社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
MINISTRY OF WATER RESOURCES

No. 1 1

THE STUDY
ON
ELEVEN CENTERS WATER SUPPLY AND SANITATION
IN
FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

APPENDIXES
AYKEL

(Volume Ⅲ-Ⅴ)

FEBRUARY, 1996

SANYU CONSULTANTS INC.
KYOWA ENGINEERING CONSULTANTS CO., LTD.

GOVERNMENT OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)
FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
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PREFACE

This is the Appendixes for Aykel presenting the results of the Study on Eleven Centers Water Supply and Sanitation (the Study) carried out in accordance with the Scope of Work agreed upon between the Government of Federal Democratic Republic of Ethiopia (GOE) through the Water Supply and Sewerage Agency (WSSA) of the Ministry of Natural Resources Development and Environmental Protection (MNRDEP), which was recently reorganized Water Supply and Sewerage Service Department (WSSD) under Ministry of Water Resources (MWR), on the one part and the Government of Japan (GOJ) through the Japan International Cooperation Agency (JICA) on the other part dated April 8, 1994.

The major objectives of this Study are 1) to conduct a feasibility study on the water supply system in order to improve living condition of the population in the Study area by enhancing the level of the water supply services in terms of water quantity, water quality and its accessibility, 2) to formulate a plan for sanitary education and the diffusion of sanitary facilities in order to raise peoples' awareness on hygiene and improve environmental sanitation, which will be able to prevent the contamination of water source(s) and to secure safe water supply, and 3) to transfer technologies to the Ethiopian counterpart personnel in order to strengthen the managerial aspects of water supply services.

The Study had been conducted over a two (2) Japanese fiscal year-period from 1994/95 to 1995/96 and divided into two (2) phases. The Phase I study was conducted between December 1994 and March 1995, and Phase II was conducted between May 1995 and February 1996, for a total study period of 15 months during which three (3) times of visit to Ethiopia were made.

The survey items and major activities are meteo-hydrological survey, geo-electric prospecting (GEP) survey, water quality, water use condition, sanitary and health condition and people's awareness, social background, socio-economy, initial environmental examination (IEE), environmental impact assessment (EIA), sanitary education practice, and existing pump investigation.

The Study Team extends heartiest thanks to WSSD especially those assigned counterparts for their close cooperation and hard work in both office and the field, and the officers of related agencies of Japan.

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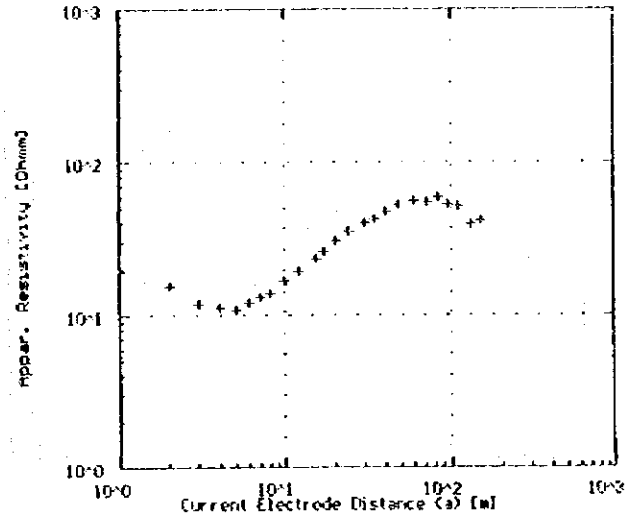
Appendix - 1

Resistivity Interpretation of VEP

Figure 1 Geoelectrical Survey, Wenner Array

VES St. No.1 -AYKEL

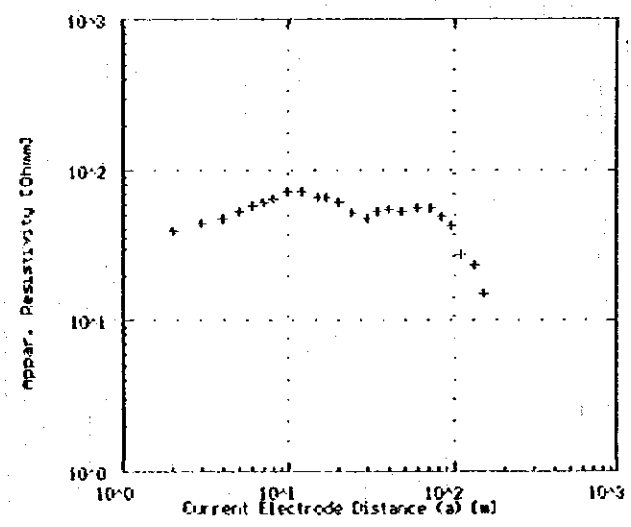


Point [No]	MN/2 [Mr]	a [m]	Res [ohms]
1	1.00	15.470	
2	2.00	15.570	
3	3.00	16.680	
4	4.00	11.050	
5	5.00	10.970	
6	6.00	12.069	
7	7.00	13.010	
8	8.00	14.070	
9	10.00	16.610	
10	12.00	19.220	
11	15.00	23.170	
12	17.00	26.110	
13	20.00	30.480	
14	24.00	36.020	
15	30.00	40.370	
16	34.00	52.020	
17	40.00	57.330	
18	45.00	53.050	
19	60.00	58.520	
20	72.00	54.210	
21	84.00	51.080	
22	96.00	53.650	
23	110.00	51.020	
24	130.00	39.190	
25	150.00	41.650	

Specific Resistivity(Ω-m)	31.6	10.6	17.55	126		28.5

77.25

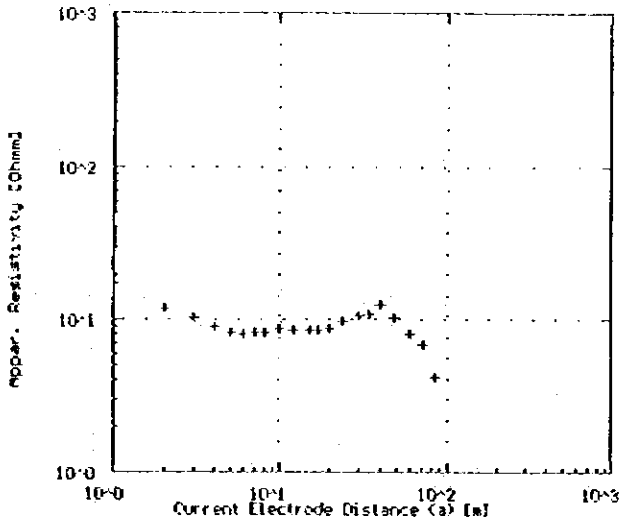
VES St. No.2 -AYKEL



Point [No]	MN/2 [Mr]	a [m]	Res [ohms]
1	1.00	35.170	
2	2.00	38.560	
3	3.00	43.520	
4	4.00	47.980	
5	5.00	53.070	
6	6.00	57.270	
7	7.00	61.160	
8	8.00	65.310	
9	10.00	72.950	
10	12.00	10.224	
11	15.00	85.960	
12	17.00	88.190	
13	20.00	60.290	
14	24.00	51.250	
15	30.00	47.100	
16	34.00	52.530	
17	40.00	55.260	
18	45.00	53.050	
19	60.00	58.520	
20	72.00	58.010	
21	84.00	49.590	
22	96.00	62.200	
23	110.00	27.630	
24	130.00	23.580	
25	150.00	15.070	

Specific Resistivity(Ω-m)	33	49.6	107.5	30.4	69	18.67

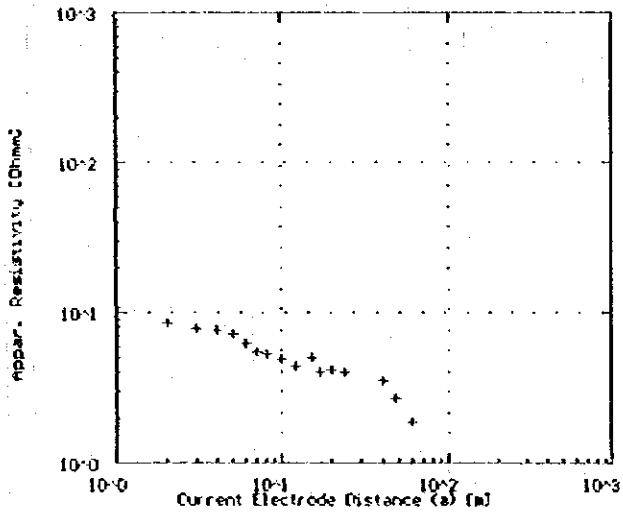
VES St. No.3 -AYKEL



Point (No)	MN/2 (Mr)	a (m)	Res (ohmm)
1	0.80	12.330	
2	2.00	10.910	
3	3.00	10.170	
4	4.00	9.950	
5	5.00	9.180	
6	6.00	9.100	
7	7.00	8.220	
8	8.00	8.340	
9	10.00	8.330	
10	12.00	8.170	
11	15.00	8.160	
12	17.00	8.540	
13	20.00	8.730	
14	24.00	8.900	
15	30.00	10.650	
16	34.00	10.730	
17	40.00	12.360	
18	48.00	10.250	
19	60.00	7.950	
20	72.00	6.390	
21	84.00	6.200	
22	96.00	8.600	

Specific Resistivity(Ω-m)	245	81.67	176	17.54

VES St. No.4 -AYKEL

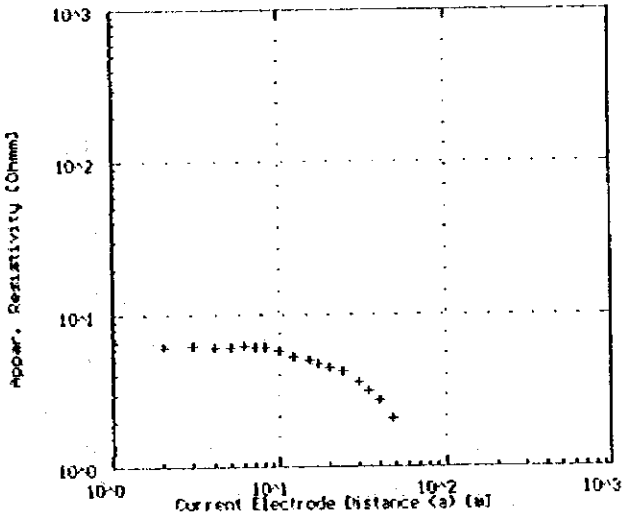


Point (No)	MN/2 (Mr)	a (m)	Res (ohmm)
1	1.00	10.930	
2	2.00	8.560	
3	3.00	7.910	
4	4.00	7.560	
5	5.00	7.130	
6	6.00	6.250	
7	7.00	5.560	
8	8.00	5.330	
9	10.00	4.960	
10	12.00	4.450	
11	15.00	5.070	
12	17.00	4.960	
13	20.00	4.150	
14	24.00	4.070	
15	40.00	3.520	
16	48.00	2.710	
17	60.00	1.800	

Specific Resistivity(Ω-m)	14	7	3.43	4.8

2.08

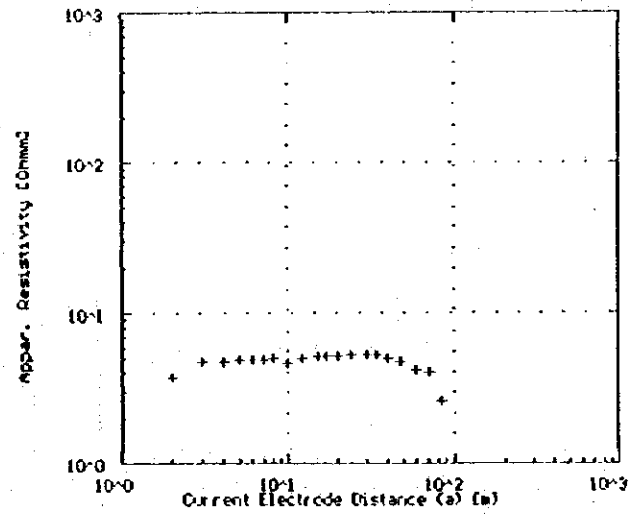
VES St. No.5 -AYKEL



Point [No]	AB/2 [m]	a [m]	Res [ohm]
1	1.00	6.660	
2	2.00	6.930	
3	3.00	6.220	
4	4.00	6.050	
5	5.00	6.150	
6	6.00	6.260	
7	7.00	6.110	
8	8.00	6.030	
9	10.00	5.700	
10	12.00	5.350	
11	15.00	5.090	
12	17.00	4.880	
13	20.00	4.520	
14	24.00	4.220	
15	30.00	3.610	
16	34.00	3.280	
17	40.00	2.760	
18	44.00	2.110	
19	50.00	0.380	

Specific Resistivity(Ω-m)	6.9	4.6	6	3	0.93

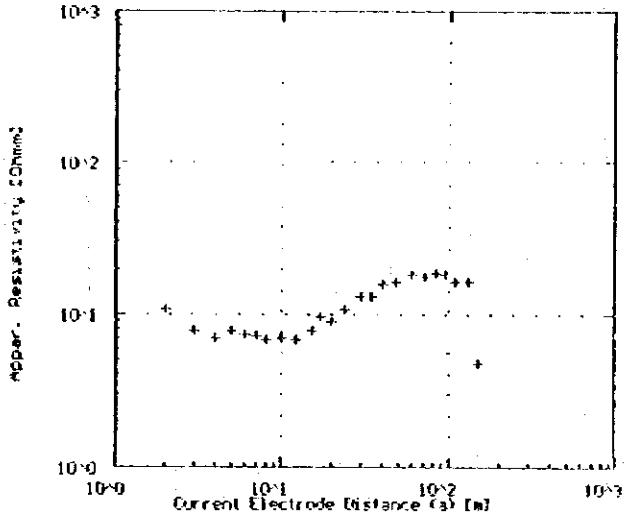
VES St. No.6 -AYKEL



Point [No]	AB/2 [m]	a [m]	Res [ohm]
1	1.00	9.110	
2	2.00	7.770	
3	3.00	6.800	
4	4.00	6.220	
5	5.00	6.060	
6	6.00	6.900	
7	7.00	6.040	
8	8.00	5.020	
9	10.00	6.050	
10	12.00	5.050	
11	15.00	5.100	
12	17.00	5.220	
13	20.00	5.150	
14	24.00	5.200	
15	30.00	5.200	
16	34.00	5.360	
17	40.00	5.020	
18	44.00	4.020	
19	50.00	0.150	
20	72.00	4.020	
21	81.00	2.040	
22	98.00	0.600	

Specific Resistivity(Ω-m)	28	4.67	3.2	0.38	

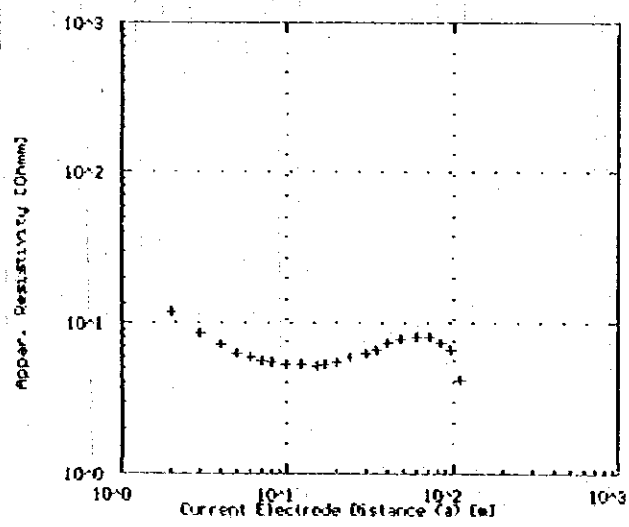
VES St. No.7 -AYKEL



Point [No]	AB/2 [Mr]	a [m]	Ess [ohms]
1	1.00	0.470	
2	2.00	10.900	
3	3.00	7.220	
4	4.00	7.060	
5	5.00	7.220	
6	6.00	7.350	
7	7.00	7.250	
8	8.00	6.730	
9	10.00	6.910	
10	12.00	6.700	
11	15.00	7.010	
12	17.00	9.650	
13	20.00	9.040	
14	24.00	10.550	
15	30.00	13.000	
16	36.00	13.030	
17	40.00	16.050	
18	50.00	16.500	
19	60.00	17.050	
20	72.00	17.020	
21	84.00	18.900	
22	95.00	18.000	
23	110.00	16.500	
24	130.00	16.370	
25	150.00	6.710	

