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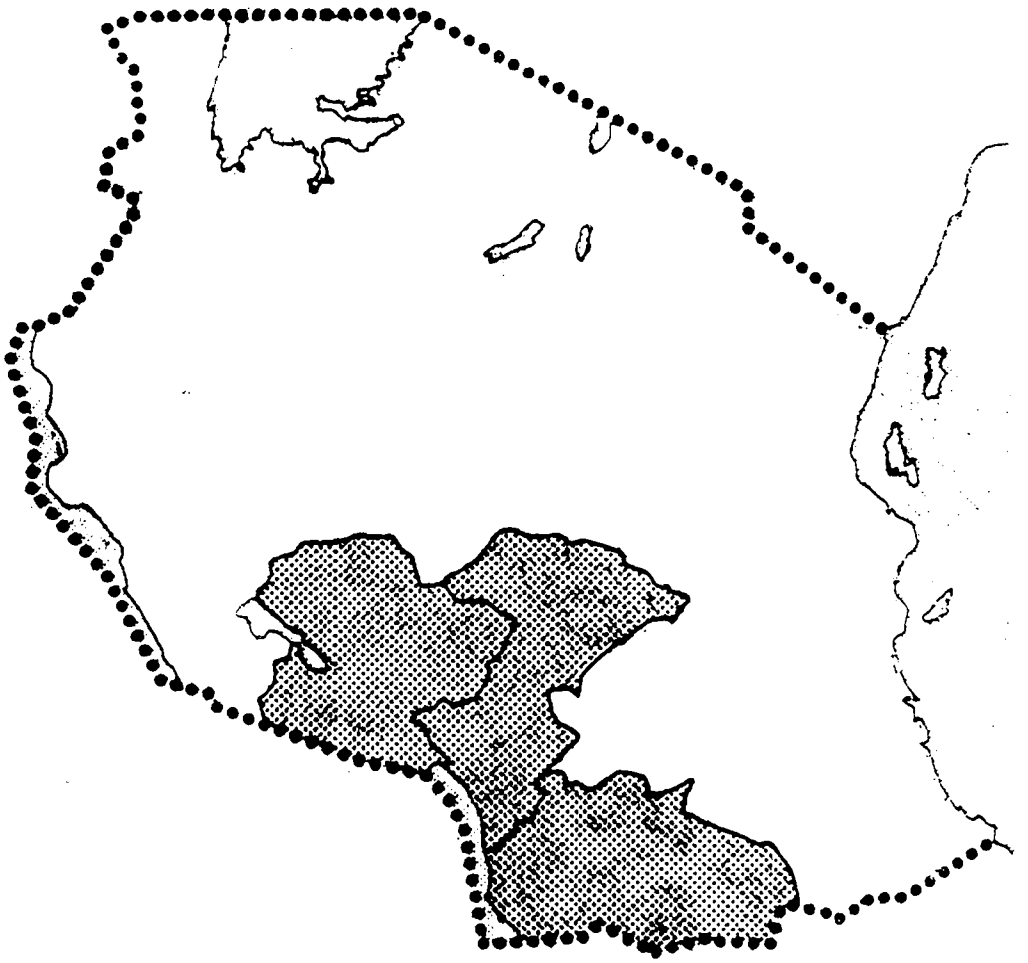
IMPLEMENTATION OF WATER MASTER PLANS FOR IRINGA, RUVUMA AND MBEYA REGIONS

