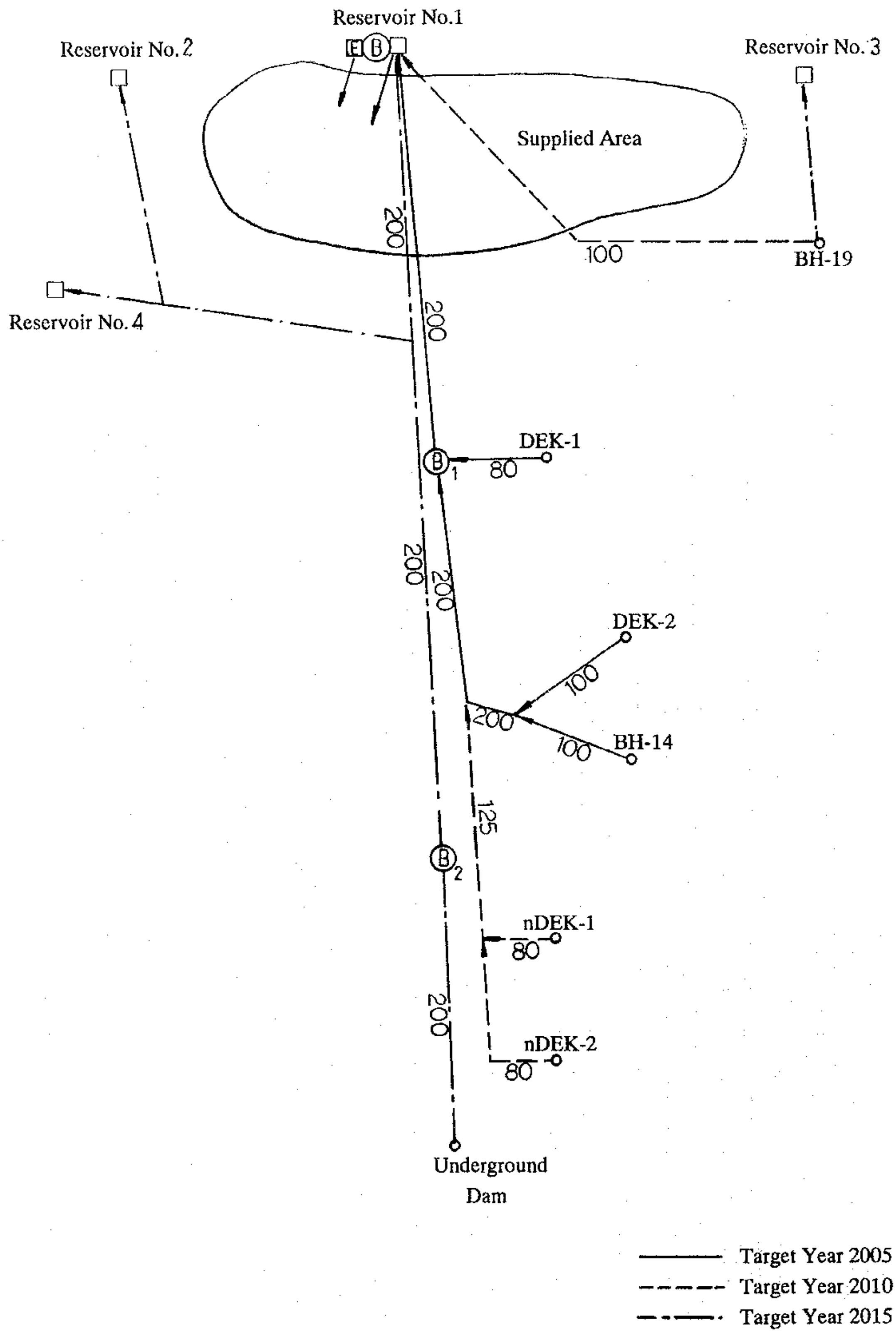
	unit	Water consum.	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe
Industry	ha	15,000	18.09			70			
Light Indus.		5,500		57					
				75					
Total			18.09			70.00			
Water Demand		2005							
		2010	81	314		210			
		2015	271	413		1,050			

(3) Number of Institutions

	unit	Water consum.	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe
School	pupil	5	3,228	15,120	5,901	7,905	3,111	6,233	3,649
Hospital	bed	100	20	30	20	20	35	40	35
Clinic	bed	100	5	5		5	5	5	5
Hotel	shop	210	5	13	7	13	5	17	13
Bar, Tea shop	shop	210	68	79	20	103	16	72	63
Restaurant	shop	210	85	75	60	61	20	45	80
Church	visiter	5	450	1,430	790	2,020	580	1,180	830
Mosque	visiter	5	60	1,220	320	300	70	480	930
Office	person	5	570	1,641	1,005	1,812	690	990	738
Factory	site	1000	19	23	23	102	27	64	43
Water Demand		1997	76	159	83	202	62	141	110
(Others)		2005	141	253	136	320	107	220	174
		2010	206	324	170	410	138	271	215
		2015	272	412	208	520	171	329	261

2.1 Plan of Water Source and Transmission Pipelines

Dekemhare



2.2 Hydraulic Calculation of Transmission Pipeline

Dekemhare	Target Year		**2005**					
	Well No.		BH-14	DEK-2	DEK-1			
Condition	Symbol	Unit	24hr ope.	24hr ope.	24hr ope.			
Elevation of Intake	EL1	m	1933.20	1944.46	1960.75			
Ground water level		m	10.00	9.40	13.50			
Elevation of Reservoir	EL2	m	2055.00	2055.00	2055.00			
Water level		m	3.50	3.50	3.50			
Discharge	Q	m3/d	553	484				
Discharge	Q1	m3/s	0.0064	0.0056				
Pipe Diameter	D	mm	100	100				
Velocity	V	m/s	0.82	0.71				
Velocity Coefficient	C		110	110				
Pipe Length	L	m	644	304				
Loss Head	h2	m	7.44	2.75				
Discharge	Q	m3/d	1037		285			
Discharge	Q1	m3/s	0.0120		0.0033			
Pipe Diameter	D	mm	200		80			
Velocity	V	m/s	0.38		0.66			
Velocity Coefficient	C		110		110			
Pipe Length	L	m	2250		628			
Loss Head	h2	m	2.85		6.31			
Actual Head	h1	m	45.80	33.94	21.75			
Total Head	H	m	56.09	39.53	28.06			
Booster Pump			(BP No.1)					
Elevation of Booster P		m	1965.5					
Discharge	Q	m3/d	1322					
Discharge	Q1	m3/s	0.0153					
Pipe Diameter	D	mm	200					
Velocity	V	m/s	0.49					
Velocity Coefficient	C		110					
Pipe Length	L	m	3941					
Loss Head	h2	m	7.81					
Actual Head	h1	m	93.00					
Total Head	H	m	100.81					

- Pumps are operated 24 hours per day.

Hydraulic Calculation of Transmission Line

Dekemhare	Target Year		**2010**					
	Well No.		nDEK-2	nDEK-1	BH-14	DEK-2	DEK-1	BH-19
Condition	Symbol	Unit	24hr ope.	24hr ope.	24hr ope.	24hr ope.	24hr ope.	24hr ope.
Elevation of Intake	EL1	m	1915	1925	1933.20	1944.46	1960.75	1963.00
Ground water level		m	10.00	10.00	10.00	9.40	13.50	10.00
Elevation of Reservoir	EL2	m	2055.00	2055.00	2055.00	2055.00	2055.00	2055.00
Water level		m	3.50	3.50	3.50	3.50	3.50	3.50
Discharge	Q	m3/d	380	380				415
Discharge	Q1	m3/s	0.0044	0.0044				0.0048
Pipe Diameter	D	mm	80	80				100
Velocity	V	m/s	0.88	0.88				0.61
Velocity Coefficient	C		110	110				110
Pipe Length	L	m	2000	500				3500
Loss Head	h2	m	34.23	8.56				23.79
Discharge	Q	m3/d	760		553	484		
Discharge	Q1	m3/s	0.0088		0.0064	0.0056		
Pipe Diameter	D	mm	125		100	100		
Velocity	V	m/s	0.72		0.82	0.71		
Velocity Coefficient	C		110		110	110		
Pipe Length	L	m	2100		644	304		
Loss Head	h2	m	14.75		7.44	2.75		
Discharge	Q	m3/d	1797				285	
Discharge	Q1	m3/s	0.0208				0.0033	
Pipe Diameter	D	mm	200				80	
Velocity	V	m/s	0.66				0.66	
Velocity Coefficient	C		110				110	
Pipe Length	L	m	2250				628	
Loss Head	h2	m	7.87				6.31	
Actual Head	h1	m	64.00	54.00	45.80	33.94	21.75	
Total Head	H	m	120.85	85.17	61.11	44.56	28.06	
Booster Pump			(BP No.2)					
Elevation of Booster P		m	1965.5					
Discharge	Q	m3/d	2082					
Discharge	Q1	m3/s	0.0241					
Pipe Diameter	D	mm	200					
Velocity	V	m/s	0.77					
Velocity Coefficient	C		110					
Pipe Length	L	m	3941					
Loss Head	h2	m	18.10					
Actual Head	h1	m	93.00					105.50
Total Head	H	m	111.10					129.29

- Pumps are operated 24 hours per day.
- " * " means that booster pumps shall be installed in the line.
- This transmission line is used in the year of 2015.

Hydraulic Calculation of Transmission Line

Dekemhare	Target Year		2015				
	Well No.		U-DAM				
Condition	Symbol	Unit	24hr ope.				
Elevation of Intake	EL1	m	1900				
Ground water level		m	10.00				
Elevation of Reservoir	EL2	m	2055.00				
Water level		m	3.50				
Discharge	Q	m3/d	2510				
Discharge	Q1	m3/s	0.0291				
Pipe Diameter	D	mm	200				
Velocity	V	m/s	0.93				
Velocity Coefficient	C		110				
Pipe Length	L	m	11200				
Loss Head	h2	m	72.69				
Actual Head	h1	m	168.50				
Total Head	H	m	241.19				
			*				

- Pumps are operated 24 hours per day.
- " * " means that booster pumps shall be installed in the line.