Specific Resistivity(Ω-m)	54.5	9.08	3.76	0.35

VES St. No.8 -AYKEL

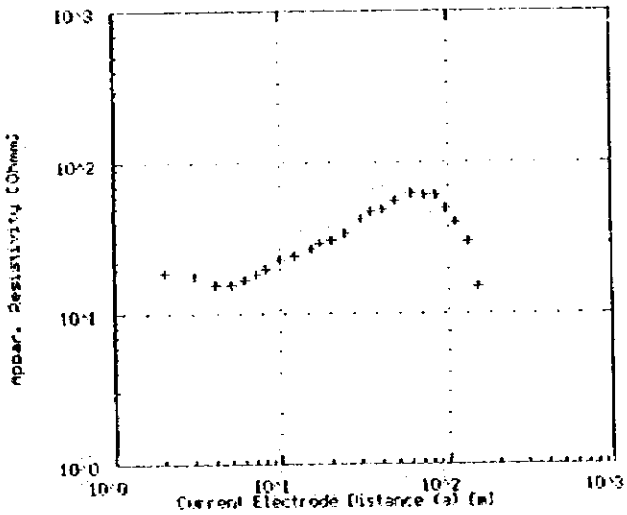


Point [No]	AB/2 [Mr]	a [m]	Ess [ohms]
1	1.00	13.440	
2	2.00	11.810	
3	3.00	8.100	
4	4.00	7.210	
5	5.00	6.280	
6	6.00	5.990	
7	7.00	5.670	
8	8.00	5.530	
9	10.00	5.360	
10	12.00	5.280	
11	15.00	5.105	
12	17.00	5.240	
13	20.00	5.530	
14	24.00	5.590	
15	30.00	6.220	
16	36.00	6.620	
17	40.00	7.610	
18	50.00	7.860	
19	60.00	8.100	
20	72.00	8.160	
21	84.00	7.390	
22	95.00	6.830	
23	110.00	6.150	

Specific Resistivity(Ω-m)	20	5	15.6	40

11.1

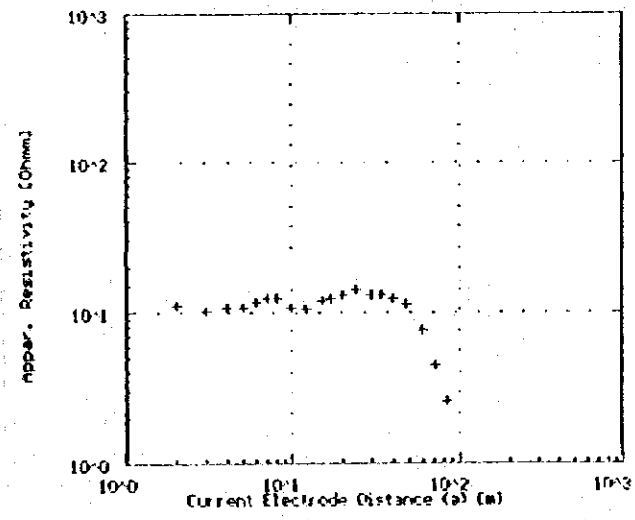
VES St. No.9 -AYKEL



Point [No]	MN/2 [Mr]	a [m]	Res [ohmm]
1	1.00	21.930	
2	2.00	18.950	
3	3.00	17.500	
4	4.00	15.575	
5	5.00	15.700	
6	8.00	16.770	
7	7.00	19.000	
8	9.00	20.190	
9	10.00	22.810	
10	12.00	25.120	
11	15.00	26.850	
12	17.00	29.250	
13	20.00	31.820	
14	24.00	35.520	
15	30.00	42.500	
16	36.00	47.930	
17	40.00	49.600	
18	48.00	55.370	
19	60.00	61.980	
20	72.00	61.910	
21	86.00	61.950	
22	95.00	50.640	
23	110.00	48.780	
24	130.00	38.210	
25	150.00	15.070	

Specific Resistivity(Ω-m)	25	16.67	9	52.8	150.15	84	9.23

VES St. No.10 -AYKEL

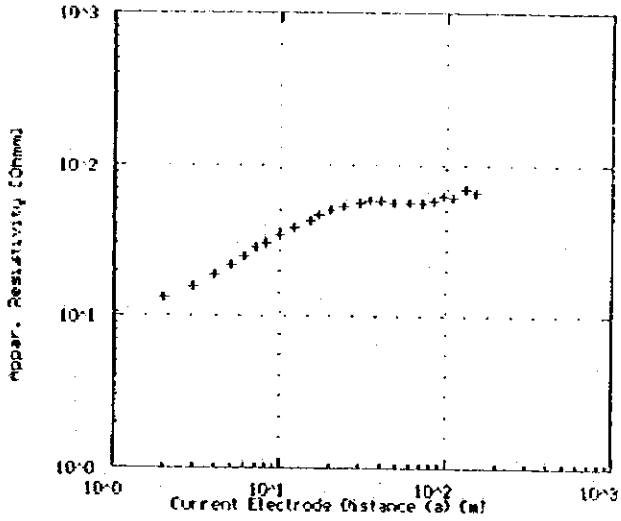


Point [No]	MN/2 [Mr]	a [m]	Res [ohmm]
1	1.00	15.160	
2	2.60	11.010	
3	3.00	10.170	
4	4.00	10.060	
5	5.00	10.050	
6	6.00	11.500	
7	7.00	12.670	
8	9.60	12.310	
9	10.00	10.740	
10	12.00	10.700	
11	15.00	12.250	
12	17.00	12.300	
13	20.00	13.050	
14	24.00	14.320	
15	30.00	13.930	
16	36.00	13.930	
17	40.00	12.550	
18	60.00	11.460	
19	80.00	7.540	
20	72.00	6.520	
21	86.00	2.860	

Specific Resistivity(Ω-m)	23.7	9.48	35.45	8.27	25.75		1.22

7.25

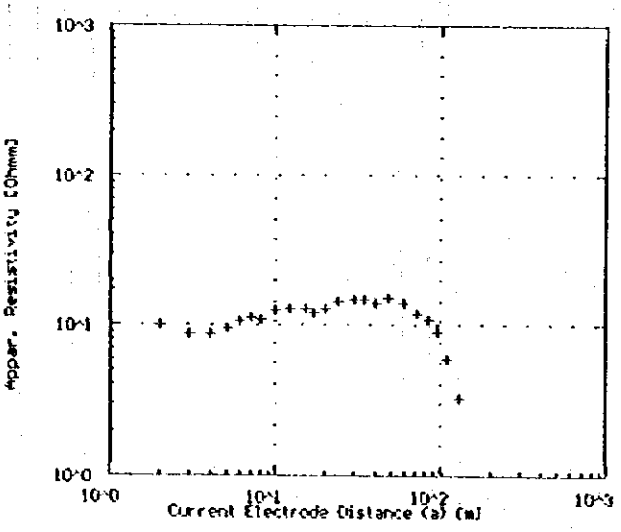
VES St. No.11 -AYKEL



Point [No]	MN/2 [Mr]	a [m]	Res [ohm]
1	1.00	10.490	
2	2.00	12.050	
3	3.00	15.640	
4	4.00	18.610	
5	5.00	21.350	
6	6.00	24.650	
7	7.00	28.030	
8	8.00	30.950	
9	10.00	34.560	
10	12.00	38.410	
11	15.00	43.930	
12	17.00	46.970	
13	20.00	50.260	
14	24.00	53.510	
15	30.00	56.520	
16	34.00	57.660	
17	40.00	57.300	
18	50.00	56.970	
19	60.00	55.370	
20	72.00	56.070	
21	86.00	58.560	
22	96.00	61.300	
23	110.00	60.680	
24	130.00	70.210	
25	150.00	85.910	

Specific Resistivity(Ω·m)	9.5	23.75	84	56	84

VES St. No.12 -AYKEL

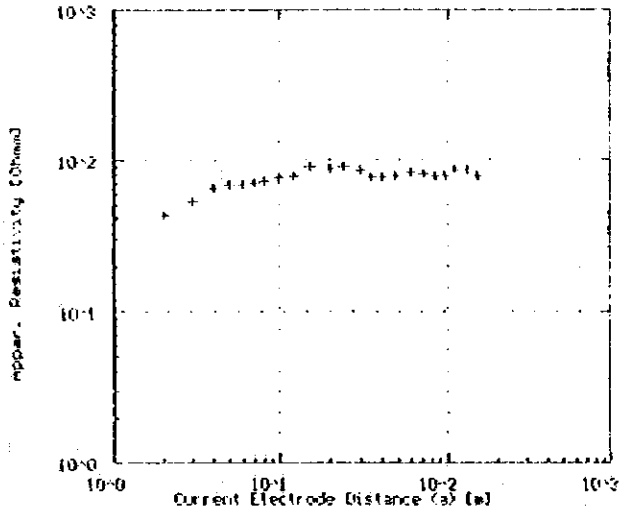


Point [No]	MN/2 [Mr]	a [m]	Res [ohm]
1	1.00	17.210	
2	2.00	9.920	
3	3.00	8.070	
4	4.00	9.190	
5	5.00	9.620	
6	6.00	10.550	
7	7.00	11.210	
8	8.00	11.900	
9	10.00	12.320	
10	12.00	12.770	
11	15.00	12.210	
12	17.00	12.200	
13	20.00	12.010	
14	24.00	11.170	
15	30.00	11.000	
16	34.00	10.730	
17	40.00	10.070	
18	50.00	15.220	
19	60.00	13.260	
20	72.00	11.760	
21	86.00	10.010	
22	96.00	9.000	
23	110.00	8.000	
24	130.00	3.220	

Specific Resistivity(Ω·m)	41	8.2	17.6	15.6	1.32

7.25

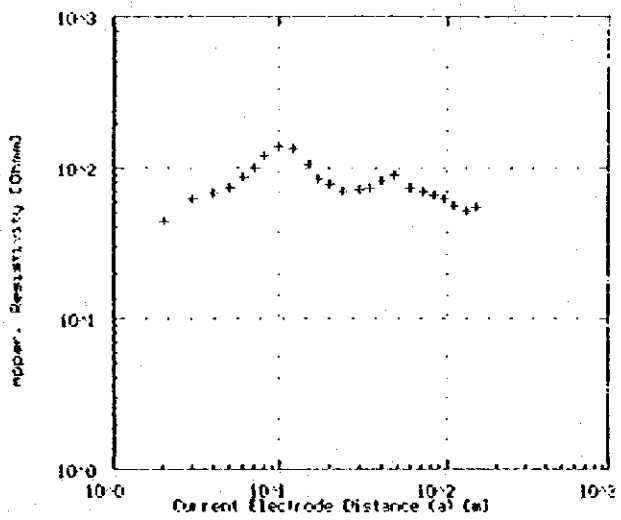
VES St. No.13 -AYKEL



Point (N)	MN/2 (m)	a (m)	ρa (ohm-m)
1	1.00	11.658	
2	2.00	17.299	
3	3.00	22.569	
4	4.00	27.519	
5	5.00	32.190	
6	6.00	37.659	
7	7.00	40.340	
8	8.00	42.350	
9	10.00	45.350	
10	12.00	49.139	
11	15.00	53.960	
12	20.00	57.920	
13	26.00	63.910	
14	33.00	65.720	
15	36.00	66.970	
16	40.00	66.520	
17	46.00	68.370	
18	60.00	62.150	
19	72.00	61.390	
20	84.03	59.139	
21	96.00	58.370	
22	110.00	51.250	
23	130.00	46.910	
24	150.00	39.139	

Specific Resistivity(Ω-m)	29	87	78

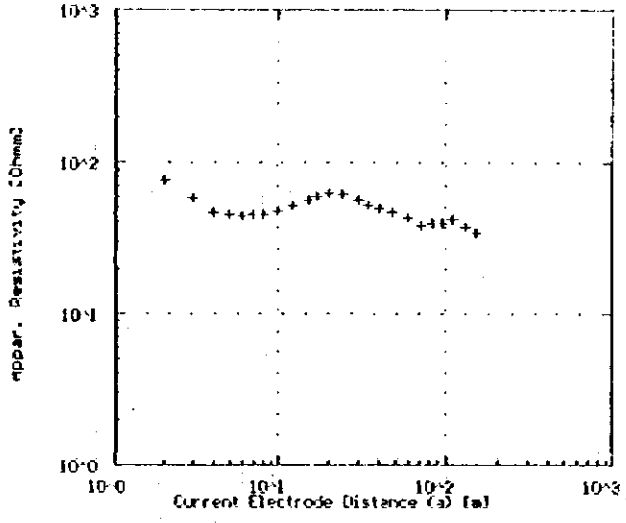
VES St. No.14 -AYKEL



Point (N)	MN/2 (m)	a (m)	ρa (ohm-m)
1	1.00	40.199	
2	2.00	43.369	
3	3.00	47.170	
4	4.00	47.870	
5	5.00	73.160	
6	6.00	97.043	
7	7.00	100.570	
8	9.00	120.070	
9	10.00	130.169	
10	12.00	135.600	
11	15.00	104.569	
12	17.00	85.639	
13	20.00	70.130	
14	24.00	59.330	
15	30.00	48.590	
16	36.00	36.730	
17	46.00	32.960	
18	58.00	33.930	
19	80.00	33.690	
20	72.00	59.620	
21	84.00	65.040	
22	95.00	63.780	
23	110.00	55.650	
24	129.00	52.250	
25	150.00	56.040	

Specific Resistivity(Ω-m)	36	90	462	40.67	145	40.5

VES St. No.15 -AYKEL



Specific Resistivity(Ω-m)	134	33.5	78	30.5		22.86

68.25

Point [No]	AB/2 [Hr]	a [m]	Rs [ohm]
1	1.00	87.920	
2	2.00	75.896	
3	3.00	57.460	
4	4.00	48.836	
5	5.00	44.900	
6	6.00	43.710	
7	7.00	45.280	
8	8.00	45.720	
9	10.00	47.330	
10	12.00	52.000	
11	15.00	55.580	
12	17.00	58.720	
13	20.00	62.000	
14	24.00	61.040	
15	30.00	55.270	
16	34.00	51.570	
17	40.00	48.580	
18	50.00	47.030	
19	60.00	42.200	
20	72.00	37.986	
21	84.00	39.560	
22	98.00	39.790	
23	110.00	41.450	
24	130.00	37.554	
25	150.00	33.910	

Appendix - 2

Result of Water Quality Test

Result of Physico-Chemical Analysis in Aykel

Sample No.1

Origin of Sample : Spring (The source)
Date of Collection: 23/Jan./95
Date of Analysis : 08/Feb./95