HYDROLOGY - LOW FLOW GAUGINGS 1985



CARL BRO • COWICONSULT • KAMPSAX - KRUGER • COKK

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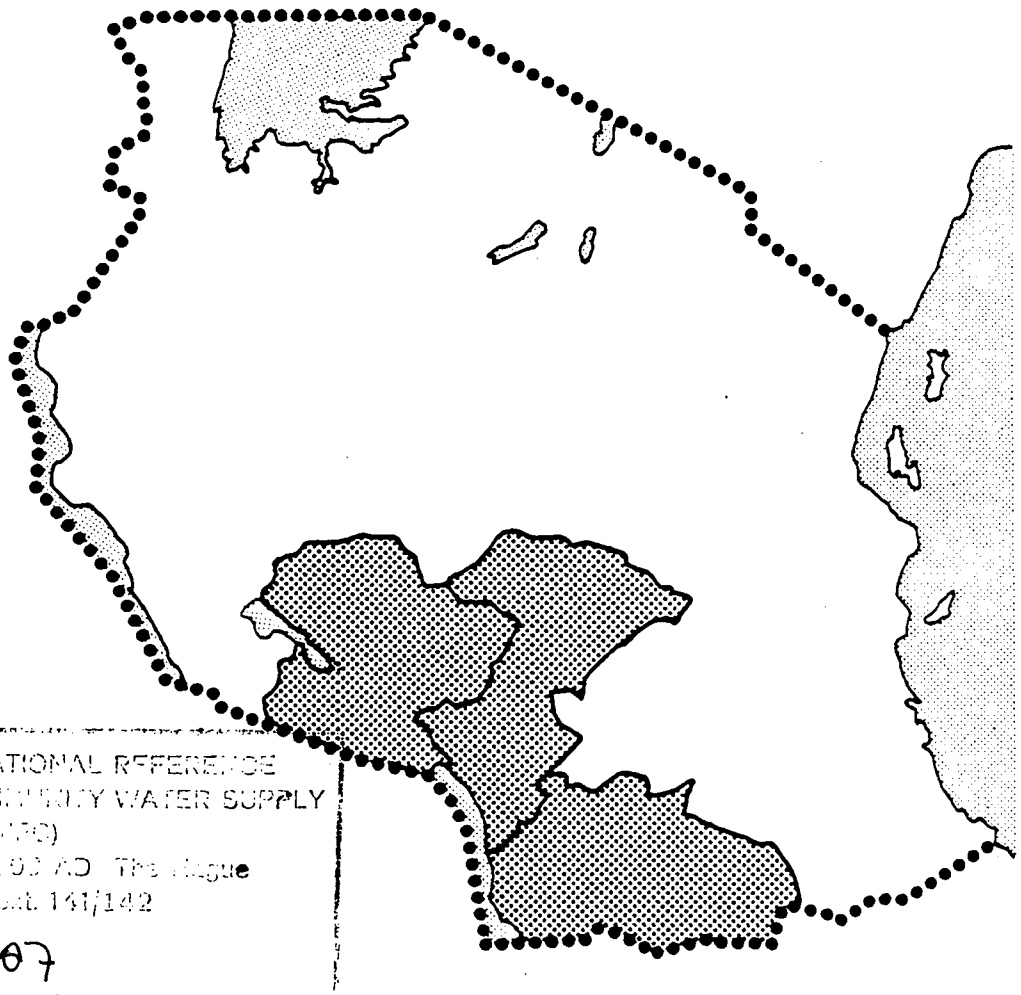

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LOW FLOW STUDIES IN IRINGA, MBEYA AND RUVUMA REGIONS, TANZANIA

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1. INTRODUCTION

In accordance with a working paper: "Minimum Flow Assessment at Village Level - DANIDA - CCKK, September 1984", a low flow study programme was performed for a selected number of villages in the three regions of Iringa, Mbeya, and Ruvuma. The aim of the study was to provide the best possible estimates of the 10-year minimum flows at the selected sources of the village water supply schemes. The results of the low flow study are given in the DANIDA - CCKK report: "Hydrology - Low Flow Gaugings 1984", and it was found that several of the selected streams, were not able to meet the 2006 year demand for the villages. It was recommended to make a new low flow programme during the dry season of 1985 for the problematic villages.

The programme was recommended to be grouped into two categories:

Category 1: Sources with insufficient water based on two measurements in 1984.