2.3 Capacity of Pump Pit

Capacity of Pump Pit

Name of Town	B.P. No.	Target Year	Max. Daily Consumption (m3/s)	Pit Capacity: Necessary (m3)	Pit Capacity: Design (m3)	Dimension of Pump Pit: Length (m)	Dimension of Pump Pit: Width (m)	Dimension of Pump Pit: High (m)	Dimension of Pump Pit: Actual (m3)	Additional Pump Pit: Capacity (m3)	Additional Pump Pit: Length (m)	Additional Pump Pit: Width (m)	Additional Pump Pit: High (m)	Additional Pump Pit: Actual (m3)	Remarks
Mendefera	BP-1	2005	0.0040	7.2	15	3.0	2.5	2.0	15						
	BP-2	2005	0.0040	7.2	15	3.0	2.5	2.0	15						
	BP-3	2010	0.0120	21.6	25	5.0	2.5	2.0	25						
	BP-4	2010	0.0150	27.0	30	6.0	2.5	2.0	30						
	BP-5	2015	0.0171	30.8	35	7.0	2.5	2.0	35						
Adiquala	BP-1	2010	0.0032	5.8	15	3.0	2.5	2.0	15					15	
	BP-1	2015	0.0092	16.6	20	4.0	2.5	2.0	20	5	1.0	2.5	2.0	5	
Dekemhare	BP-1	2005	0.0153	27.5	30	6.0	2.5	2.0	30					30	
	BP-1	2010	0.0241	43.4	45	9.0	2.5	2.0	45	15	3.0	2.5	2.0	15	
	BP-2	2015	0.0291	52.4	55	7.5	3.0	2.5	56						
Segeneiti	BP-1	2005	0.0040	7.2	15	3.0	2.5	2.0	15						
	BP-1	2010	0.0044	7.9	15	3.0	2.5	2.0	15	0					
	BP-1	2015	0.0046	8.3	15	3.0	2.5	2.0	15	0					
	BP-1'	2010	0.0060	10.8	15	3.0	2.5	2.0	15						
	BP-1'	2015	0.0072	13.0	15	3.0	2.5	2.0	15	0					
	BP-2	2010	0.0016	2.9	15	3.0	2.5	2.0	15						
	BP-2	2015	0.0026	4.7	15	3.0	2.5	2.0	15	0					
Aadi Keyih	BP-1	2005	0.0050	9.0	15	3.0	2.5	2.0	15						
	BP-1	2010	0.0064	11.5	15	3.0	2.5	2.0	15	0					
	BP-2	2005	0.0048	8.6	15	3.0	2.5	2.0	15						
	BP-2	2010	0.0064	11.5	15	3.0	2.5	2.0	15	0					
	BP-3	2010	0.0020	3.6	15	3.0	2.5	2.0	15						
	BP-4'	2010	0.0024	4.3	15	3.0	2.5	2.0	15						
	BP-4	2010	0.0024	4.3	15	3.0	2.5	2.0	15						
	BP-5	2015	0.0073	13.1	15	3.0	2.5	2.0	15						
	BP-6	2015	0.0097	17.5	20	4.0	2.5	2.0	20						
Senafe	BP-1	2010	0.0048	8.6	15	3.0	2.5	2.0	15						
	BP-1	2015	0.0080	14.4	15	3.0	2.5	2.0	15	0					
	BP-2	2015	0.0034	6.1	15	3.0	2.5	2.0	15						

2.4 Capacity of Reservoir

Capacity of Reservoir

No.1

Name of Town	Rsv. No.	Target Year	Max. Daily Consumption (m3/d)	Reservoir Capacity Necessary (m3)	Reservoir Capacity Design (m3)	Dimension of Reservoir Length (m)	Dimension of Reservoir Width (m)	Dimension of Reservoir High (m)	Dimension of Reservoir Actual (m3)	Additional Reservoir Capacity (m3)	Additional Reservoir Length (m)	Additional Reservoir Width (m)	Additional Reservoir High (m)	Additional Reservoir Actual (m3)	Remarks
Debarwa	DB-1	2005	411	137	140	7.0	7.0	3.0	147					147	
	DB-1	2010	754	251	260	9.6	9.0	3.0	259	120	5.5	7.0	3.0	116	
	DB-1	2015	1,318	439	440	12.5	12.0	3.0	450	180	9.0	7.0	3.0	189	
Mendefera	MD-1	2005	1,001	334	340	10.0	10.0	3.5	350					350	
	MD-1	2010	2,283	761	770	15.0	15.0	3.5	788	430	12.5	10.0	3.5	438	
(80.0)	MD-1	2015	3,009	1003	1010	17.0	17.0	3.5	1012	240	7.0	10.0	3.5	245	
(13.7)	MD-2	2015	515	172	180	8.5	8.5	2.5	181						
(3.4)	MD-3	2015	128	43	50	4.5	4.5	2.5	51						(Adi Wegri)
(2.9)	MD-4	2015	109	36	40	4.0	4.0	2.5	40						(Adi Hare)
Adiquala	AQ-1	2005	532	177	180	7.5	8.0	3.0	180					180	
(81.0)	AQ-1	2010	639	213	220	8.6	8.6	3.0	222	40	4.0	4.0	3.0	48	
(63.8)	AQ-1	2015	843	281	290	10.0	10.0	3.0	300	70	4.5	5.0	3.0	68	
	AQ-1'	2005	532	22	25	3.5	3.0	2.5	26					26	H=13m, Q=1hr
	AQ-1'	2010	639	27	30	3.5	3.5	2.5	31	5	2.0	2.0	2.0	8	H=13m, Q=1hr
	AQ-1'	2015	843	35	35	4.0	4.0	2.5	40	5	2.0	2.0	2.0	8	H=13m, Q=1hr
(19.0)	AQ-2	2010	150	50	50	4.0	4.5	3.0	54					54	H=13m
(30.5)	AQ-2	2015	403	134	140	7.0	7.0	3.0	147	90	5.5	5.5	3.0	91	H=13m
(5.7)	AQ-3	2015	75	25	30	3.5	3.5	2.5	31						Mini & Shinfio
Dekemhare															
(84.2+15.8)	DK-1	2005	1,320	440	440	8.5	15.0	3.5	446					446	
(88.8+11.2)	DK-1	2010	2,452	817	820	16.0	15.0	3.5	840	380	7.5	15.0	3.5	394	
(86.7+6.0))	DK-1	2015	4,600	1533	1540	30.0	15.0	3.5	1575	720	14.0	15.0	3.5	735	
(15.8)	DK-1'	2005	209	9	10	2.0	3.0	2.0	12					12	H=12m, Q=1hr
(11.2)	DK-1'	2010	275	11	15	3.0	3.0	2.0	18						H=12m, Q=1hr
(6.0)	DK-1'	2015	298	12	15	3.0	3.0	2.0	18						H=12m, Q=1hr
(2.9)	DK-2	2015	144	48	50	4.5	4.5	2.5	51						Hadamu
(1.8)	DK-3	2015	89	30	30	3.5	3.5	2.5	31						Metsalu
(2.6)	DK-4	2015	129	43	50	4.5	4.5	2.5	51						Amhare

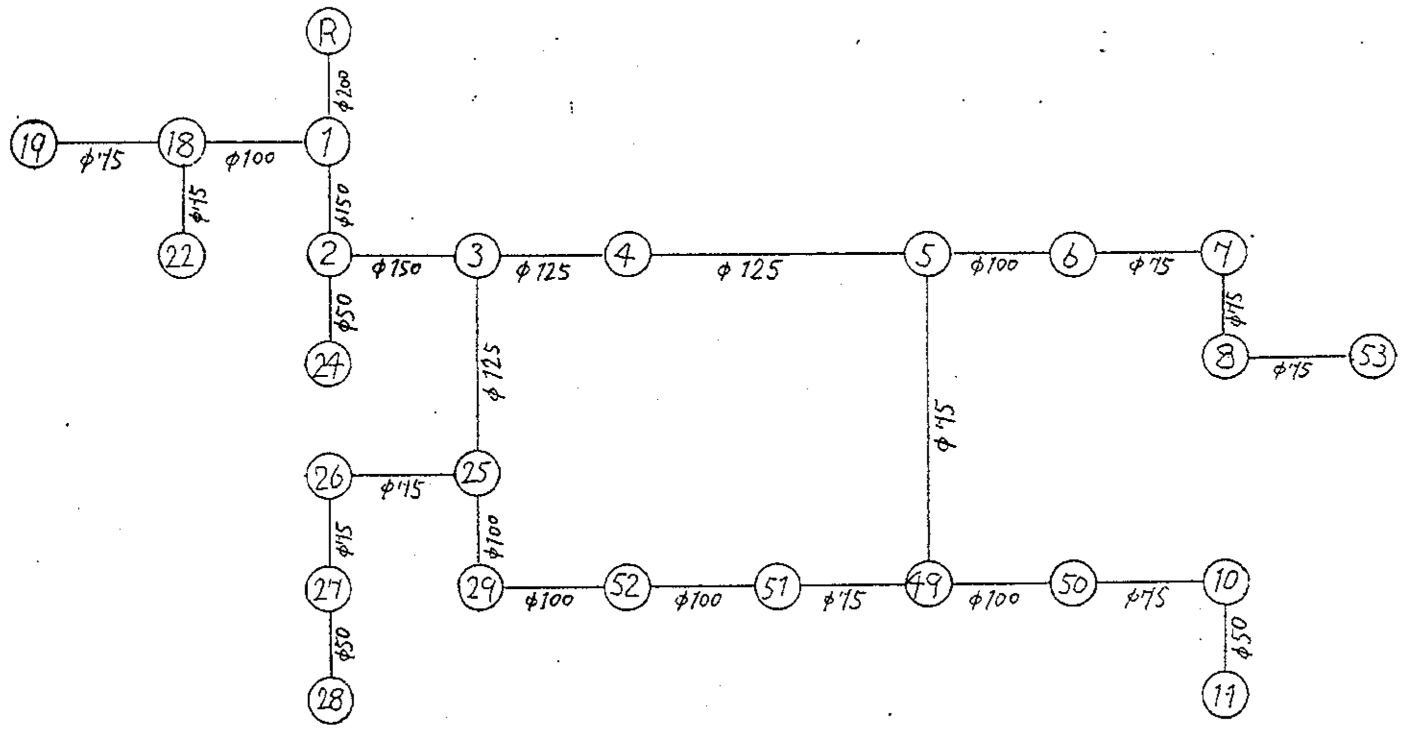
Capacity of Reservoir

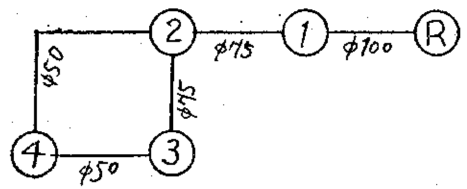
No.2

Name of Town	Rsv. No.	Target Year	Max. Daily Consumption (m3/d)	Reservoir Capacity		Dimension of Reservoir				Additional Reservoir					Remarks
				Necessary (m3)	Design (m3)	Length (m)	Width (m)	High (m)	Actual (m3)	Capacity (m3)	Length (m)	Width (m)	High (m)	Actual (m3)	
Segeneiti	SG-1	2005	344	115	120	7.0	7.0	2.5	123					123	
(74.0)	SG-1	2010	383	128	130	7.2	7.2	2.5	130	10	2.0	2.0	2.5	10	
(50.9)	SG-1	2015	400	133	140	7.5	7.5	2.5	141	10	2.0	2.0	2.5	10	
(26.0)	SG-2	2010	134	45	50	4.5	4.5	2.5	51					51	H=12.5m
(49.1)	SG-2	2015	385	128	130	7.2	7.2	2.5	130	80	6.0	6.0	2.5	90	H=12.5m
Aadi Keyih	AD-1	2005	849	283	290	10.0	10.0	3.0	300					300	H=5.5m
	AD-1	2010	1,424	475	480	12.5	13.0	3.0	488	190	6.5	10.0	3.0	195	H=5.5m
	AD-1	2015	2,095	698	700	15.5	15.5	3.0	721	220	7.5	10.0	3.0	225	H=5.5m
Senafe	SN-1	2005	698	233	240				600						Existing
	SN-1	2010	1,030	343	350				600						
(81.4)	SN-1	2015	1,381	460	470				600						
(18.6)	SN-2	2015	316	105	110	6.5	6.5	2.6	110						Afema