Physical Characteristics

Appearance	: Slightly turbid
Odor	: Odorless
Taste	: -
Color	: 113 Pt-Co
Settleable Solids	: Present
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 40
Turbidity	: 21 FTU
Temperature	: -
Conductivity	: 0.09 ms/cm

General Chemical Characteristics

Total Hardness as $CaCO_3$	: 40
Carbonate Hardness as $CaCO_3$	: 40
Non Carbonate Hardness as $CaCO_3$	: Nil
Total Alkalinity as $CaCO_3$	: 40
Bicarbonate Alkalinity as $CaCO_3$	: 40
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: 7.00
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: -	Cl^-	: 5.00
Na^+	: -	NO_2^-	: 0.20
K^+	: -	NO_3^-	: 4.20
Ca^{++}	: 16.00	F^-	: 0.53
Mg^{++}	: 2.40	HCO_3^-	: 48.80
Fe(Total)	: 0.41	CO_3^{--}	: Nil
Mn^{++}	: 0.05	SO_4^{--}	: 11.00
Cu^{++}	: 0.27	PO_4^{---}	: 0.23

Remarks; All the analyzed chemical constituents are within the acceptable range in accordance with WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Physico-Chemical Analysis in Aykel

Sample No.2

Origin of Sample : Islamwonz Spring
Date of Collection: 19/Jun./95
Date of Analysis : 24/Jul./95

Physical Characteristics

Appearance	: Clear
Odor	: Odorless
Taste	: -
Color	: 121 Pt-Co
Settleable Solids	: Present (Very small)
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 102
Turbidity	: 23 FTU
Temperature	: 19.2 °C
Conductivity	: 0.17 ms/cm

General Chemical Characteristics

Total Hardness as $CaCO_3$	: 80
Carbonate Hardness as $CaCO_3$	: 60
Non Carbonate Hardness as $CaCO_3$	: 20
Total Alkalinity as $CaCO_3$	: 60
Bicarbonate Alkalinity as $CaCO_3$	: 60
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: 7.51
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: 0.19	Cl^-	: 25.00
Na^+	: -	NO_2^-	: 0.06
K^+	: -	NO_3^-	: 14.08
Ca^{++}	: 16.00	F^-	: 0.116
Mg^{++}	: 9.76	HCO_3^-	: 73.20
Fe(Total)	: 0.64	CO_3^{--}	: Nil
Mn^{++}	: 0.10	SO_4^{--}	: Nil
Cu^{++}	: 0.08	PO_4^{---}	: 0.24

Remarks; All the analyzed chemical constituents, except Turbidity and Color, are within the acceptable range in accordance with WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Physico-Chemical Analysis in Aykel

Sample No.3

Origin of Sample : Sholaitu Spring
Date of Collection: 19/Jun./95
Date of Analysis : 24/Jul./95

Physical Characteristics

Appearance	: Clear
Odor	: Odorless
Taste	: -
Color	: 34 Pt-Co
Settleable Solids	: Absent
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 72
Turbidity	: 9 FTU
Temperature	: 19.1 °C
Conductivity	: 0.12 ms/cm

General Chemical Characteristics

Total Hardness as $CaCO_3$	: 40
Carbonate Hardness as $CaCO_3$	: 40
Non Carbonate Hardness as $CaCO_3$	: Nil
Total Alkalinity as $CaCO_3$	: 40
Bicarbonate Alkalinity as $CaCO_3$	: 40
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: 7.44
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: 0.15	Cl^-	: 10.00
Na^+	: -	NO_2^-	: 0.12
K^+	: -	NO_3^-	: 15.40
Ca^{++}	: 12.00	F^-	: 0.108
Mg^{++}	: 2.44	HCO_3^-	: 48.80
Fe(Total)	: 2.43	CO_3^{--}	: Nil
Mn^{++}	: 0.10	SO_4^{--}	: Nil
Cu^{++}	: 0.01	PO_4^{---}	: 0.23

Remarks; All the analyzed chemical constituents, except Turbidity, Color and Iron, are within the acceptable range in accordance with WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Physico-Chemical Analysis in Aykel

Sample No.4

Origin of Sample : Hand dug well (Kebelel, Ketena3)
Date of Collection: 23/Jan./95
Date of Analysis : 07/Feb./95

Physical Characteristics

Appearance	: Very Clear
Odor	: Odorless
Taste	: -
Color	: 1 Pt-Co
Settleable Solids	: Absent
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 200
Turbidity	: 1 FTU
Temperature	: -
Conductivity	: 0.41 ms/cm

General Chemical Characteristics

Total Hardness as $CaCO_3$	: 180
Carbonate Hardness as $CaCO_3$	: 180
Non Carbonate Hardness as $CaCO_3$	: Nil
Total Alkalinity as $CaCO_3$	: 70
Bicarbonate Alkalinity as $CaCO_3$	: 70
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: 6.00
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: -	Cl^-	: 45.00
Na^+	: -	NO_2^-	: 2.10
K^+	: -	NO_3^-	: 4.70
Ca^{++}	: 52.00	F^-	: Nil
Mg^{++}	: 11.99	HCO_3^-	: 85.40
Fe(Total)	: 0.01	CO_3^{--}	: Nil
Mn^{++}	: Nil	SO_4^{--}	: 1.00
Cu^{++}	: 0.08	PO_4^{---}	: 0.32

Remarks; All the analyzed chemical constituents are within the acceptable range in accordance with WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Faecal Coliform Test in Aykel, Sampled and Analyzed on June/19,20/'95

No.	Kebele	Source	Place of Sampling	No of F.C. per 100ml	Remarks
1	-	Spring	Spring	TMTC	Sampled at spring eye box1, The source
2	-	Spring	Spring	TMTC	Sampled at spring eye box2, The source
3	-	Spring	Chamber	TMTC	Sampled at collecting chamber of No1&No2
4	-	Spring	Spring	TMTC	Sampled at 150m upstream of No1&No2
5	-	Spring	Spring	TMTC	sampled at 170m upstream of No1&No2
6	-	Spring	Sholiatu	TMTC	Not protected
7	-	Spring	Koke	TMTC	Not protected
8	-	Spring	Dildy1	TMTC	Not protected
9	-	Spring	Dildy2	TMTC	Not protected
10	-	Spring	Shola	TMTC	Not protected
11	2	Spring	Jerry-can	TMTC	Fetched at No.1 spring on the day
12	2	Spring	Jerry-can	TMTC	Fetched at No.1 spring on the day
13	2	Spring	Jerry-can	TMTC	Fetched at No.1 spring on the day
14	2	Spring	Jerry-can	TMTC	Fetched at No.1 spring on the day
15	2	Spring	Jerry-can	TMTC	Fetched at No.1 spring on the day
16	2	Spring	Jerry-can	TMTC	Fetched at No.1 spring on the day
17	1	HDW	HDW	TMTC	By Water Aid, Ph=6.5, WT=21°C,WL=-12m
18	1	HDW	HDW	TMTC	WT=25°C, WL=-11m fr GL
19	1	HDW	HDW	TMTC	Ph=6.5, WT=21°C, WL=-10m fr GL
20	1	HDW	HDW	TMTC	WT=22°C, WL=-11m fr GL
21	1	HDW	HDW	TMTC	Ph=6.5, WT=22°C, WL=-10m fr GL
22	1	HDW	HDW	TMTC	Ph=6.2, WT=21°C, WL= -9m fr GL
23	1	HDW	HDW	82	Ph=6.2, WT=21°C, WL= -8m fr GL
24	1	HDW	HDW	TMTC	Ph=6.5, WT=21°C, Not for drinking
25	1	HDW	HDW	TMTC	Ph=6.5, WT=21°C, WL=-11m fr GL
26	1	HDW	HDW	TMTC	WT=23°C, WL=-11m fr GL
27	1	HDW	HDW	TMTC	WT=21°C, WL=-11m fr GL
28	1	HDW	HDW	TMTC	WT=23°C, WL= -9m fr GL
29	2	HDW	HDW	TMTC	WT=22°C, WL=-12m fr GL
30	2	HDW	HDW	TMTC	Ph=6.5, WT=22°C, WL=-13m fr GL
31	1	HDW	Jerry-can	TMTC	Ph=6.5, Dried up during rainy season
32	1	HDW	Jerry-can	98	Not for drinking

Sample No.1 to 3 and No.11 to 16 are for Water Committee spring.

Note; "F.C. means Faecal Coliform.
"BH" means borehole.
"HDW" means hand-dug-well.
"P.Conn." means private connection.
"Y.Conn." means yard connection.
"P.Foun." means public fountain.
"Barrel" means Barrel-container made of steel.
"TMTC" means too many to count.

Appendix - 3

Social and Gender Data

AYKEL - Activity Profile by gender

Spring/Well/Former Public Fountain Users

Activity	Gender			Time	Place
	M	F	Remarks		
Fetches drinking water (most use a variety of sources)	y	y	mostly women and girls, some boys.	am/pm	spring - if dark the men accompany
Does the laundry	y	y	mostly women		spring/home
Waters livestock	y	n	mostly men		
Takes water from container	y	y	all		
Teaches children hygiene	y	y	those at home		
Disposes of solid waste	n	y			
Digs a compost pit	n	n	very few have		
Constructs a latrine	y	n	paid labour		
Digs a drainage channel	-	-	none have		
Tends a kitchen garden	-	-	none have		
Disposes of animal waste	n	y	very few have		
Keeps latrine clean	n	y			
Keeps compound clean	n	y			
Takes sick child to clinic	y	y	mostly women or older children		

y = Yes, n = No

AYKEL - Daily Schedule

Spring Users

Man	Time	Woman
	6	
Wake up, washes	7	Wakes up and washes
Works at home	8	Prepares breakfast
Eats breakfast	9	**Collects water**
Works at home	10	"
(Silversmith/Jewelry maker)	11	Cleans house
"	12	Prepares lunch
Eats lunch with wife	13	Eats lunch with husband
Works at home	14	**Collects water**
"	15	"
Drinks coffee	16	Prepares and drinks coffee with family
Works	17	*Spins cotton*
Goes to drink tela in town	18	"
Returns home	19	Prepares supper
Eats supper with family	20	Eats supper with family
Goes to sleep	21	Cleans the home
	22	Goes to sleep
	23	

Man is disabled

Both are Christian

Collection of water takes two hours because of the queue

Well Water Users

Man	Time	Woman
Gets up, washes, goes to Mosque		Gets up, washes, prepares breakfast
	6	
Returns, Eats breakfast	7	Eat breakfast with family
Goes to work in town	8	Prepares/drinks coffee
(Household fuel business)	9	**Collects water**
"	10	Does laundry
"	11	Cleans house
"	12	Prepares lunch
Returns home to eat lunch	13	Eats lunch with husband
Returns to work	14	Drinks coffee with friends
"	15	*Spins cotton*
"	16	Does domestic chores
"	17	"
Goes out with friends	18	"
Returns home	19	Prepares supper
Eats supper	20	Eats supper with family
Talks with family	21	Cleans the dishes
Goes to sleep	22	Goes to sleep
	23	

Use public fountain and spring water as well as private well water

Both are Muslim

When the well is dry, she fetches water from the spring very early in the morning

AYKEL - Access and Control Profile

Spring/Well/Former Public Fountain Users

Resources	Access		Control		Comments
	male	female	male	female	
Money for water	y	y	y	y	
Money for soap	y	y	y	y	
Money for water container	y	y	y	y	
Money for water pot cover	y	y	y	y	
Money for building materials for drying shelf	y	y	y	y	both men and women organised
Money for building latrine	y	y	y	y	
Money for medicine	y	y	y	y	
Money for school fees	-	-	-	-	free school
Tools for digging pits	y	y	n	n	very few have
Tools for constructing latrine	y	y	n	n	
Seeds and tools for vegetable gardens	-	-	-	-	none have
Land for digging pits	n	n	n	n	few have
Land for digging latrines	n	n	n	n	few have
Land for digging drains	n	n	n	n	few have
Land for vegetable gardens	n	n	n	n	few have
Income from selling water	y	y	y	y	
Income from selling vegetables	y	y	y	y	
Improved health	y	y	y	y	
Reduced time spent collecting water	n	y	n	y	mostly women
Reduced time spent caring for sick	y	y	y	y	mostly women

y=Yes, n=No

AYKEL - Needs Analysis

Former Public Fountain/Well/Spring Users

		Gender		Remarks
		M	F	
Practical needs				
Water	Adequate quantities of water from the water supply system each day	y	y	Rich people would like private connections, others would like public fountains. All would like the system to be reliable
	Spring water quality preferred to well water quality	y	y	Maximise water available from spring sources. People prepared to pay more for better service
	Reduced time spent for water collection	y	y	Reduced queues and reduced distance to water supply facilities
Sanitation	Improved health associated with improvements in sanitation	y	y	Community latrines for those in rented housing and those who can not afford private latrines
	Kebele to allocate areas for refuse disposal and provide training and support for the safe disposal of refuse.	y	y	All groups felt that garbage disposal was an important issue to be addressed.
	Public showers at central location in town	y	y	Public showers could be charged at 75C to 1 Birr each time
Health education	Poorest communities need largest imputs in health education	y	y	
Strategic needs				
Water	Public fountains possible to be managed by the community with support from Authorities	y	y	Poorest community felt that they would not be able to manage their public fountain
	Additional public fountains to be constructed with the help of community labour.	y	y	All groups could assist with labour and with transportation of materials.
Sanitation	Community latrines to be managed by the community	y	y	All groups expressed the need to have support and even enforcement from Authorities for improvements in sanitation, including the use and management of community latrines.
	Public showers to be managed by the Authorities	y	y	Men and women from Aykel use public showers in Gondar
Health education	Support for existing health education initiatives. Increase motivation for people to improve their sanitary behaviours	y	y	Health awareness is relatively better in Aykel. Incidence of diarrhoea and level of sanitary behaviours worst of all Centres

y = Yes, n = No

AYKEL - Social and Gender Considerations

Social/Gender differences	Underlying factors	Impact of the project	Possible measures to be taken
Variation in type and level of water service demanded	Variations in social and economic status	Richer households will not be satisfied without private connections	Improvements to the water system should include both public fountains and private connections
Water carriers and well owners keen on improvements in public water supply system	Some labourers and well owners generate their income from cartage of water from springs and wells	The improvements to the town water supply will take away a market for these groups	Discuss and develop ways of ensuring employment or income generation for these groups
Women only defaecate under cover of darkness	The need for privacy determines the time that women can defaecate	Women may all require latrine facilities at the same time thus putting pressure on resources	Sharing and management of community latrines must be facilitated with discussion of all community members
Women fetch water most of the time and women usually do the laundry. Boys help in collection of water from springs	Water collection and laundry are undertaken mostly by women and girls and less often by young males	Females will benefit most from time and energy savings from having a reliable water supply available near their homes	The project needs to help women identify how to spend any time released through improved water supply

Appendix - 4

Summary of Group Meeting

AYKEL - Summary of group meetings

Group 1 details	Group characteristics	Group needs
General	Amhara, Mostly Christina some Muslim, 15 women, 5 men, tela makers and sellers and petty traders	1-Water, 2-Electricity, 3-Sanitation
Water	Former public fountain users now relying on springs and vendors. 2hrs to collect water - a difficult walk to the spring. Former public fountain had large queues and did not supply adequate water. Women and children fetch water and men also do laundry	People resent the public fountain due to the inadequate service it provided. They would prefer to buy of vendors with private connections! Could pay more money for a better service and would like the springs protected and collected for contingencies.
Sanitation	All defaecate in open field because of lack of land, organisation or enforcement body. Would contribute labour and money for community latrines with water but need supervisory body to control and enforce. Want to share latrine by sex not family.	Community latrines with water for washing to be shared by sex rather than by family groups.
Health	Common diseases include asthma and TB. Health education has been attended at the health centre. People could attend health education on Sundays.	Health awareness is good. Improvements in sanitary conditions may only occur with enforcement.