Category 2: Sources with insufficient water based on one measurement in 1984 and an assumed recession constant (safe side).

The recommended low flow programme for 1985 would then comprise two programmes:

Programme for category 1: Measurements at additional/alternative sources.

Programme for category 2: Measurements at proposed sources to verify the minimum flow and if necessary measurements at additional/alternative sources.

The number of proposed villages for further investigations were as shown in Table 1 below.

Table 1 - Villages with too little water in the year 2006

	2-year minimum	10-year minimum
Iringa	21	26
Mbeya	8	8
Ruvuma	29	33

All villages where there was a deficit of water were described in brief in Section 4 in the 1984 report. This section is shown in Appendix 1 and has been used as a working paper for the 1985 low flow programme. In addition, few new villages from the 3-year rolling plan have been included.

The low flow measurement programme was performed as described in the 1984 report, and was conducted during the months of September, October and November 1985. As the rains started end of October 1985, which is 2-3 weeks earlier than normal, some of the stations have not been measured for the second time.

2. DESCRIPTION OF FIELD WORK

In 1985 low flow measurements were taken on 93 sources. Most of these sources had been measured 1984. A few new sources have been added to the previous list, either to supplement or as alternative to the old ones, which have proven insufficient, or as new sources for additional schemes recommended by the implementation offices.

2.1 The Low Flow Measurement Programme 1985

The gauging work in the field was performed by five field teams in total for the three regions. The methods used for measuring the discharge in the selected streams were the same as employed during the 1984 low flow programme. For calculating the recession constants, the discharge for all the streams should be measured twice within the dry season, and with a time lag (time between the two measurements) of roughly 1-2 months. The intention was then to start the programme in August-September to ensure that the second gauging could be taken before the rainy season, normally starting end of October, beginning of November.

2.2 Network Station Visits

The estimated low flow will be related to the lowest flow obtained in 1985 from the permanent hydrological network stations. To this end, visits to a number of gauging stations were made to have a picture of the reliability of the data collected from these.

10-year minimum flows have been calculated for 12 stations during the Water Mater Plan of Iringa, Mbeya, and Ruvuma, see Table 2, and 7 out of these flows will be used in the following analysis. All these seven stations were visited by the hydrologists and appeared to be in a good condition giving reliable gaugings.

The water levels from a number of stations have been collected and converted to discharges of which the lowest for each station is found. The ratio of the minimum flow of 1985 and the 10-year minimum will then be used to scale the minimum flow of the measured streams in order to find its 10-year minimum.

Table 2 - 10-year minimum flows and the 1985 minimum flow with corresponding recurrence interval at selected hydrological stations

Station	River	Catch-ment area km^2	10-year min. l/s	1985 min. l/s	corresp. T year	Date of 1985 min.
1KA 22	Mtitu	445	1,130	1,760	< 2	4/11
1KA 37A	Lukosi	2890	8,092	15,300	< 2	7/11
1KA 32A	Lt Ruaha	759	228	810	< 2	29/10
1RC 8A	Kiwira	655	5,436	-	-	-
3A 8	Myovisi	152	243	-	-	-
1RC 5A	Kiwira	217	2,062	2,700	< 2	20/10
1KA 7A	Chimala	167	167	400	< 2	20/10
1RC 3A	Mbaka	645	2,540	9,200	< 2	15/10
3B 15	Mtembwa	8000	80	-	-	-
1RB 2	Ruhuhu	2220	14,830	20,130	< 2	7/11
1KB 19	Hagafiro	153	536	-	-	-
1KB 18B	Ruhudji	410	1,435	-	-	-
1 RC 2A	Kiwira	1660	8,964	-	-	-

In Table 2 is shown the gauged 1985 minimum flow used in the study to estimate the 10-year minimum for the selected sources, and an estimate of the corresponding 1985 recurrence interval for these stations. As can be seen, the low flow at all the stations in 1985 represents a recurrence interval below 2 year. It can also be expressed in that way that the possibility of getting a low flow a certain year, below the 1985 low flow, is very high. Briefly, it means that the low flow in 1985 was very high for all streams.