2.5 Plan of Distribution Pipeline (2005)

DEKEMHARE 2005





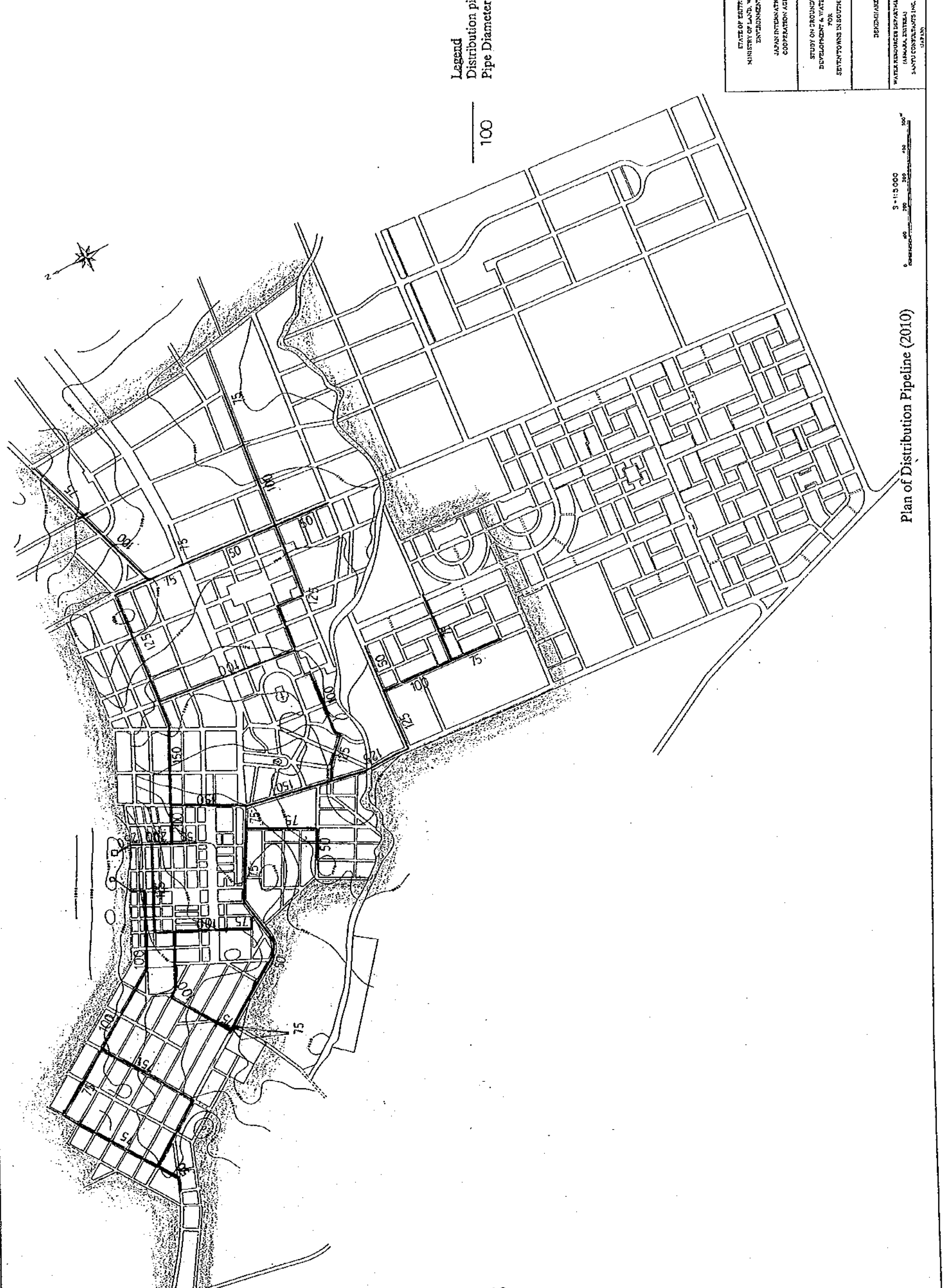
Node No.	Dynamic (WL.m)	Ground Elevation (EL.m)	Effective Head (m)	Area (ha)	Outflow Quantitiy (L/sec)
0	2055.000	2055.000	0.000	-149.40	-19.29
1	2054.606	2042.600	12.006	0.00	0.00
2	2053.978	2037.000	16.978	0.00	0.00
3	2052.865	2033.000	19.865	0.00	0.00
25	2051.646	2030.100	21.546	1.70	0.22
29	2049.496	2019.500	29.996	0.00	0.00
52	2049.162	2019.600	29.562	11.00	1.42
51	2047.723	2017.200	30.523	7.90	1.02
49	2047.026	2015.300	31.726	0.00	0.00
50	2045.250	2012.700	32.550	16.10	2.08
10	2042.766	2008.300	34.466	11.20	1.45
11	2039.369	2007.600	31.769	9.90	1.28
4	2051.100	2018.500	32.600	11.60	1.50
5	2050.634	2015.600	35.033	0.00	0.00
6	2048.985	2005.100	43.885	16.00	2.07
7	2047.445	2004.400	43.045	7.10	0.92
8	2046.906	2004.700	42.207	0.00	0.00
53	2045.531	2014.000	31.531	14.10	1.82
18	2053.545	2043.600	9.945	0.00	0.00
19	2052.420	2037.400	15.020	10.80	1.39
22	2052.928	2040.000	12.928	12.80	1.65
24	2053.529	2035.000	18.529	4.00	0.52
26	2051.215	2032.000	19.215	0.00	0.00
27	2049.943	2022.600	27.343	7.40	0.96
28	2048.062	2026.600	21.462	7.80	1.01

Pipe line No.	Node No. From	Node No. To	Dia. (mm)	Length (m)	Flow Coefficient	Flow (L/sec)	velocity (m/sec)	Loss of Head (m)	Hydraulic Gradient (m/1000m)	Head Loss Coefficient	Hydrostatic Head	Water Hummer Head	Design Pressure (kg/sq.cm)	Pipe Material
1	0	1	200	133.00	110	19.2	0.610	0.394	2.963	0.03118	1.32	1.32	2.64	
2	1	2	150	71.00	110	16.2	0.919	0.628	8.851	0.03079	1.88	1.88	3.75	
3	2	3	150	134.00	110	15.7	0.888	1.113	8.306	0.03094	2.28	2.28	4.55	
4	3	25	125	264.00	110	7.1	0.577	1.218	4.615	0.03401	2.57	2.57	5.13	
5	25	29	100	310.00	110	4.9	0.624	2.150	6.935	0.03488	3.62	1.75	5.37	
6	29	52	100	48.00	110	4.9	0.625	0.334	6.958	0.03487	3.62	1.75	5.37	
7	52	51	100	390.00	110	3.5	0.444	1.440	3.692	0.03669	3.86	1.75	5.61	
8	51	49	75	88.00	110	2.5	0.559	0.697	7.918	0.03720	4.04	1.75	5.79	
9	49	50	100	266.00	110	4.8	0.611	1.776	6.675	0.03499	4.31	1.75	6.06	
10	50	10	75	262.00	110	2.7	0.617	2.484	9.481	0.03666	4.74	1.75	6.49	
11	10	11	50	202.00	110	1.3	0.651	3.397	16.817	0.03891	4.81	1.75	6.56	
12	3	4	125	266.00	110	8.6	0.701	1.765	6.635	0.03303	3.73	1.75	5.48	
13	4	5	125	100.00	110	7.1	0.580	0.466	4.661	0.03398	4.02	1.75	5.77	
14	5	6	100	248.00	110	4.8	0.610	1.649	6.649	0.03500	5.06	1.75	6.81	
15	6	7	75	162.00	110	2.7	0.617	1.540	9.505	0.03666	5.13	1.75	6.88	
16	7	8	75	120.00	110	1.8	0.412	0.538	4.486	0.03893	5.13	1.75	6.88	
17	8	53	75	306.00	110	1.8	0.412	1.375	4.493	0.03892	5.10	1.75	6.85	
18	5	49	75	510.00	110	2.3	0.526	3.608	7.074	0.03753	4.04	1.75	5.79	
19	1	18	100	380.00	110	3.0	0.382	1.061	2.793	0.03752	1.31	1.31	2.63	
20	18	19	75	410.00	110	1.4	0.316	1.125	2.743	0.04049	1.83	1.83	3.67	
21	18	22	75	164.00	110	1.7	0.374	0.617	3.762	0.03948	1.57	1.57	3.15	
22	2	24	50	140.00	110	0.5	0.266	0.449	3.207	0.04443	2.07	2.07	4.14	
23	25	26	75	84.00	110	2.0	0.443	0.431	5.130	0.03851	2.56	2.56	5.13	
24	26	27	75	246.00	110	2.0	0.444	1.272	5.171	0.03849	3.31	3.31	6.63	
25	27	28	50	174.00	110	1.0	0.513	1.881	10.811	0.04031	3.31	3.31	6.62	
合計				5478.00										

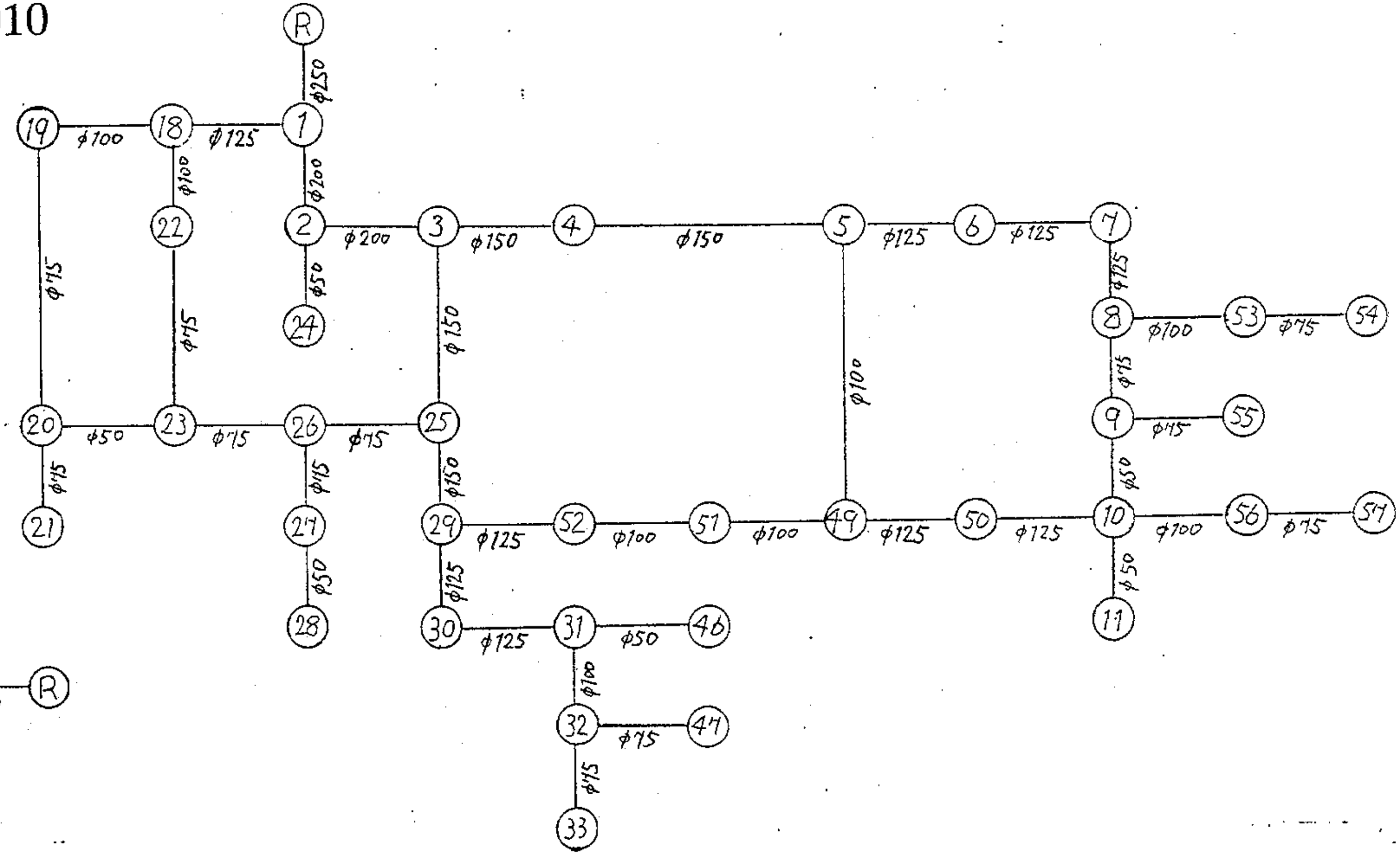
Node No.	Dynamic (WL.m)	Ground Elevation (EL.m)	Effective Head (m)	Area (ha)	Outflow Quantitiy (L/sec)
0	2067.000	2055.000	12.000	-28.10	-3.63
1	2065.047	2048.900	16.147	6.30	0.81
2	2062.628	2050.200	12.428	0.00	0.00
3	2060.814	2040.500	20.314	10.90	1.41
4	2059.003	2045.100	13.903	10.90	1.41