Group 2 details	Group characteristics	Group needs
General	Amhara, Mostly Christian some Muslim, 15 women, 3 men, 5 young women, 20 children, daily labourers launders and spring water sellers.	1-Water, 2-Poverty alleviation, 3-Health, 4-Sanitation
Water	Spring users, men and women fetch water and do laundry. Laundry done at spring. Distance is too far, water is inadequate, quality is good, some sell spring water 25C:1Jar, some private hand dug wells, quality is poor-taste is "hard" sell for 15C:Jar.	Additional functional public fountain, people ready to pay for better service and to help in construction and management but need to be co-ordinated by elected community person
Sanitation	No latrine users, all use open field. Use same place but women go at dawn and dusk. No latrines due to lack of money. Garbage disposal inadequate, require allocated land from Kebele and some instruction on waste disposal.	Receptive to community latrines sharing one cubicle for max 10 families. Public latrines with Govt. management would also be acceptable. Public shower would be used by men and women as they already use the one in Gondar on occasions.
Health	Asthma and TB are most common diseases. Cause believed to be dust and poor sanitation. Children get diarrhoea also linked with poor sanitation.	Health awareness good. Sanitary education alone will not affect the sanitary conditions these people live in. Blocks seem to be lack of land for garbage disposal and for latrines at rented homes and lack of money.

AYKEL - Summary of group meetings

Group 3 details	Group characteristics	Group needs
General	Amhara, Mostly Christian, 3 women, 1 man, Preparers of food and tela, proprietors of tea and tela houses and some Government workers	1-Water, 2-Electricity, 3-Transport
Water	Well and spring users. The wells are not adequate and dry up in April and are contaminated and have taste problems in wet season. Springs are used more and taste better.	Would like to have Private Connections
Sanitation	Some use private household latrines, others use open fields for defaecation. The problem with the latrines is that they fill up and can not be emptied. They are then sealed and perhaps a new one constructed. Community latrines would work for some.	Community latrines for poor and those without own land. Public showers (50c to 1 Birr) would be feasible.
Health	Common complaints include TB, Asthma and trachoma. Health education from the clinic was considered as inappropriate without adequate water.	Integrated water supply improvement programme with health education.

Group 4 details	Group characteristics	Group needs
General	Amhara, Mostly Muslim, 7 women, 3 young women, 2 men and 10 children, weavers and cotton spinners	1 - Water (children must queue for water and not able to go to school) 2-Sanitation
Water	Spring Users and public fountain users. PF not adequate to supply demand. Long queue at spring, quality good, distance too far. Some buy spring water off sellers 25C:jar. All family members fetch water/do laundry at spring. Path to spring not safe.	PF to operate 4 hours each day, pref. 7-11am. Would pay more (up to 25C:Jar) at PF for better service time. Ready to hire guard to look after PF - up to 1 Birr/household/month.
Sanitation	No latrines, all use open field. Women go to same place as men but only go at dawn and dusk. Lack land and money for latrines. Garbage disposal not systematic - thrown anywhere.	Keen to have community managed latrines, would help in construction with labour and materials. Would share cubicles by families. Would like Kebele to allocate land for garbage disposal and to be shown how to manage this properly.
Health	Common diseases include asthma, but there is little diarrhoea.	Aware of water and sanitation related diseases.

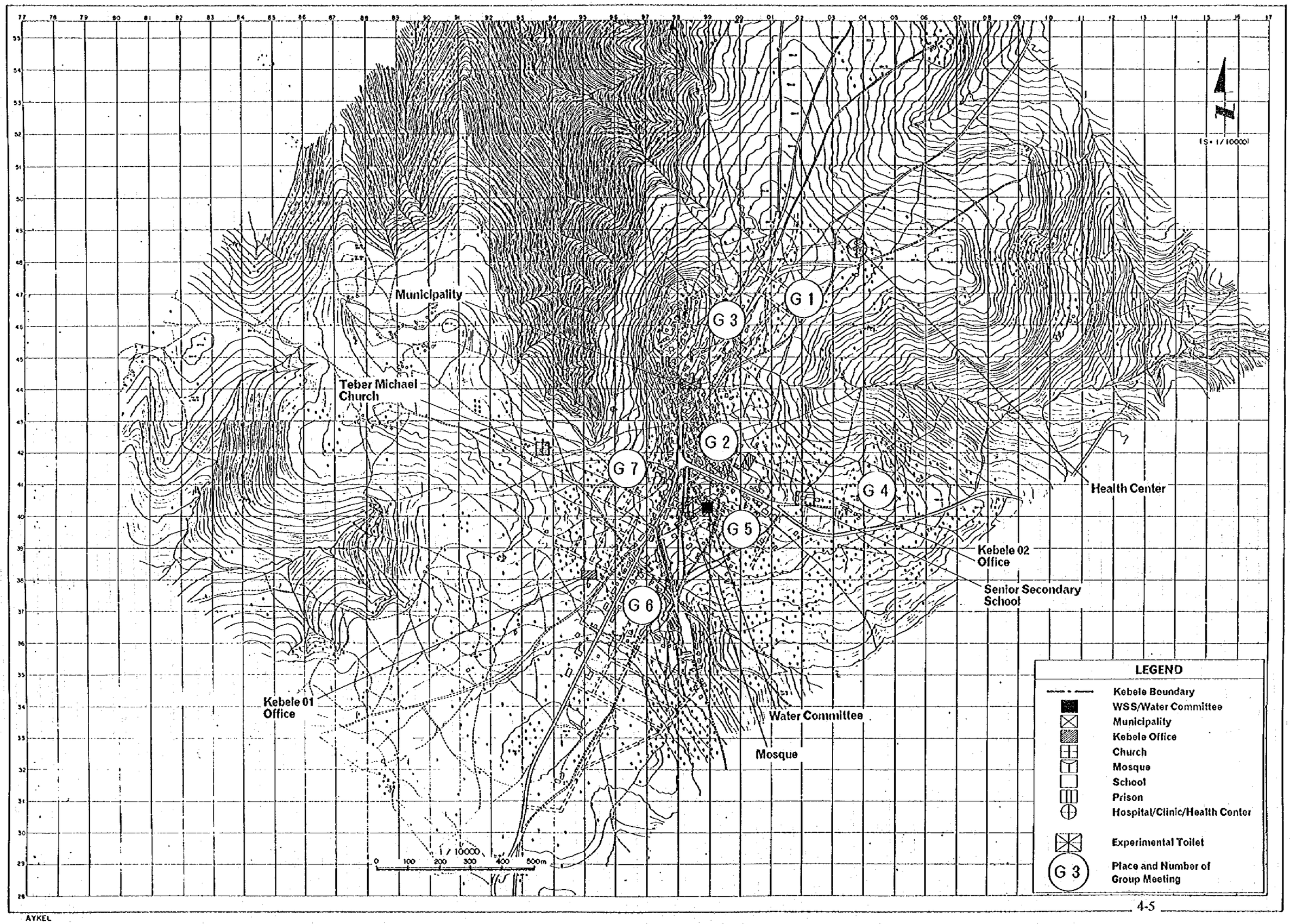
AYKEL - Summary of group meetings

Group 5 details	Group characteristics	Group needs
General	Amhara, Mostly Christian, 12 women, 3 men, laundry and handicraft activities	1-Water, 2-Food
Water	Spring users, collection takes hours due to large queue. Women fetch water for their families, men and women fetch water for payment for others. Laundry done at spring. Would like public fountain but unable to manage it could pay for the water.	Provision of public fountain, not to be managed by the community.
Sanitation	Defaecation in open fields, because of lack of capital for latrines. There is no problem of land availability although the housing is rented from Kebeles. Community latrines would be an option but not with water as there would be problems over payment.	Community latrines without water with separate facilities for men and for women.
Health	Common diseases include Pneumonia, colds and fevers. Poor awareness of cause of sanitation related diseases. Not had any health education but would participate on Sundays when they have free time (relatively)	Health centre and church based health education may not reach this portion of the community. Specialised targeting of this group may be necessary.

Group 6 details	Group characteristics	Group needs
General	Amhara, Mostly Muslim, some Christian, 6 women, 10 men, 18 children, Business people with shops and bars and trading.	1 - Water (Private Connections), 2-Electricity, 3 - Road/Transportation
Water	PF and spring users, PF not adequate even when functioning, some private wells used for domestic chores not drinking. Laundry done with spring water at home. Men, women and children fetch water Spring quantity and quality good, but needs storage tank	Improved storage of spring system and supply PF's more and provide these people with PC's. Can afford and are registered for PC's.
Sanitation	All have latrines. Vacuum truck not possible and no shortage of land, so when latrines are full they are closed and new ones are dug. Pay labourers to dig and build latrines. Garbage disposed of in open land away from their homes.	Needs are satisfied.
Health	Common diseases include asthma and TB linked with the dust	Fully aware of the links with water and sanitation to disease.

AYKEL - Summary of group meetings

Group 7 details	Group characteristics	Group needs
General	Amhara, Mixed religions, 10 women, 4 young women, 5 men, many children, selling tela and some Government workers	1-Water, 2-Electricity, 3-Sanitation
Water	Spring water users and some handdug well users. Spring takes time due to distance and queues particularly in dry season (Mar/Apr). Spring water quality good. Laundry done at stream by all. Water fetched by all. Some buy from well vendors 25C-15C;Pot	Prefer spring water supplied through public fountain. Would provide labour for it's construction and would manage it themselves including payment of water seller.
Sanitation	Some use latrines most use open field due to lack of affordability. Community latrines would be an option, to be shared by groups of families. Would provide labour for latrine construction. Would like public shower and would pay for it's use.	Community latrines to be managed by the community. Public showers would also be used and both men and women would pay to use them occasionally. Refuse disposal needs to be organised in a designated place by the Kebele.
Health	Complaints include Asthma and diarrhoea (especially children). Health awareness is high.	Health education imputs already seem to have had a significant effect. These should be strengthened.


N
(S= 1/10000)
Municipality
Teber Michael Church
G 1
G 2
G 3
G 4
G 5
G 6
G 7
Health Center
Kebele 02 Office
Senior Secondary School
Kebele 01 Office
Water Committee
Mosque
1 / 10000
0 100 200 300 400 500m
LEGEND
Kebele Boundary
WSS/Water Committee
Municipality
Kebele Office
Church
Mosque
School
Prison
Hospital/Clinic/Health Center
Experimental Toilet
G 3
Place and Number of Group Meeting

AYKEL

Appendix - 5

Financial and Socio-Economic Data

Table 1 (1) Summary of Financial Aspects of WSS in Eleven Centers

Item	Dupti	Mille	Bati	Werota	Aykel	Debre Tabor
1. Population	14,737	3,902	14,354	21,845	11,718	25,575
2. Water production & consumption in 1993/1994 (m3)	n.a. 35,565e	n.a. 29,232e	113,523 90,218	58,318 46,104	11,303e 10,173e	11,930 9,773
*Water consumption/ population/day (l)	6.6e	20.5e	17.2	5.8	2.4e	1.0
*Leakage ratio (%)	n.a.	n.a.	20.5	20.9	10.0e	18.1
3. Income & Expenditure in 1993/1994 (birr)	51,267 60,188	48,818 38,182	131,144 132,245	64,648 53,304	50,863e 22,560e	31,337 78,328
*Bill collection rate (%)	85.7	79.1	94.4	99.9	-	67.8
*Income/consumption (birr/m3)	1.44e	1.67e	1.45	1.40	5.00e	3.21
*Expenditure/production (birr/m3)	n.a.	n.a.	1.16	0.91	2.00e	6.57
*Income/Expenditure (%)	85.2	127.9	99.2	121.3	225.5e	40.0
4. No. of personnel,	10	11	25	18	13	18
female, tempo-	1	5	5	4	4	5
rary/contract	10	11	8	0	8	0
*Production/worker (m3)	n.a.	n.a.	4,541	3,240	3,478e	663
*Income/worker (birr)	5,126	4,438	5,246	3,592	3,913e	1,741
*Expenditure/ worker (birr)	6,019	3,471	5,290	2,961	1,735e	4,352
5. Average monthly salaries (birr)	129	96	204	217	70	173
6. No. of house/	190(70)	89	852	396	-	320
yard connections,	8(2)	8(5)	12	7(6)	5(3)	13(2)
public fountains,	1	1				
hydrants						

Notes: 1. e = estimates or assumptions 2. n.a.= not available
3. parenthesized figure = functional

Table 1 (2) Summary of Financial Aspects of WSS in Eleven Centers

Item	Nefas Mewcha	Chagni	Bure	Bichena	Dejen
1. Population	13,726	26,823	14,742	14,629	10,250
2. Water production & consumption in 1993/1994 (m3)	42,216 31,206	74,219 55,045	66,278 55,008	17,810 15,826	46,409 41,201
*Water consumption/ population/day (l)	6.2	5.6	10.2	3.0	11.0
*Leakage ratio (%)	26.1	25.8	17.0	11.1	11.6
3. Income & Expenditure in 1993/1994 (birr)	56,457 79,567	68,590 72,172	66,791 102,309	34,679 71,591	62,089 67,846
*Bill collection rate (%)	91.7	85.8	98.2	96.8	89.0
*Income/consumption (birr/m3)	1.81	1.25	1.21	2.19	1.51
*Expenditure/production (birr/m3)	1.88	0.97	1.54	4.02	1.46
*Income/Expenditure (%)	71.0	95.0	65.3	48.4	91.5
4. No. of personnel, female, temporary/contract	19 5 1	17 6 2	22 7 0	20 6 2	17 3 0
*Production/worker (m3)	2,222	4,366	3,013	891	2,745
*Income/worker (birr)	2,971	4,035	3,035	1,735	3,652
*Expenditure/ worker (birr)	4,188	4,245	4,650	3,580	3,991
5. Average monthly salaries (birr)	153	143	241	170	211
6. No. of house/ yard connections, public fountains, hydrants	383 14(13)	327 12	478 13(12)	238 7	390 7

Notes: 1. e = estimates or assumptions 2. n.a. = not available
3. parenthesized figure = functional

Table 2 (1) Financial Condition of Water Supply Service in Aykel

1. Official Water Price: 10 cents/20 litre or 5 birr/m3

   Note: They have public fountains only as distribution facilities.

2. Production and Consumption of Water, 1993/94

   1) Production : 11,303 m3 (assumption)

   2) Consumption: 10,173 m3 (assumption)

      * Daily water consumption as divided by total population = 3.1 litre

      * Leakage ratio = 10.0% (assumption)

3. Income and Expenditure (Mar.- May, 1994)

   1) Income : 12,715.78 birr

      Major sources of income

      (1) Cash water sales 12,715.78 birr (100.0%)

      * Bill collection rate = not applicable

      * Income per unit consumption of water = 5.00 birr/m3 (estimates)

   2) Expenditure: 5,640 birr

      Major items of expenditure

      (1) Fuel 3,330 birr (59.0%)
      (2) Salaries for contract employees 1,680 birr (29.8%)
      (3) Oil 330 birr (5.9%)
      (4) Administrative and operating cost 300 birr (5.3%)

      * Expenditure per unit production of water = 2.00 birr/m3 (estimates)

      * Income-expenditure ratio = 225.5%

4. Organization and Personnel

   1) No. of personnel: 13 (4) [8]

Table 2 (2) Financial Condition of Water Supply Service in Aykel

(1) Chairman, Water Committee	1
(2) Secretary	1
(3) Administration 2 [2] guards, 1 [1] messenger, 1 store keeper	4 [3]
(4) Finance 1 treasurer, 1 accountant, 1 auditor, 4 (4) [4] water sellers	6 (4) [4]
(5) Urban water supply & sewerage 1 motor operator	1 [1]

Notes: 1. Parenthesized and bracketed figures denote the number of female and temporary workers respectively.
2. The secretary functions as the accountant at the same time.