3. DATA ANALYSES

The questionnaires from each of the selected water supply sources have been analysed and a recession constant calculated, where possible. The recession constants are calculated using the equation

$$Q_2 = Q_1 \times e^{-k(t2-t1)}$$

where

Q_1 is the discharge at the time t_1
Q_2 is the discharge at the time t_2
k is the recession constant varying for each catchment

The recession constants for the selected water supply sources are shown in Table 3.

The lowest discharge for 1985 for the seven selected hydrological stations was found. The number of days $(t_2 - t_1)$ from the latest low flow measurement (Q_1) to the lowest discharge at the nearest hydrological station was then found and used in the above equation to find Q_2 (the absolute lowest flow for 1985 at the sources).

At each hydrological station the ratio of the 10-year minimum $(Q_{10\text{-year min}})$ and the lowest 1985 discharge $(Q_{\text{min 1985}})$ is found and used to scale the calculated 1985 minima of the sources $(q_{\text{min 1985}})$ near to it in order to estimate their 10-year minima $(q_{10\text{-year min}})$.

The equation is shown below, and the calculated 10-year minima for the sources are shown in Table 4.

$$q_{10\text{-year min}} = q_{\text{min 1985}} \quad \left(\frac{Q_{10\text{-min}}}{Q_{\text{min 1985}}}\right)$$

For the sources, at which only one measurement is valid, the 1984 recession constant, if any, has been used, and if no 1984 constant exists, an estimate is made using known recession constants from the same area and a safety factor of 1.5.

Table 3 - Recession constants

District/Village name	1st measurement l/s	Date	2nd measurement l/s	Date	Recession constant $days^{-1}$	Remarks
IRINGA						
ISMANI GROUP 1 (MGERA)	80.20	5.10.85				
" " 2 (MKUNGUGU)	8.73	2.10.85	10.48	14.11.85		
" " 3 (LUGALO)	1.015	4.10.85	0.308	16.11.85	0.0277	
NYAMAHANA	167.7	11.10.85				
ILULA	17.5	3.10.85				
MAGUBIKE 1	24.73	7.10.85	29.84	15.11.85		
" 2 (KINYANG'AMA)	3.12	9.10.85	5.29	18.11.85		
ILULA ITUNDA	10.85	4.10.85				
IMAGE	31.70	8.10.85	34.00	15.11.85		
MTITU 1 (MTITU)	444.00	2.10.85				
" 2 (LUPALAMA)	36.00	11.10.85				
" 3 (KIPOLWI)	13.15	5.10.85				
IBUMU	4.81	3.10.85	4.75	14.11.85	0.0003	
MUFINDI						
MADUMA	0.762	26.09.85	2.41	12.11.85		
NYAKIPAMBO	6.21	21.09.85				
MTAMBULA	0.52	20.09.85				NEW VILLAGE
LWANG'WA	0.883	12.11.85				NEW VILLAGE
MBALAMAZIWA	8.50	04.09.85			0.0021	
NJOMBE						
BOIMANDA	8.37	18.09.85	13.25	25.10.85		
USALULE	980.0	09.09.85	327.0	23.10.85	0.0249	
NG'ANDA	150.0	25.09.85				NEW VILLAGE
IBUMILA	95.0	09.09.85				NEW VILLAGE
ITIPINDI	429.0	07.09.85				NEW VILLAGE
NJOOMLOLE	25.56	10.09.85	33.027	26.10.85		NEW VILLAGE
MAKETE						
LUPALILO 1	7.93	20.09.85	7.77	2.11.85	0.0005	
" 2	1.78	18.09.85	1.04	7.11.85	0.0107	
IKONDA 1	0.88	23.09.85	0.99	8.11.85		
" 2	7.62	23.09.85	7.39	8.11.85	0.0007	
INIHO 1 (KIVALE)	9.41	13.09.85	5.53	30.10.85	0.0113	NEW VILLAGE
" 2 (WANGAMIHO)	4.14	30.10.85				
" 3 (MWELA)	6.32	17.09.85	5.79	30.10.85	0.0020	
KIDOPE	23.0	12.09.85	10.96	31.10.85	0.0155	NEW VILLAGE
IKATA (BULONGWA)	25.87	11.09.85	20.36	30.10.85	0.0049	
LUDEWA						
MAWENGI	2.49	14.09.85				
ITUNDU (LIPUGU)	5.66	9.11.85				NEW SOURCE
LUFUMBU 1	0.433	14.09.85	0.19	5.11.85	0.0158	NEW VILLAGE
" 2	0.52	16.09.85	0.048	4.11.85	0.0486	
" 3	3.73	16.09.85	2.90	5.11.85	0.0050	
" 4	1.31	13.09.85	0.842	4.11.85	0.0085	