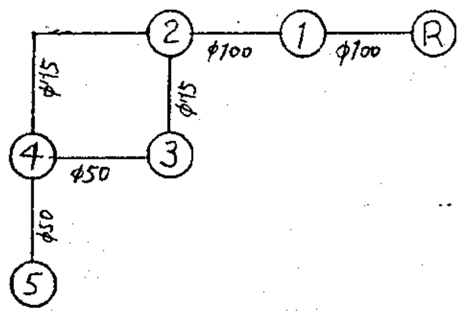
Pipe line No.	Node No. From	Node No. To	Dia. (mm)	Length (m)	Flow Coefficient	Flow (L/sec)	velocity (m/sec)	Loss of Head (m)	Hydraulic Gradient (m/1000m)	Head Loss Coefficient	Hydrostatic Head	Water Hummer Head	Design Pressure (kg/sq.cm)	Pipe Material
1	0	1	100	491.00	110	3.6	0.462	1.953	3.977	0.03647	1.89	1.89	3.77	
2	1	2	75	240.00	110	2.8	0.637	2.419	10.080	0.03648	1.88	1.88	3.77	
3	2	3	75	309.00	110	2.1	0.476	1.814	5.870	0.03810	2.72	2.72	5.45	
4	3	4	50	333.00	110	0.7	0.354	1.811	5.438	0.04259	2.72	2.72	5.44	
5	2	4	50	636.00	110	0.7	0.363	3.625	5.699	0.04243	2.26	2.26	4.52	
合計				2009.00										

2.6 Plan of Distribution Pipeline (2010)



DEKEMHARE 2010





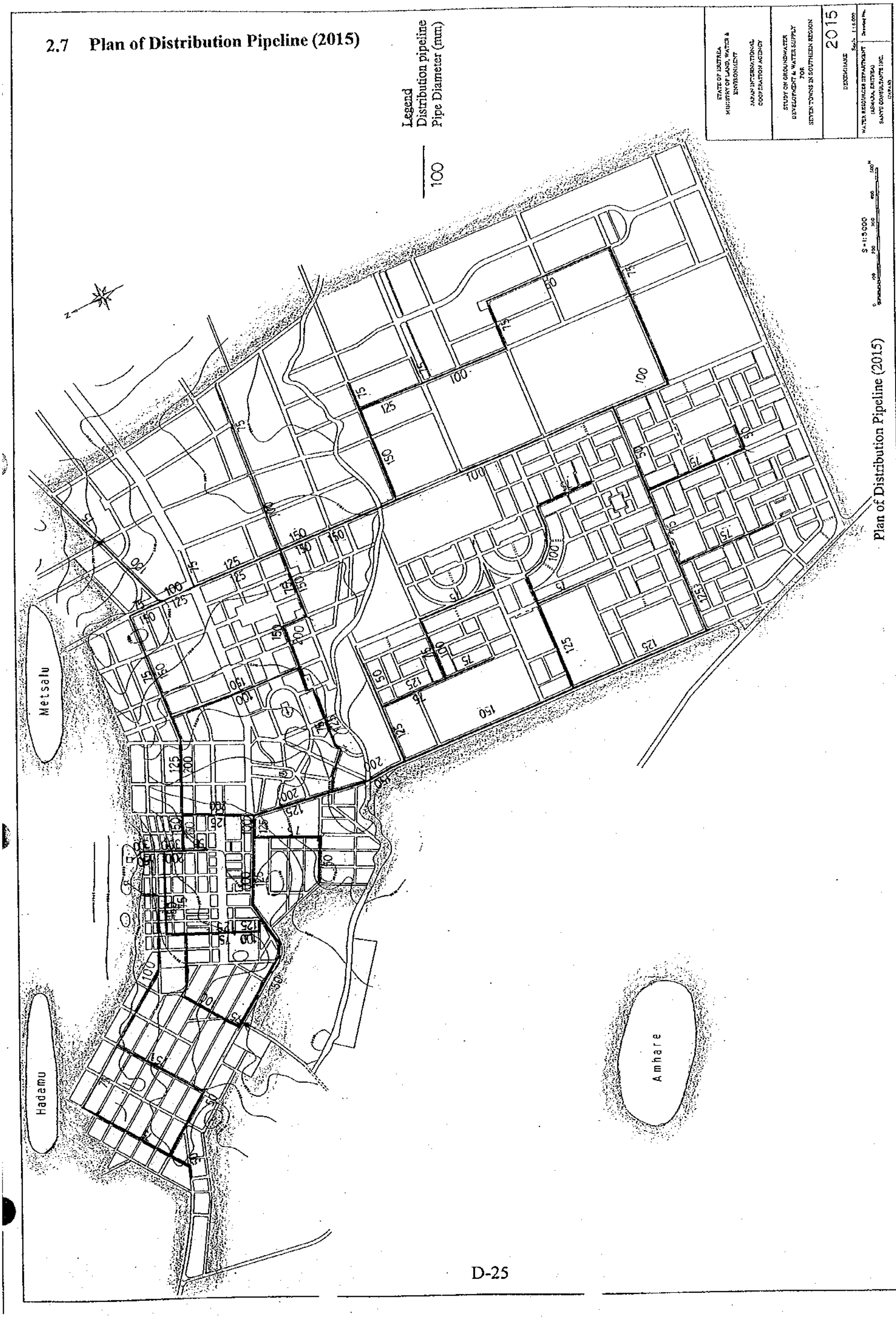
Node No.	Dynamic (WL.m)	Ground Elevation (EL.m)	Effective Head (m)	Area (ha)	Outflow Quantitiy (L/sec)
0	2055.000	2055.000	0.000	-291.90	-37.79
1	2054.540	2042.600	11.939	0.00	0.00
2	2054.027	2037.000	17.027	0.00	0.00
3	2053.080	2033.000	20.080	0.00	0.00
4	2050.571	2018.500	32.071	11.60	1.50
5	2049.780	2015.600	34.179	0.00	0.00
6	2047.516	2005.100	42.416	16.00	2.07
7	2046.544	2004.400	42.144	7.10	0.92
8	2045.969	2004.700	41.269	0.00	0.00
9	2044.331	2008.700	35.631	0.00	0.00
10	2042.795	2008.300	34.495	11.20	1.45
11	2039.379	2007.600	31.779	9.90	1.28
18	2053.024	2043.600	9.424	0.00	0.00
19	2051.625	2037.400	14.226	10.80	1.40
20	2051.217	2035.700	15.517	0.00	0.00
21	2051.076	2035.200	15.876	17.90	2.32
22	2052.505	2040.000	12.505	12.80	1.66
23	2051.943	2037.500	14.443	0.00	0.00
24	2053.575	2035.000	18.575	4.00	0.52
25	2051.348	2030.100	21.248	1.70	0.22
26	2051.273	2032.000	19.273	0.00	0.00
27	2049.994	2022.600	27.394	7.40	0.96
28	2048.102	2026.600	21.502	7.80	1.01
29	2049.567	2019.500	30.067	0.00	0.00
30	2048.463	2019.000	29.463	0.00	0.00
31	2047.640	2016.400	31.240	8.00	1.04
32	2045.967	2018.000	27.967	8.10	1.05
33	2044.869	2018.300	26.569	16.10	2.08
46	2046.568	2013.000	33.568	4.80	0.62
47	2045.150	2013.000	32.150	12.10	1.57
49	2046.012	2015.300	30.712	0.00	0.00
50	2044.016	2012.700	31.316	16.10	2.08
51	2046.450	2017.200	29.250	7.90	1.02
52	2049.378	2019.600	29.778	11.00	1.42
53	2044.282	2014.000	30.282	14.10	1.83
54	2042.302	2019.500	22.802	19.30	2.50
55	2043.320	2008.100	35.220	17.50	2.27
56	2040.600	2002.600	38.000	18.60	2.41
57	2037.481	2003.800	33.681	20.10	2.60