* Production per worker = 3,478 m3/year (estimates)

* Income and expenditure per worker = 3,913 birr, 1,735 birr/year (estimates)

2) Average monthly salaries of employees: 70 birr for contract workers

Note: Water Committee members work without remuneration.

5. No. of Distribution Facilities

   Public fountains : 5 (3 functional)

   Note: 100 households have hand-dug wells.

6. Problems and Bottlenecks

1) Capacity of the reservoir is not enough.
2) Shortage of public fountains.
3) Shortage of water meters.
4) There are cracks in the collection chamber.
5) There are maintenance problems for the generator and pumps. Technical assistance is needed in this regard.
6) Water Committee members have their own jobs aside from their role as the committee members. They feel overloaded. They want to transfer their positions to some professionals.

Table 3 (1) Summary of Socio-Economic Aspects of Eleven Centers

Item	Dupti	Mille	Bati	Werota	Aykel	Debre Tabor
I. Administrative Conditions						
1. No. of gov't employees	500e	336	366	322	412	1,674
*No. of gov't employees/1,000 population	34	86	25	15	35	65
2. Average salaries of gov't employees (birr)	311	311	355	308	391	397
II. Population						
1. Population	14,737	3,902	14,354	21,845	11,718	25,575
2. Ethinic composition for top two (%)[Amh.=Amhara, Afa.=Afar, Oro.=Oromo, Tig.=Tigre, Kim.=Kimant, Age.=Agew]	Amh.84 Afa. 6	Amh.69 Oro.14	Amh.49 Oro.28	Amh.97 Tig. 3	Amh.73 Kim.20	Amh.100
3. Religious composition, Christians & Moslems (%)	42 58	43 57	12 88	80 19	81 19	95 5
4. Family size	4.5	4.6	6.2	6.3	5.5	5.7
5. Area (ha)	1,600e	68	260	640	322	1,402
*Population density (persons/ha)	9.2e	57.4	55.2	34.1	36.4	18.2
III. Educational Conditions						
1. No. of pupils/ students	3,182	457	2,500	3,817	3,944	7,950
*No. of pupils/ students per 100 population	22	12	17	17	34	31
2. Literacy ratio (%)	70	62	48	63	80e	74
3. Primary school enrollment ratio (%)	62	53	53	57	85e	75
IV. Medical Conditions						
1. No. of medical personnel	36	4	22	9	18	81

Table 3 (2) Summary of Socio-Economic Aspects of Eleven Centers

Item	Dupti	Mille	Bati	Werota	Aykel	Debre Tabor
*No. of medical personnel per 1,000 population	2.4	1.0	1.5	0.4	1.5	3.2
2. No. of cases for top ten diseases	14,943	1,611	11,642	18,084	13,683	21,318
*Estimated No. of cases per year as percentage of population (%)	30.4	12.4	24.3	24.8	35.0	25.0
3. Under 5 mortality rate (/1000)[n.a.=not available]	213	154	163	95	n.a.	73
4. Life expectancy (years)	47	53	52	61	55e	64
5. Households using septic tank / pit latrine (%)	86	45	68	61	39	65
V. Economic Conditions						
1. No. of commercial/industrial establishments [parenthesized figures=No. of hotels/restaurants]	1,105 (331)	204 (162)	243 (68)	812 (201)	450 (115)	1,672 (574)
*No. of establishments per 1,000 population	75 (22)	52 (42)	17 (5)	37 (9)	38 (10)	65 (22)
2. Monthly household income (birr)	334	223	306	262	182	248

Note: e=estimates

Table 3 (3) Summary of Socio-Economic Aspects of Eleven Centers

Item	Nefas Mewcha	Chagni	Bure	Bichena	Dejen
I. Administrative Conditions					
1. No. of gov't employees	541	727	845	499	378
*No. of gov't employees/1,000 population	39	27	57	57	37
2. Average salaries of gov't employees (birr)	297	368	292	374	407
II. Population					
1. Population	13,726	26,823	14,742	14,629	10,250
2. Ethinic composition for top two (%)[Amh.=Amhara, Afa.=Afar, Oro.=Oromo, Tig.=Tigre, Kim.=Kimant, Age.=Agew]	Amh.100	Amh.74 Age.19	Amh.94 Age. 4	Amh.99 Oro. 1	Amh.99 Tig. 1
3. Religious composition, Christians & Moslems (%)	94 6	44 56	92 7	67 33	65 35
4. Family size	5.9	6.1	6.8	6.2	6.8
5. Area (ha)	648	920	1,280	200	280
*Population density (persons/ha)	21.2	29.2	11.5	73.1	36.6
III. Educational Conditions					
1. No. of pupils/students	3,743	5,339	4,388	3,465	2,661
*No. of pupils/students per 100 population	27	20	30	24	26
2. Literacy ratio (%)	70	74	61	69	61
3. Primary school enrollment ratio (%)	59	77	69	68	64
IV. Medical Conditions					
1. No. of medical personnel	43	25	22	27	5

Table 3 (4) Summary of Socio-Economic Aspects of Eleven Centers

Item	Nefas Mewcha	Chagni	Bure	Bichena	Dejen
*No. of medical personnel per 1,000 population	3.1	0.9	1.5	1.8	0.5
2. No. of cases for top ten diseases	22,002	11,782	15,112	7,441	3,790
*Estimated No. of cases per year as percentage of population (%)	48.1	13.2	30.7	15.3	11.1
3. Under 5 mortality rate (/1000)[n.a.=not available]	196	144	131	173	155
4. Life expectancy (years)	49	54	56	52	53
5. Households using septic tank / pit latrine (%)	58	61	58	45	54
V. Economic Conditions					
1. No. of commercial/industrial establishments	860 (209)	546 (91)	246 (65)	414 (47)	345 (74)
[parenthesized figures=No. of hotels/restaurants]					
*No. of establishments per 1,000 population	63 (15)	20 (3)	17 (4)	28 (3)	34 (7)
2. Monthly household income (birr)	202	203	253	324	312

Note: e=estimates

Table 4 (1) Socio-Economic Condition of Aykel

I. Administrative Conditions

1. Administrative Classification: Region 3, Zone = North Gonder

2. Government Organizations
1) Agricultural Bureau
2) Natural Resources Development and Environmental Protection (NRDEP)
3) Weroda Administration
4) Commercial Bank of Ethiopia
5) Financial Bureau
6) Educational Bureau
7) Municipality
8) Health Center
9) Prison Administration
10) Culture and Sports Office
11) Police
12) Post Office
13) Telecommunications
14) Weroda Court
15) Weroda Attorney
16) Meteorologic Bureau
17) Water Supply Service (WSS)

Notes: 1. Schools are not included in the above organizations.
2. There are two NGO's, namely Red Cross and Ethiopian Orthodox Church.

3. No. of Government Employees and Their Average Monthly Salaries: 412, 391 birr

* No. of government employees per 1,000 population: 35

4. No. of Kebele: 2

II. Socio-Economic Conditions

1. Population
1) Total population: 11,718

2) Ethnic composition: Amhara (73.3%), Kimant (19.8%), Tigre (6.9%)

3) Religious composition: Christians (81.0%), Moslems (19.0%)

4) Average family size: 5.5 persons

Table 4 (2) Socio-Economic Condition of Aykel

2. Area: 322 ha * Population density: 36.4 persons/ha

3. Educational Conditions
1) No. of schools, class rooms, teachers and pupils/students

Items	Kinder-garten	Elementary School	Junior High S.	Senior High S.
(1) No. of schools	1	2	1	1
(2) No. of class rooms	2	21	6	10
(3) No. of teachers	2	56	10	26
(4) No. of pupils/students	95	1,891	799	1,159

* No. of pupils/students per 100 population: 34

2) Literacy ratio: 80% (observation)

3) Primary school enrollment ratio: 85-90% (observation)

4. Medical Conditions
1) No. of medical institutions/establishments:
1 Health Center(4 beds), 1 private drug store

2) No. of medical personnel:
3 nurses, 13 health assistants, 1 laboratory technician, 1 doctor ... 18 in total

Other related personnel: 1 sanitarian

3) Incidence of diseases (Jul. 1993 - Jun. 1994)

(1) Top ten diseases

i.	Intestinal parasite	2,755 cases	
ii.	Skin diseases	1,881	
iii.	Tonsilitis	1,744	
iv.	Upper respiratory tract infection	1,291	
v.	Malaria	1,234	
vi.	Pneumonia	1,156	
vii.	Gastritis	1,138	
viii.	Bronchitis	896	
ix.	Skin infection	842	i. to x.
x.	Eye diseases	746	= 13,683

Table 4 (3) Socio-Economic Condition of Aykel

(2) Estimated number of cases per year as percentage of population:
(13,683 x 1.5) / (11,718 x 5) = 35.0%

Notes: 1.5 = coefficient to estimate the total number of cases,
5 = coefficient to estimate covered population

4) Under 5 mortality rate: not available

5) Life expectancy: 50-60 years (observation)

6) Households more or less using septic tank and pit latrine: 39.0%

5. No. of Holy Places: 2 churches, 1 mosque, 1 other

6. Economic Conditions
i) No. of commercial and industrial establishments

Classification	Annual Income (birr)			
	< 1,000	1,000 - 3,000	3,000 <	Total
1. Hotels and restaurants				
Hotels, restaurants and bars	0	90	3	93
Tea rooms	0	22	0	22
Sub-total	0	112	3	115
2. Shops	0	200	103	303
3. Cottage industry				
Oil factories	0	0	1	1
Flour mills	0	0	10	10
Leather factories	0	0	5	5
Sub-total	0	0	16	16
4. Butcheries	0	16	0	16
Total	0	328	122	450

Note: No. of local drink producers: 500 households
* No. of commercial and industrial establishments per 1,000 population: 38

Table 4 (4) Socio-Economic Condition of Aykel

2) Major occupations
(1) Trade (2) Agriculture and animal husbandry
(3) Government employees (4) Day laborers

3) Major products: edible oil, leather products, flour

4) Market
(1) Major marketable items:
agricultural products, livestock, household items, clothes, etc.

(2) Prices of major marketable items

Grains (unit: birr/100 kg)

tef	wheat	millet	maize	beans	oil seeds
230	200	180	150	300	350

Livestock (unit: birr/one)

ox	cow	sheep/goat	donkey	chicken
600	400	65	200	6

Consumers' items (unit: birr)

butter (kg)	milk (litre)
18	1.5

(3) Market days - Sat. and Thu. (10,000 - 15,000 people gather.)

4) Average monthly household income: 182.0 birr

Sources: Water Committee, Woroda Council, Financial Bureau, Educational Bureau and Health Center in Aykel; Socio-Economic Sampling Questionnaire Survey by JICA; Central Statistical Authority

Appendix - 6

Result of Initial Environmental Examination

Project Description on Initial Environmental Examination in Aykel

Items	Description
Project Title	Eleven Centers Water Supply and Sanitation
Background	1. Insufficient water supply and low per-capita-consumption due mainly to high population growth , aged facilities and poor O&M. 2. Poor sanitation prevailing the Project site which could contaminate the water source(s).
Objectives	To supply domestic water which meets people's demand and to improve sanitary condition.
Location	Aykel, Chilga, Region-3
Executing Agency	Water Supply and Sewerage Service Department Ministry of Water Resource
Beneficiaries	About 11,700 of the population to be benefited.
Dimensions of the Plan	Rehabilitation of existing facilities, and new boreholes, reservoir and distribution network.
Type of Work	Rehabilitation and new construction work
Purpose	1. To provide domestic water and improve sanitation facilities. 2. To initiate people's awareness on water use and sanitation.
Water Resource	Groundwater, There are many springs outside town but not to be considered as the source because of its susceptivity to contamination.
Water Quality	Chemical aspects are within WHO guideline values Biological contamination is notified.
Main Facilities	Boreholes with pumping system.
Water Storage Facilities	Reservoir (ground tank type)
Filtration Plant	Not to be considered.
Related facilities	Distribution pipes, public fountains, drainage system and latrines
Remarks	1. Chlorine or its derivatives such as mainly calcium hypochlorite is used for disinfection in Ethiopia.

Site Description on Initial Environmental Examination in Aykel

Items	Description
Project Title	Eleven Centers Water Supply and Sanitation
Social Environment	
Residents (population, tribe, consciousness)	Population about 11,700, almost Amhara with about 75 %
Facilities related to life (electricity, etc.)	The electricity is generated.
Health and Sanitation (diseases, clinic, etc.)	0 hospital, 1 health center, 1 drug store Malaria is very common in this town.
Natural Environment	
Topography, Geology and Hydrogeology	Located at northwestern margin of Lake Tana basin. Basalt and tuff are major structure.
Meteo-hydrology Groundwater/spring/river	Annual rainfall about 1670mm. There are many springs and hand dug wells. No river.
Endangered fauna and flora	Nil
Public Nuisance	
Nuisances	Water supply condition is critical in terms of both quality and quantity. During rainy season, stagnant water appear in almost center of the town but not so serious.
Regulations and Compensation	Although the land is officially owned by the state, those who lose their dwelling and commercial area because of the project will be given substitute land. Also, Compensation will be made for properties such as houses and trees, which will be damaged.
Remarks	1. The present water sources are highly contaminated. 2. Because of pump failure, the water supply had been stopped for about 1 month as of July 1995.

Scoping Format for Initial Environmental Examination in Aykel

Environmental Components	Classi-fication	Description
1.Social Environment		
1.1 Resettlement	B	The facilities are small and expected to give no resettlement.
1.2 Economic Activities	D	The economic activities will be enhanced by the water supply and sanitation improvement.
1.3 Facilities	B	The construction work and the facilities have little impact on existing facilities such as schools and hospitals.
1.4 Collapse of Communities	B	Nil. If a water users committee was organized by the community itself to look after the facilities especially public fountains, the community would be enhanced
1.5 Archaeological and Cultural Heritage	B	Nil
1.6 Vested Rights	C	Compensation shall be given for land and properties if these were affected by the Project. Water vendors may lose their income source by the newly supplied water.
1.7 Public Health and Hygienic Condition	D/C	Sanitary improvement will enhance the condition. Drainage system must be accompanied with the improvement of water supply.
1.8 Waste Disposal	B	During construction works, there will be little waste disposal from the view of the small construction scale. After commissionning, no waste disposal is expected.
1.9 Accidental Damages to Facilities	C	Consideration be paid to the alignment of pipelines in order to avoid public nuisance to dwellers.
2. Natural Environment		
2.1 Geographic and Geological Condition	B	No effect is expected to geographic and geological condition.
2.2 Soil Erosion	C	The earth work gives little soil erosion, judging from the construction scale.

Note) A; Advance Impact, B; Negligible Impact C; Unknown Impact D; Enhancement

to be continued.....

2.3 Surface Water Quality and Quantity	B	Nil
2.4 Groundwater Quality and Quantity	C	Effect of overpumping be considered.
2.5 Hydrological Situation	B	No effect is expected to hydrological situation.
2.6 Terrestrial Fauna	B	Nil
2.7 Aquatic Fauna	B	Nil
2.8 Vegetation	B	Little effect is expected to vegetation.
2.9 Climatic Conditions	B	No effect is expected to climatic conditions.
2.10 Aesthetic Condition	B	The facilities would give little change to the condition judging from the size.
3. Public Nuisance		
3.1 Air Pollution	B	Nil
3.2 Water Pollution	B	Nil
3.3 Soil Pollution	B	Nil
3.4 Noise and Vibration	B	The construction works do not give rise to noticeable noise and vibration.
3.5 Land Subsidence	B	The location of new boreholes is designed away from the dwelling area. The land is composed of basalt lava mainly, giving little expectation of land subsidence.
3.6 Odour	B	Nil
3.7 Traffic Nuisance	C	In case of pipeline being laid across road the traffic will be interrupted.

Note) A; Advance Impact, B; Negligible Impact C; Unknown Impact D; Enhancement

Appendix - 7

Project Cost Break-Down (Water Supply)

Summary of Cost Estimation of Water Supply in Aykel

No.	Description	F.C.(B)	L.C.(B)	Total(B)
I.	Target year of 2005			
1	Civil Work			
	Mobilization and Demobilization	200,000	300,000	500,000
	Excavation and Earth-work	15,000	54,500	69,500
	Trench excavation	267,190	614,070	881,260
	Pipe-work	287,370	287,370	574,740
	Reservoir	117,000	117,000	234,000
	Pumping station, R.C.pump house	132,048	87,984	220,032
	Access road	445,000	1,035,000	1,480,000
	Bore-hole (200mm casing)	44,800	67,200	112,000
	Water purifiction unit	10,000	15,000	25,000
	Booster pump and necessary works	360,000	600,000	960,000
	Electric submersible pump and necessary works	40,000	60,000	100,000
	Power supply	111,550	112,325	223,875
	Concrete work	90,950	159,800	250,750
	Masonsy work	6,000	24,500	30,500
	Structure	103,460	241,400	344,860
	Temporary work(10% of above total)	223,037	377,615	600,652
	Total of civil work	2,453,405	4,153,764	6,607,169
2	Material & Equipment	8,211,716	574,820	8,786,536
	Sub Total	10,665,121	4,728,584	15,393,705
3	Engineering cost(12% of sub tatal)	1,847,245		1,847,245
4	Contingency(5% of above cost)	625,618	236,429	862,047
	Total(birr)	13,137,984	4,965,013	18,102,997
	Total(Yen:1birr=15yen)			271,545,000
5	Buildings		993,424	993,424
6	WSSD's management cost		381,928	381,928
	Total		1,375,352	1,375,352
7	Prise escalation(6%)	788,279	380,422	1,168,701
	Grand Total	13,926,263	5,345,435	19,271,698
II.	Target year of 2010			
1	Morbilization and demorbilization			300,000
2	Rising line			960,000
3	Distribution network			1,200,000
4	New borehole with pumps & materials			1,318,000
5	Booster pump with house			534,000
6	Power supply facilities			170,000
7	Chamber and structures			324,000
8	Buildings			843,300
9	Others			488,700
	Sub total			6,138,000
10	Engineering cost (10%)			613,800
11	Contingency (10%)			675,180
	Total			7,427,000
	Prise escalation(42%)			3,119,000
	Grand Total			10,546,000

Cost Estimation of Construction & Materials/Equipment of Aykel : Target year of 2005

No.	Description	Unit	Q'ty	Unit-Rate F.C.(B)	Unit-Rate L.C.(B)	Amount F.C.(B)	Amount L.C.(B)	Remarks
1.	Mobilization and Demobilization	LS				200,000	300,000	
2.	Excavation and Earth-work							
2-1	Clearing and grubbing the site	ha	5	480	2,400	2,400	12,000	to remove bushes, small forest and trees
2-2	Clear off the site	sqm	8,000	1	4	8,000	32,000	to remove top soil to an average depth of 20cm
2-3	Bulk excavation							
	a) Earth excavation	cum	200	6	14	1,200	2,800	
	b) Excavation of weathered rock	cum	50	10	20	500	1,000	
	c) Soft rock excavation	cum	100	14	32	1,400	3,200	
	d) Sound rock excavation	cum	50	30	70	1,500	3,500	
3.	Trench excavation							
3-1	Trench excavation for water pipe							
	1) Single pipe in trench							
	a) 0.6~1.0m depth	m	9,190	4	8	36,760	73,520	
	b) 1.0~1.5m depth	m	10,120	7	17	70,840	172,040	
3-2	Trench, Rock excavation	cum	300	30	70	9,000	21,000	
3-3	Back-fill with the same material	m	5,800	5	11	29,000	63,800	
3-4	Selected soil bedding	m	13,510	2	5	27,020	67,550	150mm thick below barrel
3-5	Back-fill with selected material	m	13,510	7	16	94,570	216,160	compacted in layers not more than 20cm thick
4.	Pipe-work							
4-1	Presure pipe NP 10							with push-in flexible joints
	1) PVC pipe							
	a) DN 50mm	m	8,030	5	5	40,150	40,150	
	b) DN 75mm	m	1,160	8	8	9,280	9,280	
	c) DN 100mm	m	2,750	10	10	27,500	27,500	
	d) DN 150mm	m	9,800	17	17	166,600	166,600	
4-2	Pressure steal pipe							fitting and supports for bridge and road
	DN 200mm	m	320	137	137	43,840	43,840	
5.	Reservoir							
5-1	Ground level reservoir	m3	130	900	900	117,000	117,000	
6.	Pumping station, R.C.pump house	sqm	72	1,834	1,222	132,048	87,984	with accessaries
7.	Access road	m	5,000	89	207	445,000	1,035,000	3m wide gravel road with draine ditch

Cost Estimation of Construction & Materials/Equipment of Aykel : Target year of 2005

No.	Description	Unit	Q'ty	Unit-Rate F.C.(B)	Unit-Rate L.C.(B)	Amount F.C.(B)	Amount L.C.(B)	Remarks
8.	Bore-hole							
8-1	New driling	m	140	320	480	44,800	67,200	including, casing, packing and pumping test
8-2	Rehabirition	set		16,000	24,000	0	0	
9.	Water purifiction unit	No.	1	10,000	15,000	10,000	15,000	
10.	Booster pump	No.	6	60,000	100,000	360,000	600,000	foundation, pump, and motor with accessories
11.	Electric submersible pump (for deep well)	No.	2	20,000	30,000	40,000	60,000	foundation, and pump with accessories
12.	Power supply							
12-1	Generating set	No.	3	5,850	8,775	17,550	26,325	gererater with accessaries
12-2	High tension line	m	10,000	8	7	80,000	70,000	
12-3	Low tension line	m	1,000	6	4	6,000	4,000	
12-4	Trensformer	No.	2	4,000	6,000	8,000	12,000	transformer with accessaries
13.	Concrete work							
13-1	Normal concrete (250kg of cement per cum)	cum	100	250	500	25,000	50,000	including form-work, vibration and curing
13-2	Reinforced concrete (360kg of cement per cum) Water retaining structure	cum	150	275	642	41,250	96,300	including vibration and curing
13-3	Form-work Wall	sqm	100	37	87	3,700	8,700	including all necessary works
13-4	Reinforcement bars; Steel bars	kg	3,000	7	2	21,000	4,800	including cutting, bending and placing
14.	Masonsy work							
14-1	Roughly dressed 40cm thick stone elevation wall	sqm	100	60	245	6,000	24,500	up to 3m height
14-2	Brick work with mortor 25cm thick	sqm		23	92	0	0	
15.	Structure							
15-1	Construction of public fountains	No.	6	1,580	3,680	9,480	22,080	
15-2	Construction of hydrant	No.	10	230	540	2,300	5,400	
15-3	Construction of R.C.C. aeration chamber	No.	6	5,730	13,370	34,380	80,220	
15-4	Construction of R.C.C. valve chamber	No.	10	5,730	13,370	57,300	133,700	
	Sub-Total of Construction work					2,230,368	3,776,149	

No.	Description	Unit	Q'ty	Unit-Rate F.C.(B)	Unit-Rate L.C.(B)	Amount F.C.(B)	Amount L.C.(B)	Remarks
16.	Material & Equipment (Ref.table)							
16-1	CIF Cost at Addis Ababa					8,211,716		
16-2	Inland transportation cost						574,820	CIF cost x 7 %
	Sub-Total of Material & Equipment					8,211,716	574,820	
	Total					10,442,084	4,350,969	
17.	Building							
17-1	Office	sqm	90		1,910		171,900	
17-2	Workshop	sqm	66		1,624		107,184	
17-3	Store	sqm	110		1,337		147,070	
17-4	Residence	sqm	270		2,101		567,270	
	Total						993,424	

Imported Cost (Material & Equipment) of Aykel :Target year of 2005

No.	Description	Unit	Q'ty	Unit Rate (B)	Amount (B)
1.	Pipe material including joint and accessories				
1.1	PVC pipe NP-10				
	a) DN 50mm	m	8,440	15	126,600
	b) DN 75mm	m	1,220	30	36,600
	c) DN 100mm	m	2,890	40	115,600
	d) DN 150mm	m	10,290	80	823,200
1.2	Suspended pressure steel pipe				
	DN 200mm W/O gilt and screw	m	340	288	97,920
1.3	Fitting cost Total cost × 20%				239,984
2	Pumps (Pump with electric motor/accessories)				
2.1	Centrifugal pumps				
	a) Q= 0.7 m3/min H= 13m HP= 3.7kw	set	2	100,000	200,000
	b) Q= 0.42m3/min H=225m HP= 55 kw	set	4	800,000	3,200,000
2.2	Submersible pumps with accessories				
	a) Q= 0.12m3/min H= 100m HP=	set		130,000	0
	b) Q= 0.3m3/min H= 100m HP= kw	set	2	171,000	342,000
3	Power Supply(Materials&accessories)				
3.1	Power supply generating set 50 KVA	set	3	450,000	1,350,000
3.2	Tension line				
	a) High tension over head line	m	10,000	50	500,000
	b) Low tension over head line	m	1,000	28	28,000
3.3	Plate-form mounted transformer				
	Supply of transformer wiht acccessories Transformer 100 KVA (H-Type)	set	2	75,800	151,600
4	Valve (Valve with accessories)				
4.1	Sluice valve				
	a) ϕ50	set		1,000	0
	b) ϕ75	set	2	1,300	2,600
	c) ϕ150	set	4	1,700	6,800
4.2	High speed air valve				
	a) ϕ50	set	6	7,000	42,000
4.3	Check valve				
	a) 100mm	set	1	10,000	10,000
	b) 150mm	set	1	15,000	15,000
5	Flow meter (Meter with accessories ϕ150)	set	2	60,000	120,000
6	Reservoir equipment	set	2	100,000	200,000
7	Well (Materials with accessories)				
7.1	Casing pipe FRP DN 200	m	84	2,093	175,812
7.2	Screen FRP DN 200	m	56	5,700	319,200
7.3	Riser pipe, stainless DN 65	m	160	180	28,800
8	Water purification unit	set	1	80,000	80,000
	Total				8,211,716

Investment Cost of Target Year 2010 in Aykel

No.	Description	Unit	Q'ty	Unit Rate (B)	Amount (B)
1	Morbilization and demorbilization	LS			300,000
2	Rising line	Km	3.2	300,000	960,000
3	Distribution network	Km	8	150,000	1,200,000
4	New borehole with pumps and materials	Set	2	659,000	1,318,000
5					
6	Booster pump with house	Set	1	534,000	534,000
7	Power asupply facilities	Site	1	170,000	170,000
8	Chamber and structures	Set	12	27,000	324,000
9	Buildings	M2	9	93,700	843,300
	Others	LS			488,700
	Sub total				6,138,000
11	Enginering cost (10%)				613,800
12	Contingency (10%)				675,180
	Total				7,426,980

Appendix - 8

Meteorological Data

Table 1 Monthly Precipitation

Station: Aykel Unit:mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1968	–	–	–	–	–	–	544.8	–	–	181.0	–	–	–
1969	–	–	–	205.0	–	161.0	–	–	–	15.0	0.0	0.0	–
1980	–	–	–	–	–	292.1	408.5	302.2	126.3	–	22.0	0.0	–
1981	1.5	0.6	0.3	45.1	70.4	151.5	278.9	250.1	155.9	49.6	0.5	0.0	1004.4
1982	1.3	0.0	60.6	64.1	76.9	80.7	227.2	199.1	132.3	84.9	0.0	0.0	927.1
1983	1.7	0.0	0.0	5.2	–	167.2	408.5	340.9	96.7	85.9	9.1	0.0	–
1984	0.0	0.0	13.3	7.3	–	189.4	291.7	145.9	157.7	8.6	4.5	3.1	–
1985	0.0	0.0	36.0	31.7	219.4	116.6	271.8	257.2	140.2	110.9	32.1	0.0	1215.9
1986	0.0	0.0	0.0	0.0	0.0	215.4	402.9	339.8	276.7	100.2	0.7	0.0	1335.7
1987	1.3	0.0	15.2	26.4	279.7	–	–	–	–	–	–	–	–
1989	0.0	0.0	18.2	87.8	143.4	174.8	319.6	246.0	135.3	82.2	10.4	0.0	1217.7
1990	3.9	0.0	1.3	32.3	52.2	153.3	257.3	207.7	237.2	59.4	0.0	0.0	1004.6
1991	0.0	0.0	–	–	–	–	–	250.3	149.8	139.1	2.9	2.8	–
1992	0.0	0.0	0.0	49.5	–	–	–	–	0.0	0.0	0.0	0.0	–
1993	0.0	1.9	8.0	143.3	112.5	–	–	–	–	–	–	–	–
1994	–	–	–	12.1	50.8	–	214.4	272.5	–	–	–	–	–

Table 2 Long Term Monthly Mean Potential Evapotranspiration (PET)

Station: Gonder Unit:mm

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1st 10 days	44	45	47	46	49	54	57	63	62	60	60	58	
2nd 10 days	59	57	52	50	45	42	42	39	39	39	39	41	
3rd 10 days	41	43	45	46	47	45	43	42	42	42	43	44	
Total	144	145	144	142	141	141	142	144	143	141	142	143	1712

Note: - = not calculated due to missing data

Table 3 Monthly Average Maximum Air Temperature

Station: Aykel unit: ℃

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1969	–	–	–	–	–	19.6	–	–	–	16.8	14.7	–
1980	–	–	–	–	–	23.1	21.0	20.4	20.5	–	26.2	25.8
1981	26.5	28.3	30.0	27.7	24.5	22.4	18.8	19.9	20.5	22.4	23.7	24.3
1982	24.3	25.1	25.4	26.2	24.5	22.7	20.2	19.0	21.3	21.9	22.6	23.9
1983	23.8	25.4	27.3	28.0	–	22.4	21.0	19.8	21.2	21.7	23.9	24.8
1984	24.6	26.7	26.8	27.7	–	21.1	20.3	21.1	21.3	24.4	25.0	24.2
1985	25.1	24.3	26.4	26.3	23.3	22.1	19.5	19.6	21.5	22.9	23.9	24.4
1986	24.9	26.8	29.3	29.0	25.2	23.0	19.9	19.6	20.8	22.1	24.1	23.7
1987	23.9	26.0	26.5	27.2	24.1	–	–	–	–	–	–	–
1989	24.0	24.8	25.6	26.2	23.4	21.8	20.6	20.5	21.3	22.6	24.8	24.3
1990	25.3	25.3	–	27.8	27.8	25.2	21.6	21.9	22.0	23.7	25.8	26.4
1991	25.8	27.3	–	–	–	–	–	22.1	23.9	24.4	25.9	26.2
1992	25.8	26.5	30.3	30.3	–	26.3	23.2	21.1	23.7	23.8	25.2	–
1993	26.4	27.0	–	–	–	25.8	–	–	–	–	–	–
1994	–	–	–	–	–	21.2	19.4	19.5	–	–	–	–