Pipe line No.	Node No. From	Node No. To	Dia. (mm)	Length (m)	Flow Coefficient	Flow (L/sec)	velocity (m/sec)	Loss of Head (m)	Hydraulic Gradient (m/1000m)	Head Loss Coefficient	Hydrostatic Head	Water Hummer Head	Design Pressure (kg/sq.cm)	Pipe Material
1	0	1	250	133.00	110	37.5	0.764	0.460	3.462	0.02906	1.32	1.32	2.64	
2	1	2	200	71.00	110	31.0	0.987	0.513	7.221	0.02904	1.88	1.88	3.76	
3	2	3	200	134.00	110	30.7	0.976	0.947	7.066	0.02909	2.28	2.28	4.56	
4	3	4	150	266.00	110	16.8	0.951	2.509	9.432	0.03063	3.73	1.75	5.48	
5	4	5	150	100.00	110	15.3	0.866	0.792	7.917	0.03106	4.02	1.75	5.77	
6	5	6	125	248.00	110	10.2	0.833	2.263	9.127	0.03220	5.07	1.75	6.82	
7	6	7	125	162.00	110	8.2	0.664	0.972	6.000	0.03330	5.14	1.75	6.89	
8	7	8	125	120.00	110	7.2	0.589	0.575	4.795	0.03390	5.14	1.75	6.89	
9	8	9	75	154.00	110	2.9	0.656	1.638	10.634	0.03633	5.10	1.75	6.85	
10	9	10	50	334.00	110	0.6	0.323	1.536	4.600	0.04317	4.74	1.75	6.49	
11	10	11	50	202.00	110	1.3	0.653	3.416	16.910	0.03890	4.81	1.75	6.56	
12	1	18	125	380.00	110	6.5	0.533	1.516	3.988	0.03441	1.32	1.32	2.63	
13	18	19	100	410.00	110	3.3	0.426	1.398	3.411	0.03692	1.84	1.84	3.67	
14	19	20	75	80.00	110	1.9	0.441	0.408	5.103	0.03853	2.00	2.00	4.01	
15	20	21	75	20.00	110	2.3	0.526	0.141	7.056	0.03754	2.05	2.05	4.11	
16	18	22	100	164.00	110	3.2	0.408	0.519	3.162	0.03714	1.57	1.57	3.15	
17	22	23	75	164.00	110	1.6	0.356	0.562	3.427	0.03977	1.82	1.82	3.65	
18	23	20	50	425.00	110	0.4	0.189	0.726	1.708	0.04673	2.00	2.00	4.01	
19	2	24	50	140.00	110	0.5	0.267	0.451	3.224	0.04441	2.07	2.07	4.14	
20	3	25	150	264.00	110	13.8	0.782	1.732	6.559	0.03153	2.57	2.57	5.13	
21	25	26	75	84.00	110	0.8	0.172	0.075	0.892	0.04429	2.56	2.56	5.13	
22	26	23	75	320.00	110	-1.2	-0.273	-0.670	-2.094	-0.04137	2.37	2.37	4.75	
23	26	27	75	246.00	110	2.0	0.446	1.280	5.202	0.03847	3.31	3.31	6.63	
24	27	28	50	174.00	110	1.0	0.514	1.891	10.870	0.04030	3.31	3.31	6.62	
25	25	29	150	310.00	110	12.9	0.728	1.781	5.746	0.03187	3.63	1.75	5.38	
26	29	30	125	292.00	110	6.4	0.518	1.104	3.783	0.03455	3.68	1.75	5.43	
27	30	31	125	218.00	110	6.3	0.517	0.823	3.774	0.03456	3.94	1.75	5.69	
28	31	32	100	262.00	110	4.7	0.597	1.673	6.385	0.03511	3.94	1.75	5.69	
29	32	33	75	190.00	110	2.1	0.472	1.098	5.777	0.03815	3.77	1.75	5.52	
30	31	46	50	242.00	110	0.6	0.317	1.072	4.430	0.04330	4.27	1.75	6.02	
31	32	47	75	240.00	110	1.6	0.355	0.817	3.404	0.03979	4.27	1.75	6.02	
32	5	49	100	510.00	110	5.1	0.646	3.768	7.387	0.03471	4.04	1.75	5.79	
33	49	50	125	266.00	110	9.2	0.750	1.996	7.503	0.03271	4.31	1.75	6.06	
34	50	10	125	262.00	110	7.1	0.580	1.221	4.662	0.03398	4.75	1.75	6.50	
35	49	51	100	88.00	110	-4.1	-0.522	-0.438	-4.977	-0.03582	4.04	1.75	5.79	
36	51	52	100	390.00	110	-5.1	-0.652	-2.928	-7.507	-0.03466	3.86	1.75	5.61	
37	52	29	125	48.00	110	-6.5	-0.530	-0.189	-3.947	-0.03443	3.63	1.75	5.38	
38	8	53	100	306.00	110	4.3	0.551	1.687	5.512	0.03553	5.11	1.75	6.86	
39	53	54	75	245.00	110	2.5	0.566	1.980	8.082	0.03713	4.17	1.75	5.92	
40	9	55	75	150.00	110	2.3	0.513	1.011	6.738	0.03768	4.76	1.75	6.51	
41	10	56	100	304.00	110	5.0	0.638	2.195	7.219	0.03477	5.31	1.75	7.06	
42	56	57	75	358.00	110	2.6	0.589	3.119	8.713	0.03691	5.31	1.75	7.06	
合計				9476.00										

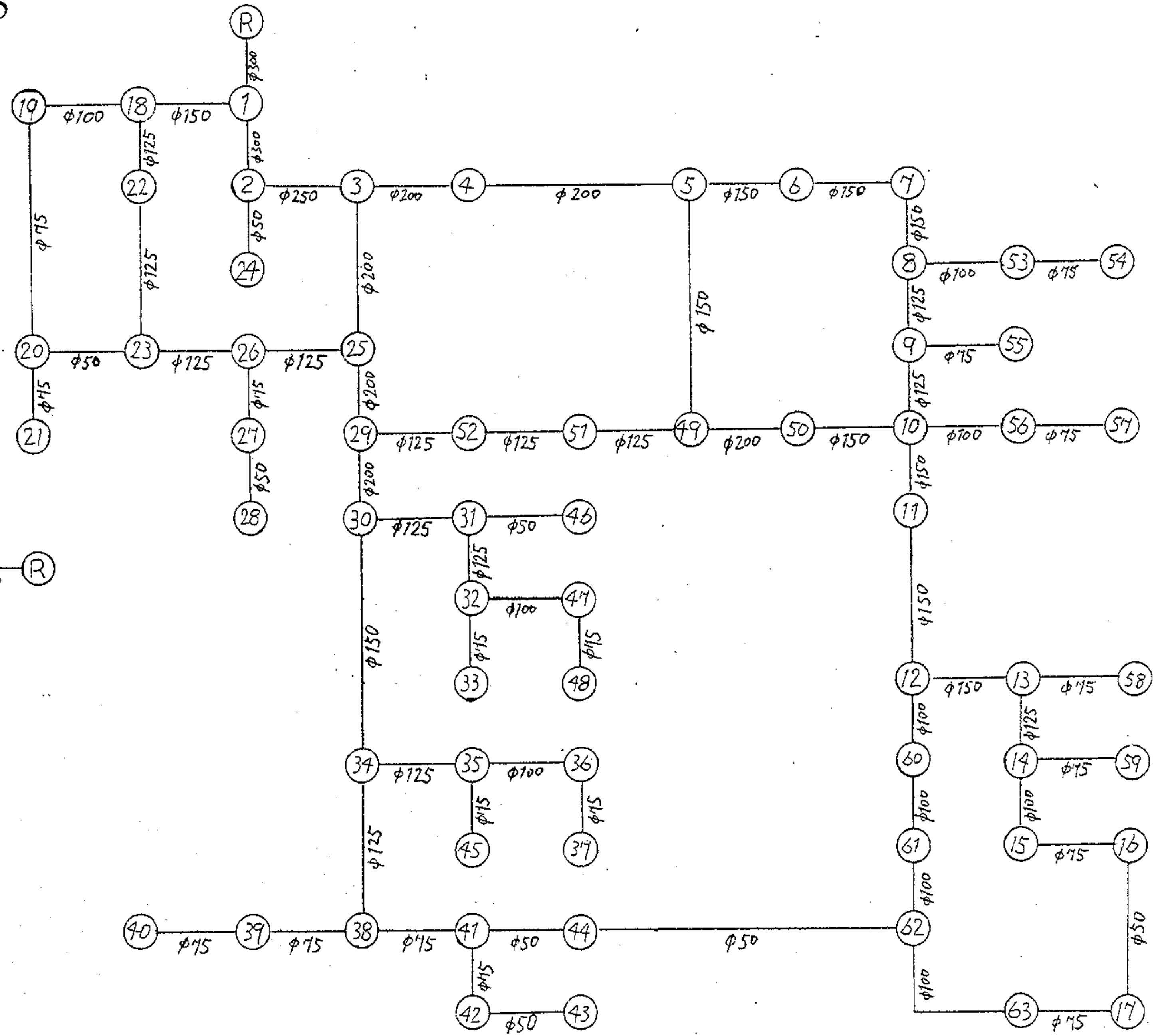
Node No.	Dynamic (WL.m)	Ground Elevation (EL.m)	Effective Head (m)	Area (ha)	Outflow Quantitiy (L/sec)
0	2067.000	2055.000	12.000	-37.00	-4.79
1	2063.744	2048.900	14.844	6.30	0.82
2	2062.617	2050.200	12.417	0.00	0.00
3	2060.905	2040.500	20.405	10.90	1.41
4	2059.407	2045.100	14.307	10.90	1.41
5	2056.910	2045.900	11.010	8.90	1.15

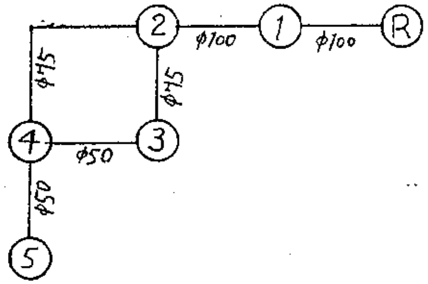
Pipe line No.	Node No. From	Node No. To	Dia. (mm)	Length (m)	Flow Coefficient	Flow (L/sec)	velocity (m/sec)	Loss of Head (m)	Hydraulic Gradient (m/1000m)	Head Loss Coefficient	Hydrostatic Head	Water Hummer Head	Design Pressure (kg/sq.cm)	Pipe Material
1	0	1	100	491.00	110	4.8	0.609	3.256	6.631	0.03501	1.89	1.89	3.77	
2	1	2	100	240.00	110	4.0	0.506	1.127	4.695	0.03599	1.89	1.89	3.77	
3	2	3	75	309.00	110	2.0	0.461	1.713	5.543	0.03827	2.72	2.72	5.45	
4	3	4	50	333.00	110	0.6	0.319	1.497	4.496	0.04325	2.72	2.72	5.44	
5	4	5	50	180.00	110	1.2	0.587	2.498	13.877	0.03952	2.26	2.26	4.52	
6	2	4	75	636.00	110	1.9	0.439	3.210	5.047	0.03856	2.26	2.26	4.53	
合計				2189.00										

2.7 Plan of Distribution Pipeline (2015)



DEKEMHARE 2015





Node No.	Dynamic (WL.m)	Ground Elevation (EL.m)	Effective Head (m)	Area (ha)	Outflow Quantitiy (L/sec)
0	2055.000	2055.000	0.000	-534.40	-74.68
1	2054.336	2042.600	11.736	0.00	0.00
2	2054.069	2037.000	17.069	0.00	0.00
3	2052.859	2033.000	19.859	0.00	0.00
4	2050.580	2018.500	32.080	11.60	1.62
5	2049.799	2015.600	34.199	0.00	0.00
6	2047.221	2005.100	42.121	16.00	2.24
7	2045.910	2004.400	41.510	7.10	0.99
8	2045.052	2004.700	40.352	0.00	0.00
9	2043.757	2008.700	35.057	0.00	0.00
10	2042.115	2008.300	33.815	11.20	1.57
11	2039.706	2007.600	32.106	9.90	1.38
12	2036.948	2004.500	32.448	0.00	0.00
13	2034.657	2002.200	32.458	13.10	1.83
14	2032.634	1997.700	34.934	12.00	1.68
15	2029.919	1997.000	32.919	18.10	2.53
16	2028.050	1995.400	32.650	18.00	2.52
17	2027.427	1993.000	34.427	20.00	2.79
18	2052.903	2043.600	9.303	0.00	0.00
19	2051.322	2037.400	13.922	10.80	1.51
20	2050.868	2035.700	15.168	0.00	0.00
21	2050.706	2035.200	15.506	17.90	2.50
22	2052.223	2040.000	12.223	12.80	1.79
23	2051.844	2037.500	14.344	0.00	0.00
24	2053.545	2035.000	18.545	4.00	0.56
25	2051.172	2030.100	21.072	1.70	0.24
26	2051.222	2032.000	19.222	0.00	0.00
27	2049.747	2022.600	27.146	7.40	1.03
28	2047.568	2026.600	20.968	7.80	1.09
29	2048.802	2019.500	29.302	0.00	0.00
30	2047.595	2019.000	28.595	0.00	0.00
31	2046.171	2016.400	29.771	8.00	1.12
32	2045.064	2018.000	27.064	8.10	1.13
33	2043.800	2018.300	25.500	16.10	2.25
34	2042.781	2022.500	20.281	0.00	0.00
35	2041.303	2017.000	24.303	7.70	1.08
36	2039.858	2004.600	35.258	8.60	1.20
37	2038.311	2004.000	34.311	16.20	2.26
38	2038.499	2017.000	21.499	10.70	1.50
39	2035.355	2015.000	20.355	10.80	1.51
40	2034.676	2012.000	22.676	10.80	1.51
41	2035.010	2006.200	28.810	0.00	0.00
42	2033.146	2004.000	29.146	6.50	0.91
43	2031.546	2002.000	29.546	7.00	0.98
44	2032.521	2003.000	29.521	7.00	0.98
45	2039.171	2016.400	22.771	16.20	2.26
46	2044.943	2013.000	31.943	4.80	0.67
47	2044.236	2013.000	31.236	12.10	1.69
48	2042.304	2007.000	35.304	12.00	1.68
49	2046.075	2015.300	30.775	0.00	0.00

Node No.	Dynamic (WL.m)	Ground Elevation (EL.m)	Effective Head (m)	Area (ha)	Outflow Quantitiy (L/sec)
50	2045.138	2012.700	32.438	16.10	2.25
51	2046.417	2017.200	29.217	7.90	1.10
52	2048.453	2019.600	28.853	11.00	1.54
53	2043.100	2014.000	29.100	14.10	1.97
54	2040.820	2019.500	21.320	19.30	2.70
55	2042.581	2008.100	34.481	17.50	2.45
56	2039.582	2002.600	36.982	18.60	2.60
57	2035.989	2003.800	32.189	20.10	2.81
58	2032.916	1997.500	35.416	17.40	2.43
59	2030.996	1995.600	35.396	16.00	2.24
60	2035.590	2002.000	33.590	0.00	0.00
61	2033.856	2001.000	32.856	0.00	0.00
62	2032.402	2008.000	24.402	0.00	0.00
63	2028.963	1997.000	31.963	14.40	2.01

Pipe line No.	Node No. From	Node No. To	Dia. (mm)	Length (m)	Flow Coefficient	Flow (L/sec)	velocity (m/sec)	Loss of Head (m)	Hydraulic Gradient (m/1000m)	Head Loss Coefficient	Hydrostatic Head	Water Hummer Head	Design Pressure (kg/sq.cm)	Pipe Material
1	0	1	300	133.00	110	73.8	1.044	0.664	4.989	0.02692	1.32	1.32	2.65	
2	1	2	300	71.00	110	63.5	0.898	0.268	3.772	0.02752	1.88	1.88	3.77	
3	2	3	250	134.00	110	62.9	1.282	1.210	9.030	0.02691	2.28	2.28	4.56	
4	3	4	200	266.00	110	34.0	1.083	2.278	8.565	0.02864	3.73	1.75	5.48	
5	4	5	200	100.00	110	32.4	1.030	0.781	7.810	0.02885	4.02	1.75	5.77	
6	5	6	150	248.00	110	17.7	1.003	2.578	10.397	0.03039	5.07	1.75	6.82	
7	6	7	150	162.00	110	15.5	0.876	1.311	8.091	0.03101	5.14	1.75	6.89	
8	7	8	150	120.00	110	14.5	0.819	0.858	7.149	0.03132	5.14	1.75	6.89	
9	8	9	125	154.00	110	9.8	0.797	1.295	8.410	0.03241	5.11	1.75	6.86	
10	9	10	125	334.00	110	7.3	0.597	1.642	4.917	0.03383	4.75	1.75	6.50	
11	10	11	150	202.00	110	19.1	1.080	2.409	11.924	0.03006	4.82	1.75	6.57	
12	11	12	150	266.00	110	17.7	1.001	2.758	10.368	0.03040	5.13	1.75	6.88	
13	12	13	150	363.00	110	13.5	0.766	2.291	6.311	0.03163	5.36	1.75	7.11	
14	13	14	125	266.00	110	9.3	0.755	2.024	7.608	0.03267	5.81	1.75	7.56	
15	14	15	100	332.00	110	5.4	0.682	2.715	8.177	0.03443	5.87	1.75	7.62	
16	15	16	75	184.00	110	2.8	0.640	1.869	10.158	0.03646	6.03	1.75	7.78	
17	16	17	50	506.00	110	0.3	0.159	0.623	1.232	0.04796	6.27	1.75	8.02	
18	1	18	150	380.00	110	10.3	0.580	1.434	3.773	0.03296	1.32	1.32	2.63	
19	18	19	100	410.00	110	3.6	0.455	1.581	3.857	0.03656	1.84	1.84	3.67	
20	19	20	75	80.00	110	2.1	0.467	0.454	5.670	0.03820	2.00	2.00	4.01	
21	20	21	75	20.00	110	2.5	0.567	0.162	8.105	0.03713	2.05	2.05	4.11	
22	18	22	125	164.00	110	6.7	0.544	0.679	4.143	0.03430	1.58	1.58	3.15	
23	22	23	125	164.00	110	4.9	0.397	0.379	2.310	0.03594	1.83	1.83	3.65	
24	23	20	50	425.00	110	0.4	0.222	0.977	2.298	0.04563	2.00	2.00	4.01	
25	2	24	50	140.00	110	0.6	0.289	0.524	3.741	0.04389	2.07	2.07	4.14	
26	3	25	200	264.00	110	29.0	0.924	1.687	6.389	0.02932	2.57	2.57	5.14	
27	25	26	125	84.00	110	-2.3	-0.190	-0.050	-0.593	-0.04007	2.57	2.57	5.13	
28	26	23	125	320.00	110	-4.4	-0.362	-0.623	-1.946	-0.03644	2.38	2.38	4.75	
29	26	27	75	246.00	110	2.1	0.481	1.475	5.996	0.03803	3.31	3.31	6.63	
30	27	28	50	174.00	110	1.1	0.555	2.179	12.523	0.03984	3.31	3.31	6.62	
31	25	29	200	310.00	110	32.0	1.018	2.370	7.646	0.02890	3.63	1.75	5.38	
32	29	30	200	292.00	110	22.9	0.730	1.207	4.132	0.03036	3.68	1.75	5.43	
33	30	31	125	218.00	110	8.5	0.696	1.424	6.531	0.03307	3.94	1.75	5.69	
34	31	32	125	262.00	110	6.7	0.550	1.107	4.225	0.03425	3.94	1.75	5.69	
35	32	33	75	190.00	110	2.2	0.509	1.264	6.655	0.03772	3.77	1.75	5.52	
36	30	34	150	680.00	110	14.4	0.815	4.814	7.079	0.03134	3.68	1.75	5.43	
37	34	35	125	345.00	110	6.8	0.554	1.478	4.283	0.03421	3.88	1.75	5.63	
38	35	36	100	396.00	110	3.5	0.441	1.445	3.650	0.03672	5.11	1.75	6.86	
39	36	37	75	230.00	110	2.3	0.512	1.547	6.728	0.03768	5.17	1.75	6.92	
40	34	38	125	810.00	110	7.6	0.621	4.282	5.287	0.03364	3.88	1.75	5.63	
41	38	39	75	274.00	110	3.0	0.683	3.144	11.473	0.03611	4.07	1.75	5.82	
42	39	40	75	214.00	110	1.5	0.342	0.680	3.176	0.04002	4.37	1.75	6.12	
43	38	41	75	290.00	110	3.1	0.701	3.489	12.030	0.03597	4.95	1.75	6.70	
44	41	42	75	388.00	110	1.9	0.427	1.864	4.805	0.03871	5.17	1.75	6.92	
45	42	43	50	156.00	110	1.0	0.498	1.600	10.255	0.04048	5.37	1.75	7.12	
46	41	44	50	164.00	110	1.2	0.616	2.490	15.180	0.03923	5.27	1.75	7.02	
47	35	45	75	317.00	110	2.3	0.512	2.132	6.726	0.03768	3.93	1.75	5.68	
48	31	46	50	242.00	110	0.7	0.341	1.228	5.075	0.04283	4.27	1.75	6.02	
49	32	47	100	240.00	110	3.4	0.428	0.829	3.454	0.03688	4.27	1.75	6.02	
50	47	48	75	500.00	110	1.7	0.380	1.931	3.862	0.03939	4.87	1.75	6.62	