Note: - = not calculated due to missing data

Table 4 Monthly Average Minimum Air Temperature

Station: Aykel unit: ℃

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1969	–	–	–	–	–	13.0	–	–	–	13.0	11.2	9.5
1980	–	–	–	–	–	12.7	12.2	12.0	12.4	–	13.5	13.4
1981	13.6	13.7	12.0	14.0	14.5	13.4	12.4	12.4	12.6	12.8	12.4	12.5
1982	12.6	13.4	14.4	14.0	14.4	14.4	12.3	12.5	12.8	12.7	12.4	12.6
1983	11.7	13.2	15.2	14.6	–	13.6	12.2	12.5	13.0	12.6	12.7	12.4
1984	12.1	14.2	14.5	16.5	–	12.5	11.5	11.5	11.6	13.2	13.4	13.0
1985	13.6	11.7	11.7	14.1	13.5	13.1	12.0	12.1	13.0	12.9	13.1	13.0
1986	13.1	14.7	15.5	16.1	14.0	12.2	11.8	11.9	12.0	12.9	13.5	12.5
1987	13.1	14.8	15.2	15.6	14.2	–	–	–	–	–	–	–
1989	11.0	12.7	14.2	14.3	13.9	13.0	12.5	12.3	13.1	13.0	13.0	12.2
1990	12.9	13.3	–	15.4	15.9	13.9	12.5	12.9	12.6	13.3	13.9	13.9
1991	13.2	14.4	–	–	–	–	–	12.5	13.0	13.1	13.4	12.5
1992	12.7	12.5	15.7	15.7	–	13.4	12.0	12.3	12.5	12.9	12.5	–
1993	11.5	13.0	–	14.2	–	–	–	–	–	–	–	–
1994	–	–	–	–	–	12.9	12.4	12.3	–	–	–	–

Note: - = not calculated due to missing data

Table 5 Monthly Average Air Temperature

Station: Aykel unit: ℃

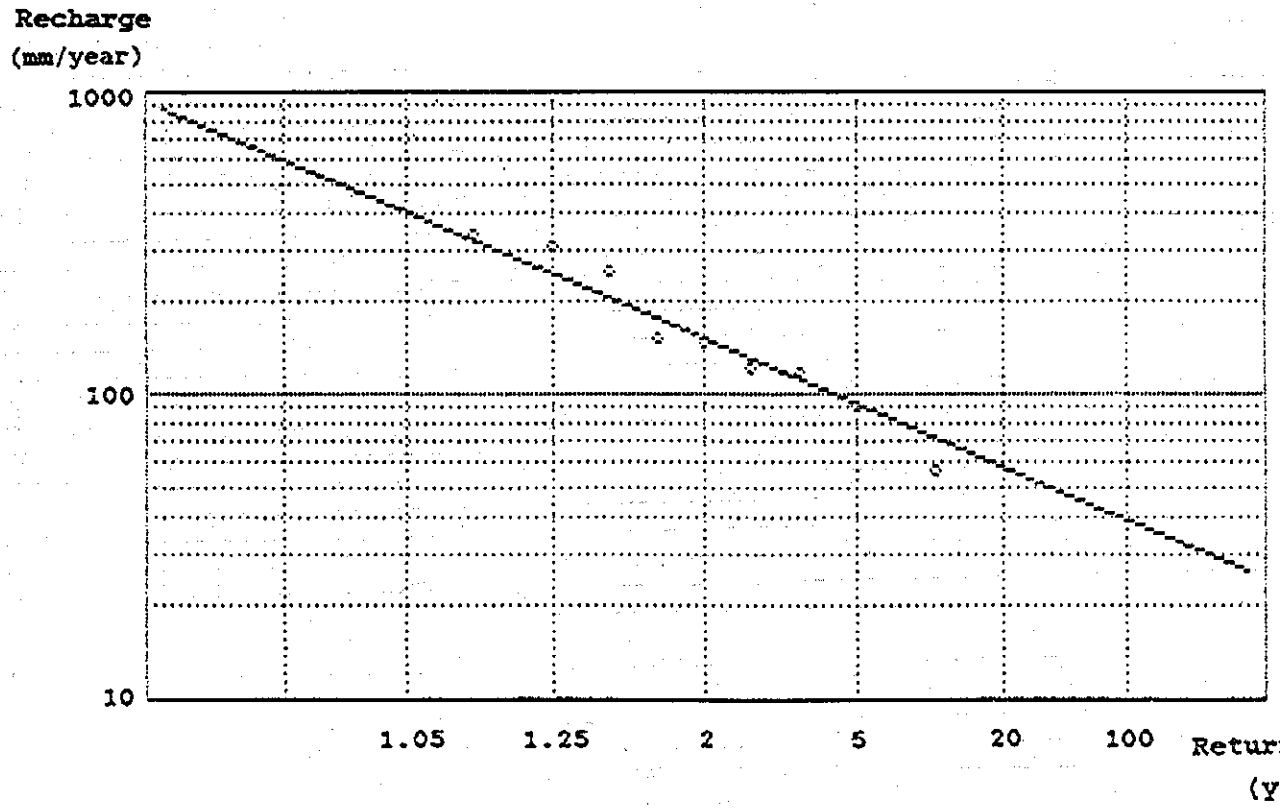
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1969	–	–	–	–	–	16.3	–	–	–	14.9	13.0	–
1980	–	–	–	–	–	17.9	16.6	16.2	16.5	–	19.9	19.6
1981	20.1	21.0	21.0	20.9	19.5	17.9	15.6	16.2	16.6	17.6	18.1	18.4
1982	18.5	19.3	19.9	20.1	19.5	18.6	16.3	31.5	17.1	17.3	17.5	18.3
1983	17.8	19.3	21.3	21.3	–	18.0	16.6	16.2	17.1	17.2	18.3	18.6
1984	18.4	20.5	20.7	22.1	–	16.8	15.9	16.3	16.5	18.8	19.2	18.6
1985	19.4	18.0	19.1	20.2	18.4	17.6	15.8	15.9	17.3	17.9	18.5	18.7
1986	19.0	20.8	22.2	22.6	19.6	17.6	15.9	15.8	16.4	17.5	18.8	36.2
1987	18.5	20.4	20.9	21.4	19.2	–	–	–	–	–	–	–
1989	17.5	18.8	19.9	20.3	18.7	17.4	16.6	16.4	17.2	37.6	19.9	18.3
1990	19.1	19.3	–	21.6	21.9	19.6	17.1	17.4	17.3	18.5	19.9	20.2
1991	19.5	20.9	–	–	–	–	–	17.3	18.5	18.8	19.7	19.4
1992	19.5	19.5	23.0	23.0	–	19.9	17.6	16.7	19.1	19.4	18.9	–
1993	19.0	20.0	–	–	–	–	–	–	–	–	–	–
1994	–	–	–	–	–	17.1	16.9	15.9	–	–	–	–

Note: - = not calculated due to missing data

Appendix - 9

Hydrological Data

Figure 1 Probability Analysis on Annual Ground Water Recharge



Results of Analysis

Return Period (year)	Probability of Exceedance	Theoretical Values
2	.5	150.85
5	.2	91.792
10	.1	70.805
20	.05	57.154

Table 1 Monthly Water Balance Sheet for Ground Water Recharge

1980

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	–	–	–	–	–	292.1	408.5	302.2	126.3	–	22.0	0.0	–
Q	–	–	–	–	–	116.8	163.4	120.9	50.5	–	8.8	0.0	–
P - Q	–	–	–	–	–	175.3	245.1	181.3	75.8	–	13.2	0.0	–
ETo	144	145	144	142	141	141	142	144	143	141	142	143	1,712
ET crop	100.8	101.5	100.8	99.4	98.7	98.7	99.4	100.8	100.1	98.7	99.4	100.1	1,199.4
ETa	–	–	–	–	–	98.7	99.4	100.8	75.8	–	13.2	0.0	–
△S	–	–	–	–	–	76.6	145.7	80.5	0.0	–	0.0	0.0	302.8

1981

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	1.5	0.6	0.3	45.1	70.4	151.5	278.9	250.1	155.9	49.6	0.5	0.0	1,004.4
Q	0.6	0.2	0.1	18.0	28.2	60.6	111.6	100.0	62.4	19.8	0.2	0.0	401.7
P - Q	0.9	0.4	0.2	27.1	42.2	90.9	167.3	150.1	93.5	29.8	0.3	0.0	602.7
ETo	144	145	144	142	141	141	142	144	143	141	142	143	1,712
ET crop	100.8	101.5	100.8	99.4	98.7	98.7	99.4	100.8	100.1	98.7	99.4	100.1	1,199.4
ETa	0.9	0.4	0.2	27.1	42.2	90.9	99.4	100.8	93.5	29.8	0.3	0.0	485.5
△S	0	0	0	0	0	0	67.9	49.3	0	0	0	0	117.2

1982

Uint:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	1.3	0.3	60.6	64.1	76.9	80.7	227.2	199.1	132.3	84.9	0.0	0.0	927.1
Q	0.5	1.0	24.2	25.6	30.8	32.3	90.9	79.6	52.9	34.0	0.0	0.0	370.8
P - Q	0.8	–	36.4	38.5	46.1	48.4	136.3	119.5	79.4	50.9	0.0	0.0	556.3
ETo	144	145	144	142	141	141	142	144	143	141	142	143	1,712
ET crop	100.8	101.5	100.8	99.4	98.7	98.7	99.4	100.8	100.1	98.7	99.4	100.1	1,199.4
ETa	0.8	0.0	36.4	38.5	46.1	48.4	99.4	100.8	79.4	50.9	0.0	0.0	500.7
△S	0	0	0	0	0	0	36.9	18.7	0	0	0	0	55.6

Note: - = not calculated due to missing data or distorted data

1983

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	1.7	0.0	0.0	5.2	--	167.2	408.5	340.9	96.7	85.9	9.1	0.0	--
Q	0.7	0.0	0.0	2.1	--	66.9	163.4	136.4	38.7	34.4	3.6	0.0	--
P - Q	1.0	0.0	0.0	3.1	--	100.3	245.1	204.5	58.0	51.5	5.5	0.0	--
ETo	144	145	144	142	141	141	142	144	143	141	142	143	1,712
ET crop	100.8	101.5	100.8	99.4	98.7	98.7	99.4	100.8	100.1	98.7	99.4	100.1	1,199.4
ETa	10.0	0.0	0.0	3.1	--	98.7	99.4	100.8	58.0	51.5	5.5	0.0	--
△S	0	0	0	0	--	1.6	145.7	103.7	0	0	0	0	251.0

1984

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	0.0	0.0	13.3	7.3	--	189.4	291.7	145.9	157.7	8.6	4.5	3.1	--
Q	0.0	0.0	5.3	2.9	--	75.8	116.7	58.4	63.1	3.4	1.8	1.2	--
P - Q	0.0	0.0	8.0	4.4	--	113.6	175.0	87.5	94.6	5.2	2.7	1.9	--
ETo	144	145	144	142	141	141	142	144	143	141	142	143	1,712
ET crop	100.8	101.5	100.8	99.4	98.7	98.7	99.4	100.8	100.1	98.7	99.4	100.1	1,199.4
ETa	0.0	0.0	8.0	4.4	--	98.7	99.4	87.5	94.6	5.2	2.7	1.9	--
△S	0	0	0	0	--	14.9	75.6	0	0	0	0	0	90.5

1985

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	0.0	0.0	36.0	31.7	219.4	116.6	271.8	257.2	140.2	110.9	32.1	0.0	1,215.9
Q	0.0	0.0	14.4	12.7	87.8	46.6	108.7	102.9	56.1	44.4	12.8	0.0	486.4
P - Q	0.0	0.0	21.6	19.0	131.6	70.0	163.1	154.3	84.1	66.5	19.3	0.0	729.5
ETo	144	145	144	142	141	141	142	144	143	141	142	143	1,712
ET crop	100.8	101.5	100.8	99.4	98.7	98.7	99.4	100.8	100.1	98.7	99.4	100.1	1,199.4
ETa	0.0	0.0	21.6	19.0	98.7	70.0	99.4	100.8	84.1	66.5	19.3	0.0	579.4
△S	0.0	0.0	0	0	32.9	0	63.7	53.5	0	0	0	0	150.1

Note: - = not calculated due to missing data or distorted data

1986

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	0.8	0.0	0.0	0.0	0.0	215.4	402.9	339.8	276.7	100.2	0.7	0.0	1,335.7
Q	0.0	0.0	0.0	0.0	0.0	86.2	161.2	135.9	110.7	40.1	0.3	0.0	534.4
P - Q	0.0	0.0	0.0	0.0	0.0	129.2	241.7	203.9	166.0	60.1	0.4	0.0	801.3
ETo	144	145	144	142	141	141	142	144	143	141	142	143	1,712
ET crop	100.8	101.5	100.8	99.4	98.7	98.7	99.4	100.8	100.1	98.7	99.4	100.1	1,199.4
ETa	0.0	0.0	0.0	0.0	0.0	98.7	99.4	100.8	100.1	60.1	0.4	0.0	459.5
△S	0	0	0	0	0	30.5	142.3	103.1	65.9	0	0	0	341.8

1989

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	0.0	0.0	18.2	87.8	143.4	174.8	319.6	246.0	135.3	82.2	10.4	0.0	1,217.7
Q	0.0	0.0	7.3	35.1	57.4	69.9	127.8	98.4	54.1	32.9	4.2	0.0	487.1
P - Q	0.0	0.0	10.9	52.7	86.0	104.9	191.8	147.6	81.2	49.3	6.2	0.0	730.6
ETo	144	145	144	142	141	141	142	144	143	141	142	143	1,712
ET crop	100.8	101.5	100.8	99.4	98.7	98.7	99.4	100.8	100.1	98.7	99.4	100.1	1,199.4
ETa	0.0	0.0	10.9	52.7	86.0	98.7	99.4	100.8	81.2	49.3	6.2	0.0	585.2
△S	0.0	0.0	0.0	0.0	0.0	6.2	92.4	46.8	0.0	0	0	0	145.4

1990

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	3.9	0.0	1.3	32.3	52.2	153.3	257.3	207.7	237.2	59.4	0.0	0.0	1,004.6
Q	1.6	0.0	0.5	12.9	20.9	61.3	102.9	83.1	94.9	23.8	0.0	0.0	401.9
P - Q	2.3	0.0	0.8	19.4	31.3	92.0	154.4	124.6	142.3	35.6	0.0	0.0	602.7
ETo	144	145	144	142	141	141	142	144	143	141	142	143	1,712
ET crop	100.8	101.5	100.8	99.4	98.7	98.7	99.4	100.8	100.1	98.7	99.4	100.1	1,199.4
ETa	2.3	0.0	0.8	19.4	31.3	92.0	99.4	100.8	100.1	35.6	0.0	0.0	481.7
△S	0.0	0.0	0.0	0.0	0.0	0.0	55.0	23.8	42.2	0	0	0	121.0

Appendix - 10

Result of Pumping Test

1. General

The pumping test was conducted at the hand dug well located in the compound of Orthodox Church Aid Office in October, 1995. The dimensions of the well have been reported as stated hereunder.