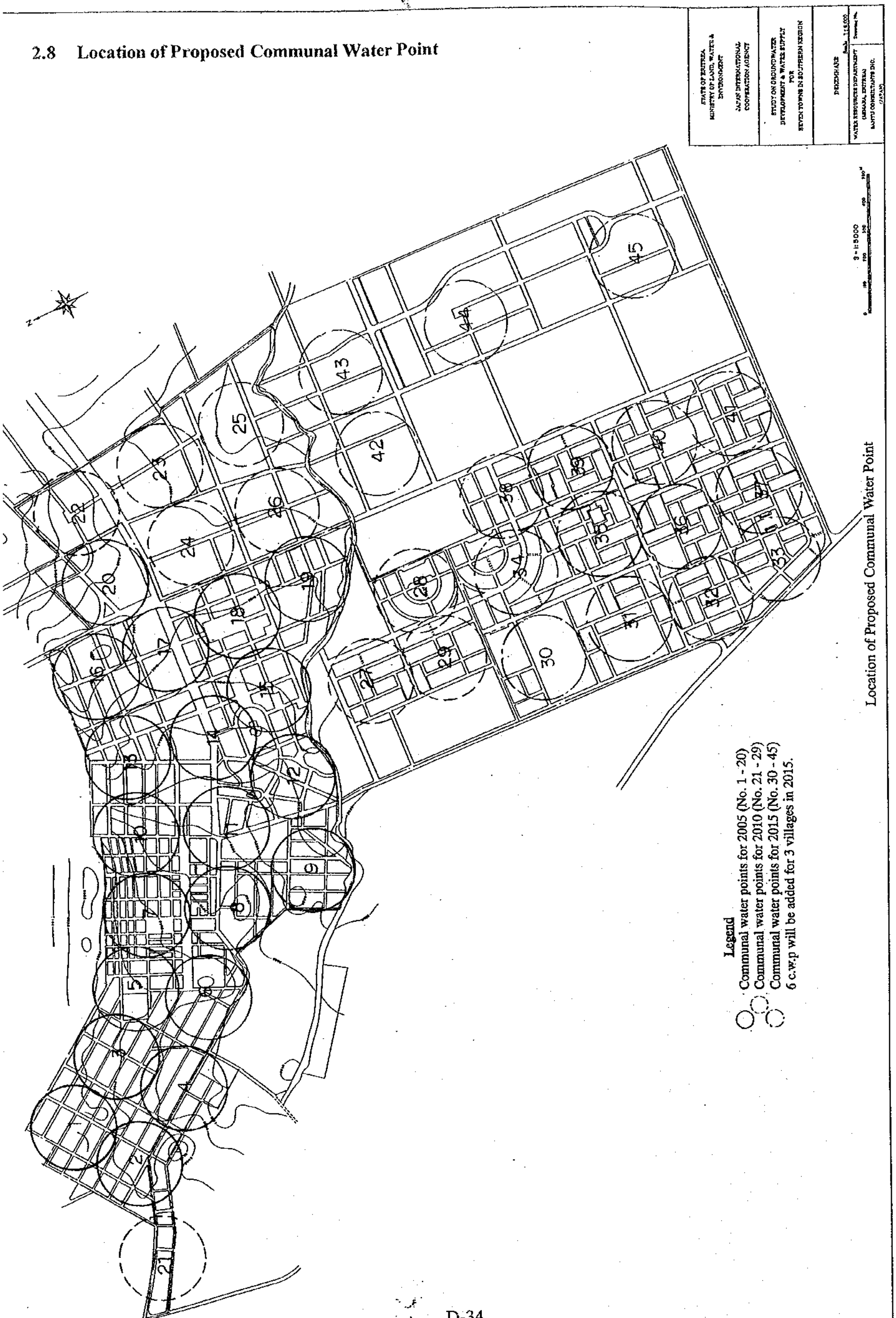
Pipe line No.	Node No. From	Node No. To	Dia. (mm)	Length (m)	Flow Coefficient	Flow (L/sec)	velocity (m/sec)	Loss of Head (m)	Hydraulic Gradient (m/1000m)	Head Loss Coefficient	Hydrostatic Head	Water Hummer Head	Design Pressure (kg/sq.cm)	Pipe Material
51	5	49	150	510.00	110	14.6	0.829	3.724	7.302	0.03126	4.05	1.75	5.80	
52	49	50	200	266.00	110	21.1	0.670	0.937	3.523	0.03075	4.31	1.75	6.06	
53	50	10	150	262.00	110	18.7	1.061	3.024	11.541	0.03014	4.75	1.75	6.50	
54	49	51	125	88.00	110	-6.4	-0.525	-0.342	-3.884	-0.03448	4.05	1.75	5.80	
55	51	52	125	390.00	110	-7.6	-0.616	-2.036	-5.221	-0.03367	3.86	1.75	5.61	
56	52	29	125	48.00	110	-9.0	-0.736	-0.348	-7.258	-0.03280	3.63	1.75	5.38	
57	8	53	100	306.00	110	4.7	0.597	1.953	6.381	0.03512	5.11	1.75	6.86	
58	53	54	75	245.00	110	2.7	0.610	2.280	9.304	0.03672	4.17	1.75	5.92	
59	9	55	75	150.00	110	2.5	0.556	1.176	7.840	0.03722	4.76	1.75	6.51	
60	10	56	100	304.00	110	5.4	0.689	2.533	8.331	0.03437	5.31	1.75	7.06	
61	56	57	75	358.00	110	2.8	0.636	3.593	10.036	0.03650	5.31	1.75	7.06	
62	13	58	75	226.00	110	2.4	0.551	1.742	7.708	0.03728	5.82	1.75	7.57	
63	14	59	75	248.00	110	2.2	0.507	1.638	6.606	0.03774	6.01	1.75	7.76	
64	12	60	100	266.00	110	4.2	0.529	1.358	5.105	0.03575	5.37	1.75	7.12	
65	60	61	100	332.00	110	4.2	0.536	1.734	5.223	0.03568	5.47	1.75	7.22	
66	61	62	100	278.00	110	4.2	0.536	1.454	5.230	0.03568	5.47	1.75	7.22	
67	62	44	50	172.00	110	-0.2	-0.116	-0.118	-0.688	-0.05025	5.27	1.75	7.02	
68	62	63	100	582.00	110	4.5	0.573	3.439	5.910	0.03533	5.87	1.75	7.62	
69	63	17	75	192.00	110	2.5	0.563	1.536	8.001	0.03716	6.27	1.75	8.02	
合計				18453.00										

Node No.	Dynamic (WL.m)	Ground Elevation (EL.m)	Effective Head (m)	Area (ha)	Outflow Quantitiy (L/sec)
0	2067.000	2055.000	12.000	-37.00	-5.17
1	2063.250	2048.900	14.350	6.30	0.88
2	2061.953	2050.200	11.753	0.00	0.00
3	2059.977	2040.500	19.477	10.90	1.52
4	2058.261	2045.100	13.161	10.90	1.52
5	2055.382	2045.900	9.482	8.90	1.24

Pipe line No.	Node No. From	Node No. To	Dia. (mm)	Length (m)	Flow Coefficient	Flow (L/sec)	velocity (m/sec)	Loss of Head (m)	Hydraulic Gradient (m/1000m)	Head Loss Coefficient	Hydrostatic Head	Water Hummer Head	Design Pressure (kg/sq.cm)	Pipe Material
1	0	1	100	491.00	110	5.2	0.658	3.750	7.637	0.03461	1.89	1.89	3.77	
2	1	2	100	240.00	110	4.3	0.546	1.297	5.406	0.03559	1.89	1.89	3.77	
3	2	3	75	309.00	110	2.2	0.498	1.976	6.393	0.03784	2.72	2.72	5.45	
4	3	4	50	333.00	110	0.7	0.344	1.716	5.153	0.04278	2.72	2.72	5.44	
5	4	5	50	180.00	110	1.2	0.633	2.880	15.999	0.03907	2.26	2.26	4.52	
6	2	4	75	636.00	110	2.1	0.473	3.691	5.804	0.03813	2.26	2.26	4.53	
合計				2189.00										

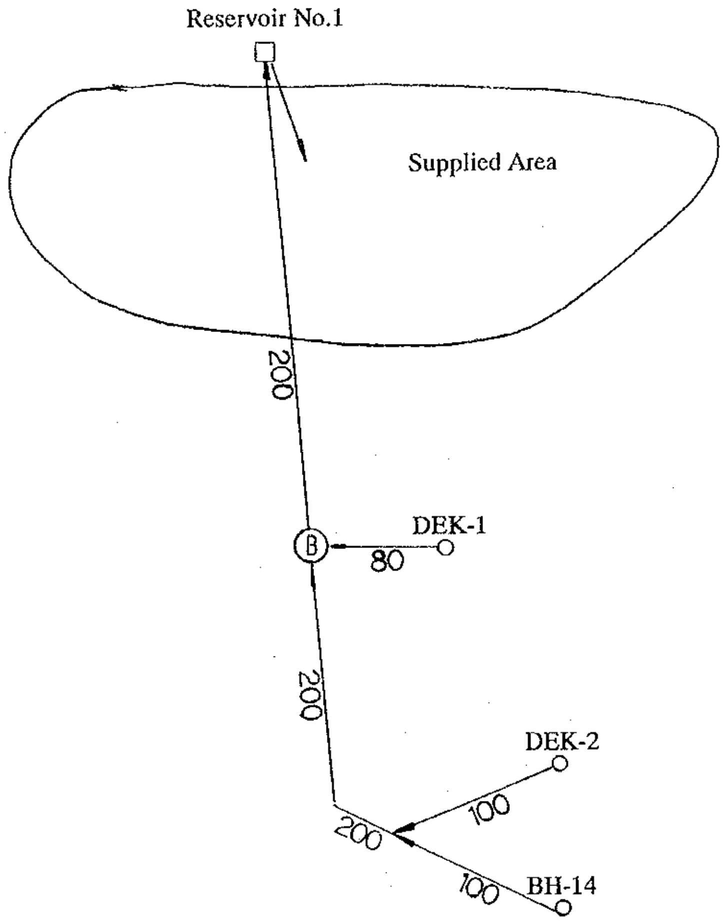

Legend
Distribution pipeline
12.0 Supplied area (ha)
STATE OF ERITREA
MINISTRY OF LAND, WATER & ENVIRONMENT
JAPAN INTERNATIONAL COOPERATION AGENCY
STUDY ON GROUNDWATER DEVELOPMENT & WATER SUPPLY FOR SEVEN TOWNS IN SOUTHERN REGION
DEKEMHARE
WATER RESOURCES DEPARTMENT (ASMARA, ERITREA)
SANYU CONSULTANTS INC. (JAPAN)
S = 1:5000
Metsalu
15.0
Hadamu
15.0
Amhare
15.0
Supplied Points and Its Area

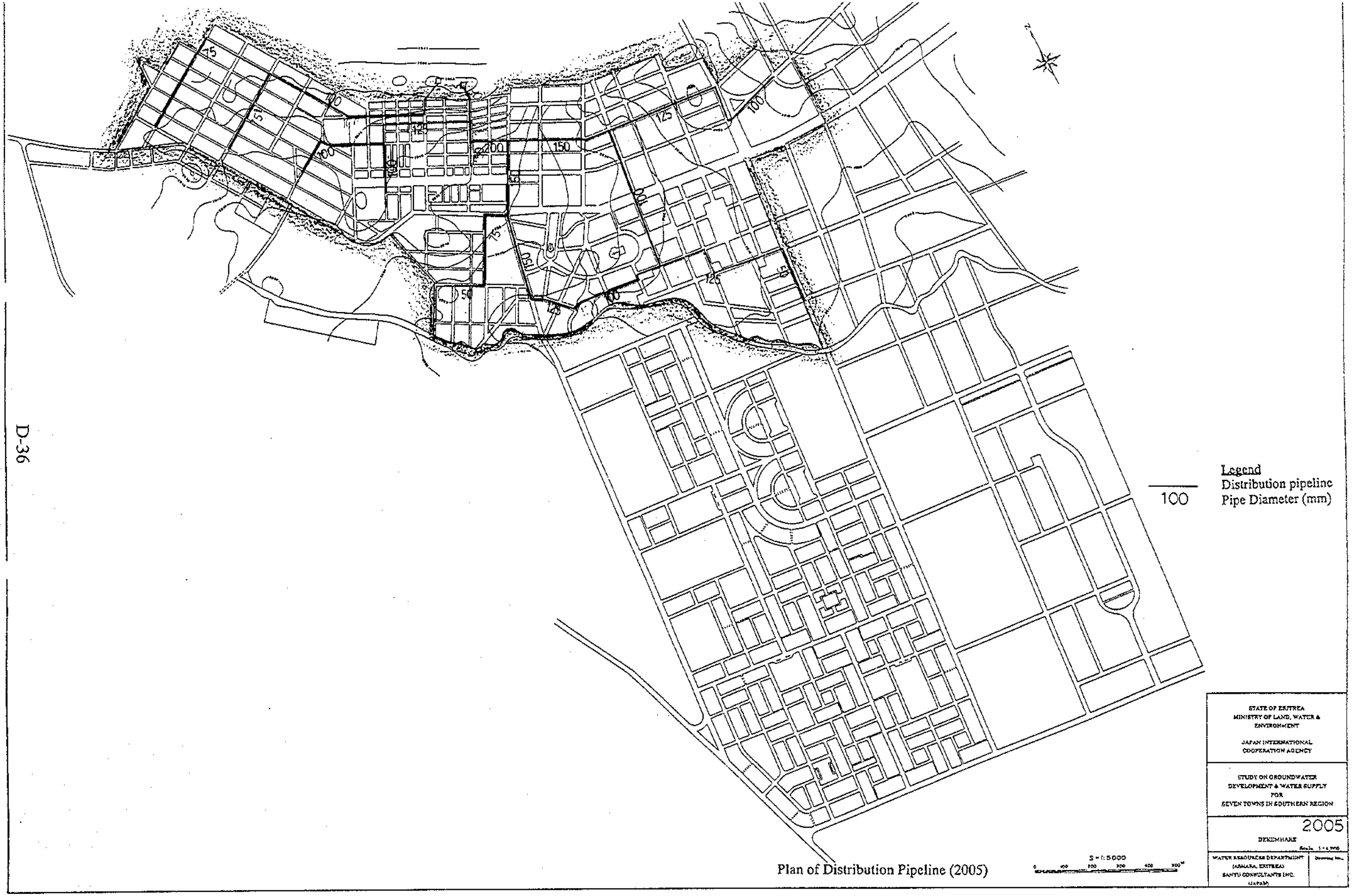
2.8 Location of Proposed Communal Water Point



2.9 Plan of Water Source and Transmission Pipeline (2005)

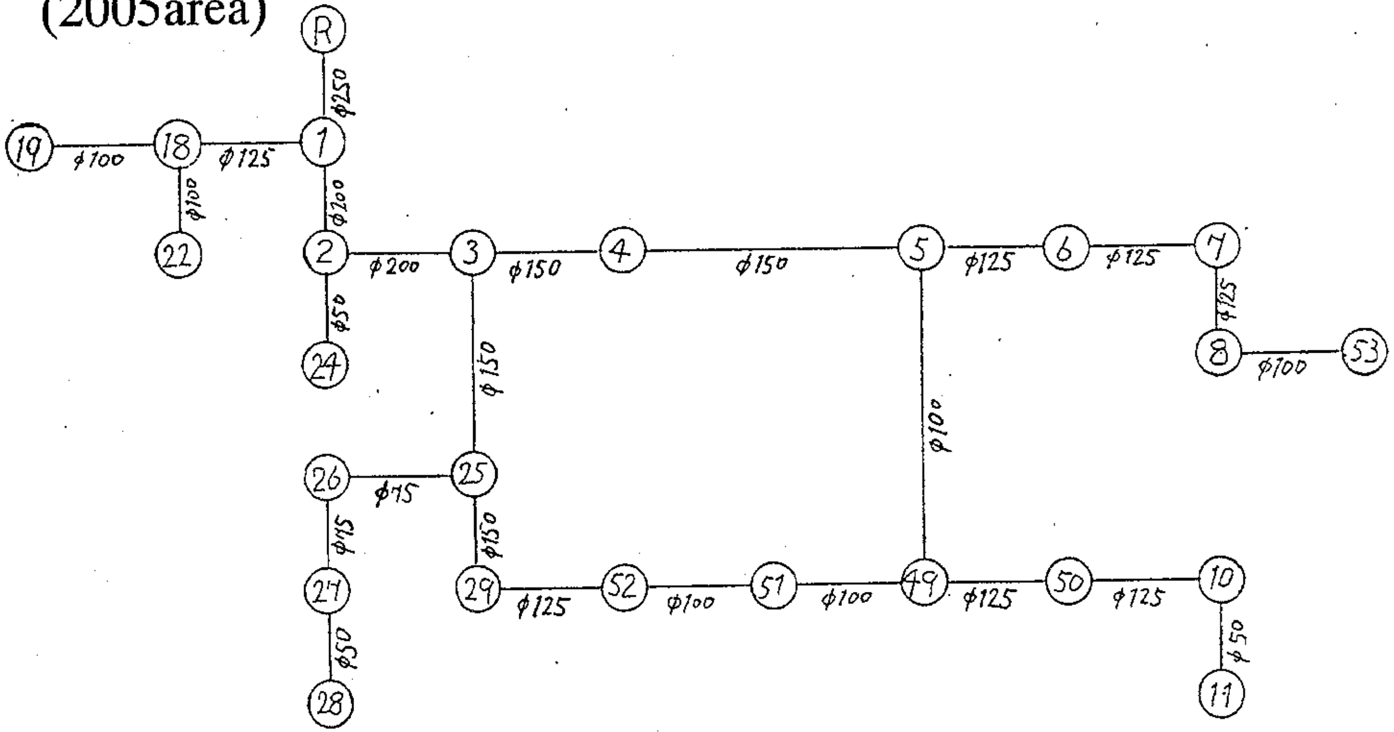
Dekemhare

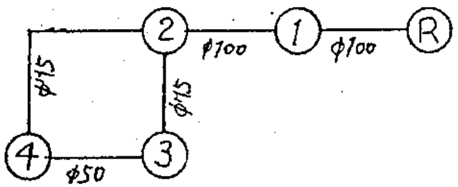




Plan of Distribution Pipeline (2005)

DEKEMHARE 2010 (2005area)





Node No.	Dynamic (WL.m)	Ground Elevation (EL.m)	Effective Head (m)	Area (ha)	Outflow Quantitiy (L/sec)
0	2055.000	2055.000	0.000	-149.40	-19.34
1	2054.865	2042.600	12.265	0.00	0.00
2	2054.713	2037.000	17.713	0.00	0.00
3	2054.441	2033.000	21.441	0.00	0.00
25	2053.983	2030.100	23.883	1.70	0.22
29	2053.718	2019.500	34.218	0.00	0.00
52	2053.618	2019.600	34.018	11.00	1.42
51	2052.410	2017.200	35.210	7.90	1.02
49	2052.277	2015.300	36.977	0.00	0.00
50	2051.674	2012.700	38.974	16.10	2.08
10	2051.466	2008.300	43.166	11.20	1.45
11	2048.060	2007.600	40.460	9.90	1.28
4	2053.646	2018.500	35.146	11.60	1.50
5	2053.434	2015.600	37.833	0.00	0.00
6	2052.867	2005.100	47.767	16.00	2.07
7	2052.736	2004.400	48.336	7.10	0.92
8	2052.691	2004.700	47.991	0.00	0.00
53	2052.350	2014.000	38.350	14.10	1.83
18	2054.500	2043.600	10.900	0.00	0.00
19	2054.222	2037.400	16.822	10.80	1.40
22	2054.348	2040.000	14.348	12.80	1.66
24	2054.259	2035.000	19.259	4.00	0.52
26	2053.565	2032.000	21.565	0.00	0.00
27	2052.287	2022.600	29.687	7.40	0.96
28	2050.398	2026.600	23.798	7.80	1.01

Pipe line No.	Node No. From	Node No. To	Dia. (mm)	Length (m)	Flow Coefficient	Flow (L/sec)	velocity (m/sec)	Loss of Head (m)	Hydraulic Gradient (m/1000m)	Head Loss Coefficient	Hydrostatic Head	Water Hummer Head	Design Pressure (kg/sq.cm)	Pipe Material
1	0	1	250	133.00	110	19.3	0.394	0.135	1.013	0.03206	1.32	1.32	2.64	
2	1	2	200	71.00	110	16.1	0.512	0.152	2.139	0.03200	1.88	1.88	3.76	
3	2	3	200	134.00	110	15.6	0.498	0.272	2.030	0.03214	2.28	2.28	4.56	
4	3	25	150	264.00	110	6.7	0.382	0.459	1.738	0.03507	2.57	2.57	5.13	
5	25	29	150	310.00	110	4.6	0.260	0.265	0.854	0.03712	3.63	1.75	5.38	
6	29	52	125	48.00	110	4.6	0.375	0.100	2.080	0.03625	3.63	1.75	5.38	
7	52	51	100	390.00	110	3.2	0.404	1.208	3.097	0.03721	3.86	1.75	5.61	
8	51	49	100	88.00	110	2.2	0.274	0.133	1.509	0.03941	4.04	1.75	5.79	
9	49	50	125	266.00	110	4.8	0.393	0.604	2.270	0.03599	4.31	1.75	6.06	
10	50	10	125	262.00	110	2.7	0.223	0.208	0.793	0.03915	4.75	1.75	6.50	
11	10	11	50	202.00	110	1.3	0.652	3.406	16.861	0.03891	4.81	1.75	6.56	
12	3	4	150	266.00	110	9.0	0.512	0.795	2.989	0.03358	3.73	1.75	5.48	
13	4	5	150	100.00	110	7.5	0.426	0.213	2.126	0.03451	4.02	1.75	5.77	
14	5	6	125	248.00	110	4.8	0.395	0.567	2.286	0.03597	5.07	1.75	6.82	
15	6	7	125	162.00	110	2.8	0.225	0.130	0.805	0.03911	5.14	1.75	6.89	
16	7	8	125	120.00	110	1.8	0.149	0.045	0.376	0.04156	5.14	1.75	6.89	
17	8	53	100	306.00	110	1.8	0.233	0.341	1.114	0.04038	5.11	1.75	6.86	
18	5	49	100	510.00	110	2.7	0.341	1.156	2.267	0.03815	4.04	1.75	5.79	
19	1	18	125	380.00	110	3.0	0.247	0.365	0.960	0.03856	1.32	1.32	2.63	
20	18	19	100	410.00	110	1.4	0.178	0.278	0.679	0.04201	1.84	1.84	3.67	
21	18	22	100	164.00	110	1.7	0.211	0.153	0.932	0.04096	1.57	1.57	3.15	
22	2	24	50	140.00	110	0.5	0.268	0.455	3.247	0.04439	2.07	2.07	4.14	
23	25	26	75	84.00	110	1.9	0.435	0.417	4.970	0.03861	2.56	2.56	5.13	
24	26	27	75	246.00	110	2.0	0.446	1.278	5.194	0.03847	3.31	3.31	6.63	
25	27	28	50	174.00	110	1.0	0.514	1.889	10.857	0.04030	3.31	3.31	6.62	
合計				5478.00										

Node No.	Dynamic (WL.m)	Ground Elevation (EL.m)	Effective Head (m)	Area (ha)	Outflow Quantitiy (L/sec)
0	2067.000	2055.000	12.000	-28.10	-3.64
1	2065.042	2048.900	16.143	6.30	0.82
2	2064.444	2050.200	14.244	0.00	0.00
3	2063.319	2040.500	22.819	10.90	1.41
4	2063.119	2045.100	18.019	10.90	1.41

Pipe line No.	Node No. From	To	Dia. (mm)	Length (m)	Flow Coefficient	Flow (L/sec)	velocity (m/sec)	Loss of Head (m)	Hydraulic Gradient (m/1000m)	Head Loss Coefficient	Hydrostatic Head	Water Hummer Head	Design Pressure (kg/sq.cm)	Pipe Material
1	0	1	100	491.00	110	3.6	0.463	1.958	3.987	0.03646	1.89	1.89	3.77	
2	1	2	100	240.00	110	2.8	0.359	0.598	2.493	0.03786	1.89	1.89	3.77	
3	2	3	75	309.00	110	1.6	0.368	1.125	3.640	0.03958	2.72	2.72	5.45	
4	3	4	50	333.00	110	0.2	0.108	0.200	0.600	0.05080	2.72	2.72	5.44	
5	2	4	75	636.00	110	1.2	0.272	1.325	2.083	0.04139	2.26	2.26	4.53	
合計				2009.00										