- Well Depth : 11.5 m
- Casing Type and Diameter : Concrete ring, 1.3 m

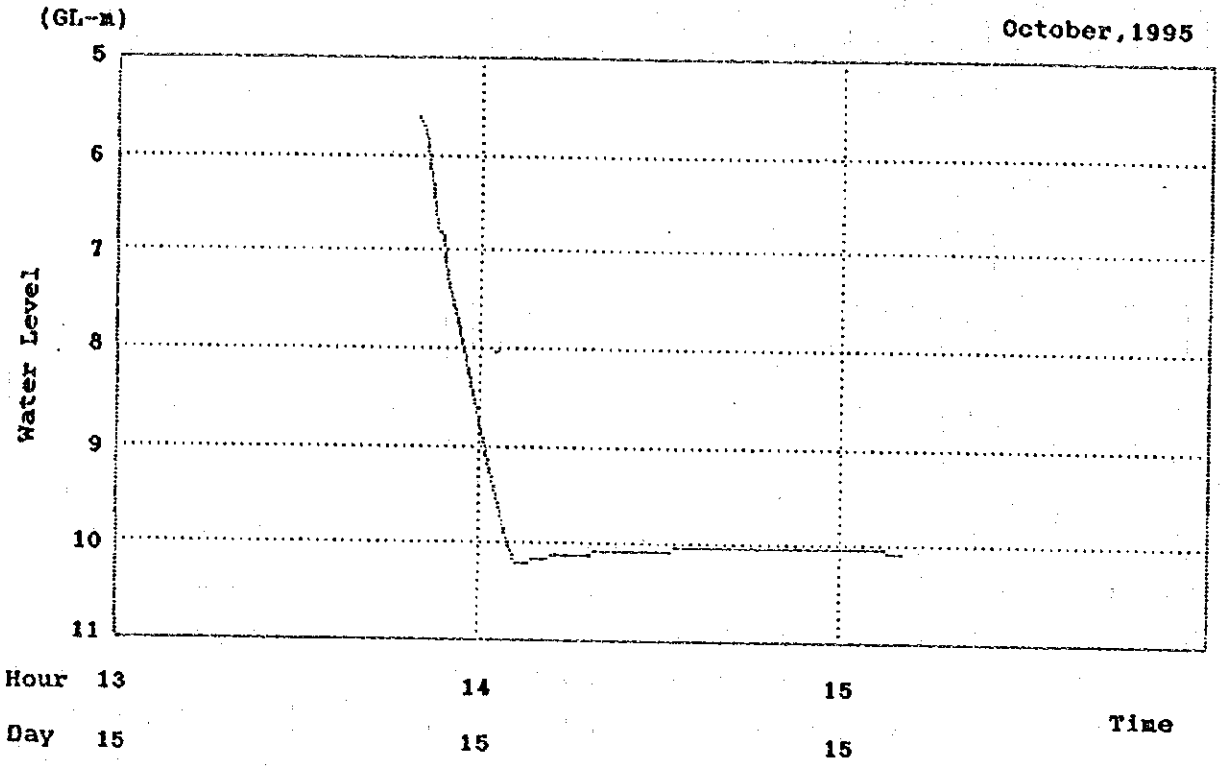
The diameter of the well is not measured but it is estimated at 1.3 m because the concrete ring is a standard type. The well does not equip slots and ground water enters from the bottom of the well. Little is known about the aquifer. Most probably it is a unconfined aquifer and consisted of tuffs which are predominant in the area. The static water level was observed at 5.6 m below ground level. However, it was about 10m below in June 1995. For the test, a 4" submersible pump was installed at 11m below ground level. The well depth was measured and it was 11.5 m deep. The test was initially planned to include the followings.

- Preliminary pumping test with 10 steps
- Step drawdown test with 5 steps
- Contineous discharge test for 24 hours and recovery observation

2. Preliminary Pumping Test

The test is aimed to know about the well, measuring the water level with different pumping rates. The pumping started at the rate of 0.58 l/s. In 16 minutes, the drawdown of 4.6 m was made and the water level reached 0.8 m above the pump position. Then, the pump was shut off in order to avoid further drawdown. The recovery was observed and it recovered 18.5 % within one hour. See Figure 1 for the variation of water level.
It is obvious that the pumping rate must be reduced for the next step. However, the pump is not designed for smaller discharge. So that the test was terminated. From this test it has learnt that the performance of the well and the efficiency of the aquifer is very low.

Figure 1 Pumping Test
Time Water Level Graph



PRELIMINARY TEST
PUMPING STAGE

DATE 15/10/95 — CONDUCTED BY WWDE

WELL NO. — SWL 5.60 m — STEP 1

LOCATION AYKEL — PUMP TYPE Submersible — NOTCH (H) mm

OWNER Orthodox Church — HEAD 100 m — DISCHARGE 0.58l/s

WELL DEPTH 11.50 m — CAP. 5 l/s — 50.1 m3/day

WELL DIA. 1.3 m — POSITION 11.0 GL-m — Hand Dug Well

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
13:50	0	5.60	0.00	0.58 lt/sec.
	0.5	5.65	0.05	
13:51	1.0	5.76	0.16	
	1.5	5.93	0.33	
13:52	2.0	6.23	0.63	
	2.5	6.57	0.97	
13:53	3.0	6.75	1.15	
	3.5	6.86	1.26	0.58 lt/sec.
13:54	4.0	6.87	1.27	
	4.5	6.90	1.30	
13:55	5.0	7.29	1.69	0.58 lt/sec.
13:56	6.0	7.54	1.94	
13:57	7.0	7.83	2.23	0.58 lt/sec.
13:58	8.0	8.14	2.54	
13:59	9.0	8.49	2.89	
14:00	10.0	8.76	3.16	
14:02	12.0	9.28	3.68	
14:04	14.0	9.82	4.22	
14:06	16.0	10.20	4.60	

PRELIMINARY TEST
RECOVERY

DATE 15/10/95 — CONDUCTED BY WWDE

WELL NO. — SWL 5.60 m — DISCHARGE OF THE FINAL STEP

LOCATION AYKEL — PUMP TYPE Submersible

OWNER Orthodox Church — HEAD 100 m — 0.58 l/s

WELL DEPTH 11.50 m — CAP. 5 l/s — 50.1 m3/day

WELL DIA. 1.3 m — POSITION 11.0 GL-m — Hand Dug Well

TIME	TIME SINCE PUMPING STOPPED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
14:08	0	10.20	4.60	
	0.5	10.16	4.56	
14:09	1.0	10.16	4.56	
	1.5	10.16	4.56	
14:10	2.0	10.16	4.56	
	2.5	10.16	4.56	
14:11	3.0	10.16	4.56	
	3.5	10.14	4.54	
14:12	4.0	10.13	4.53	
	4.5	10.13	4.53	
14:13	5.0	10.13	4.53	
14:14	6.0	10.12	4.52	
14:15	7.0	10.11	4.51	
14:16	8.0	10.10	4.50	
14:17	9.0	10.10	4.50	
14:18	10.0	10.10	4.50	
14:20	12.0	10.09	4.49	
14:22	14.0	10.09	4.49	
14:24	16.0	10.09	4.49	
14:26	18.0	10.07	4.47	
14:28	20.0	10.07	4.47	
14:33	25.0	10.05	4.45	
14:38	30.0	10.04	4.44	
14:43	35.0	10.03	4.43	
14:48	40.0	10.03	4.43	
14:53	45.0	10.02	4.42	
14:58	50.0	10.02	4.42	
15:03	55.0	10.01	4.41	
15:08	60.0	10.06	4.46	

Appendix - 11

Calculation of Water Pipeline

Output data on distribution network for Aykel Case: Ordinary, 2005

Serial Number	Pipeline Number	Nord Number Start	Nord Number End	Dia. (mm)	Pipeline Length(m)	Flow (liter/sec.)	Velocity (m/sec.)	Hydraulic Gradient (m/1000)	Loss of Head (m)	Velocity Coefficient	Remarks
1	1	1	2	200	285	11.11	0.35	0.31	1.10	110	
2	2	2	3	150	220	1.96	0.11	0.04	0.18	110	
3	3	3	4	75	335	0.25	0.06	0.04	0.11	110	
4	4	4	5	75	180	0.12	0.03	0.00	0.03	110	
5	5	4	6	75	220	-0.21	-0.05	-0.02	-0.09	110	
6	6	6	7	150	170	0.12	0.00	0.00	0.00	110	
7	7	6	8	150	280	-0.74	-0.04	-0.00	-0.03	110	
8	8	8	3	150	230	-0.92	-0.05	-0.01	-0.04	110	
9	9	2	11	150	130	8.76	0.50	0.37	2.87	110	
10	10	11	9	150	360	8.21	0.46	0.92	2.54	110	
11	11	9	10	150	535	0.40	0.02	0.00	0.00	110	
12	12	9	14	150	460	6.67	0.38	0.80	1.73	110	
13	13	14	15	150	100	0.67	0.04	0.00	0.02	110	
14	14	14	13	150	190	5.42	0.31	0.22	1.18	110	
15	15	13	17	150	760	2.13	0.12	0.16	0.21	110	
16	16	13	12	150	30	2.81	0.16	0.01	0.35	110	
17	17	12	16	75	315	1.43	0.32	0.92	2.93	110	
18	18	12	18	150	540	0.52	0.03	0.00	0.02	110	

Output data on distribution network for Aykel Case: Fire Fighting, 2005

Serial Number	Pipeline Number	Nord Number Start	Nord Number End	Dia. (mm)	Pipeline Length(m)	Flow (liter/sec.)	Velocity (m/sec.)	Hydraulic Gradient (m/1000)	Loss of Head (m)	Velocity Coefficient	Remarks
1	1	1	2	200	285	23.67	0.75	1.27	4.44	110	
2	2	2	3	150	220	1.23	0.07	0.02	0.08	110	
3	3	3	4	75	335	0.15	0.03	0.02	0.05	110	
4	4	4	5	75	180	0.07	0.02	0.00	0.01	110	
5	5	4	6	75	220	-0.13	-0.03	-0.00	-0.03	110	
6	6	6	7	150	170	0.08	0.00	0.00	0.00	110	
7	7	6	8	150	280	-0.47	-0.03	-0.00	-0.01	110	
8	8	8	3	150	230	-0.58	-0.03	-0.00	-0.02	110	
9	9	2	11	150	130	22.19	1.26	2.08	16.01	110	
10	10	11	9	150	360	21.84	1.24	5.59	15.54	110	
11	11	9	10	150	535	0.25	0.01	0.00	0.00	110	
12	12	9	14	150	460	20.87	1.18	6.57	14.29	110	
13	13	14	15	150	100	0.42	0.02	0.00	0.01	110	
14	14	14	13	150	190	20.08	1.14	2.53	13.30	110	
15	15	13	17	150	760	1.34	0.08	0.07	0.09	110	
16	16	13	12	150	30	18.44	1.04	0.34	11.36	110	
17	17	12	16	75	315	0.90	0.20	0.39	1.25	110	
18	18	12	18	150	540	17.00	0.96	5.28	9.78	110	

Output data on distribution network for Aykel Case: Ordinary, 2010

Serial Number	Pipeline Number	Nord Number Start	Nord Number End	Dia. (mm)	Pipeline Length(m)	Flow (liter/sec.)	Velocity (m/sec.)	Hydraulic Gradient (m/1000)	Loss of Head (m)	Velocity Coefficient	Remarks
1	1	1	2	200	285	19.72	0.63	0.90	3.17	110	
2	2	2	3	150	220	5.19	0.29	0.24	1.09	110	
3	3	3	4	75	335	1.33	0.30	0.86	2.57	110	
4	4	4	5	75	180	2.44	0.55	1.42	7.88	110	
5	5	4	6	75	220	-1.45	-0.33	-0.66	-3.01	110	
6	6	6	7	150	170	1.03	0.06	0.00	0.05	110	
7	7	6	8	150	280	-2.89	-0.16	-0.10	-0.37	110	
8	8	8	3	150	230	-3.07	-0.17	-0.09	-0.41	110	
9	9	2	11	150	130	14.14	0.80	0.90	6.95	110	
10	10	11	9	150	360	13.59	0.77	2.33	6.46	110	
11	11	9	10	150	535	2.24	0.13	0.12	0.23	110	
12	12	9	14	150	460	10.21	0.58	1.75	3.81	110	
13	13	14	15	150	100	1.61	0.09	0.01	0.12	110	
14	14	14	13	150	190	8.02	0.45	0.46	2.44	110	
15	15	13	17	150	760	2.41	0.14	0.20	0.26	110	
16	16	13	12	150	30	5.13	0.29	0.03	1.07	110	
17	17	12	16	75	315	1.43	0.32	0.92	2.93	110	
18	18	12	18	150	540	2.84	0.16	0.19	0.36	110	

Output data on distribution network for Aykel Case: Fire Fighting, 2010

Serial Number	Pipeline Number	Nord Number Start	Nord Number End	Dia. (mm)	Pipeline Length(m)	Flow (liter/sec.)	Velocity (m/sec.)	Hydraulic Gradient (m/1000)	Loss of Head (m)	Velocity Coefficient	Remarks
1	1	1	2	200	285	29.09	0.93	1.85	6.51	110	
2	2	2	3	150	220	3.26	0.18	0.10	0.46	110	
3	3	3	4	75	335	0.83	0.19	0.36	1.08	110	
4	4	4	5	75	180	1.53	0.35	0.60	3.32	110	
5	5	4	6	75	220	-0.91	-0.21	-0.28	-1.26	110	
6	6	6	7	150	170	0.65	0.04	0.00	0.02	110	
7	7	6	8	150	280	-1.82	-0.10	-0.04	-0.16	110	
8	8	8	3	150	230	-1.93	-0.11	-0.04	-0.17	110	
9	9	2	11	150	130	25.58	1.45	2.71	20.82	110	
10	10	11	9	150	360	25.23	1.43	7.31	20.30	110	
11	11	9	10	150	535	1.41	0.08	0.05	0.10	110	
12	12	9	14	150	460	23.10	1.31	7.93	17.24	110	
13	13	14	15	150	100	1.01	0.06	0.00	0.05	110	
14	14	14	13	150	190	21.72	1.23	2.92	15.38	110	
15	15	13	17	150	760	1.52	0.09	0.09	0.11	110	
16	16	13	12	150	30	19.90	1.13	0.39	13.08	110	
17	17	12	16	75	315	0.90	0.20	0.39	1.25	110	
18	18	12	18	150	540	18.46	1.04	6.15	11.39	110	

Appendix - 12

Geological Logs of Existing Boreholes

Borehole No.1 in Aykel

Depth	Lithology
0 - 4 m	Clay: black, basalt fragment
4 - 14 m	Clay: sandy, basalt fragment
14 - 80 m	Basalt: weathered and fresh , gypsum fragment
80 - 89 m	Sand:cemented, weathered basalt fragment
89 - 96 m	Agglomerate:brown, clay matrix
96 - 99 m	Basalt: angular, weathered
99 -101 m	Clay: volcanic fragment
101-165 m	Basalt: angular fragment weathered and clayey matrix
165-186 m	Basalt: fragment are less weathered and clay content decrease

Location : About 5km east of the town center

Source : from "AYKEL GEOLOGICAL LOG BOREHOLE #1 - EWRA" by J.TAYLOR 1980