Table 3 - Recession constants (cont'd)

District/Village name	1st measurement l/s	Date	2nd measurement l/s	Date	Recession constant $days^{-1}$	Remarks
MBOZI						
VWAWA GR.	13.04	8.11.85				
IHANDA	0.03	19.09.85				
ILEJE						
ITALE	17.9	20.09.85				
IWIJI	0.46	14.10.85				NEW VILLAGE
MBEYA						
IKHOHO	132.0	13.10.85				
ISANGALA	5.29	29.09.85	4.04	15.10.85	0.0168	
CHUNYA						
MKWAJUNI/MWAMBANI	3.78	16.09.85				
MALEZA	1.52	13.09.85				
LUPTINGATINGA	0.22	23.10.85				NEW VILLAGE
RUNGWE						
NDAGA 1 (MWANZARA)	1.72	5.09.85	3.99	12.10.85		1st measurement doubtful. Dates inverted.
" 2 (HALOWE)	1.29	5.09.85	1.66	12.10.85		
LYENJE	2.73	3.09.85	5.29	11.10.85		
SONGEA						
LIBANGO	16.91	3.10.85	17.15	22.10.85		
NAMABENGO	3.73	18.09.85	3.44	15.10.85	0.0030	
MUHUKURU	11.20	6.09.85	6.60	5.10.85	0.0182	
MAGAGURA 1			0.08	12.10.85		
" 2			0.07	12.10.85		
NGAHOKORA	3.35	8.09.85	2.7	12.10.85	0.0063	
MATIMIRA	0.46	17.09.85	0.72	16.10.85		
NAKAHUGA	0.15	4.09.85	0.16	11.10.85		
MBINGAMHALULE	0.19	6.09.85	0.16	14.10.85	0.0045	
HANGA	5.04	16.09.85	4.69	14.10.85	0.0026	
MLILAYOYO	0.35	5.10.85	0.52	11.10.85		
MBIMBI 1 (NJIRU)	0.69	16.09.85	0.59	12.10.85	0.0060	
" 2 (NJIRU)			3.44	12.10.85		NEW SOURCE
KILANGALANGA	2.00	4.10.85	1.91	21.10.85	0.0027	
NGWINDE 1	0.29	5.10.85	0.31	18.10.85		
" 2 (NALIHO)			1.59	18.10.85		NEW SOURCE
MDWEMA	0.07	17.09.85	0.06	16.10.85	0.0053	
NAMATUHI	1.70	7.09.85	1.21	4.10.85	0.0126	
NJALAMATATA	4.36	5.10.85	4.00	19.10.85	0.0062	
NAMANGOLE	2.73	4.10.85	2.34	22.10.85	0.0086	
LILONDO 1 (MATEWELE "A")	0.45	13.09.85	0.43	8.10.85	0.0018	
" 2 (MATEWELE "B")	0.37	13.09.85	0.34	8.10.85	0.0034	
" 3 (MADWALA)	3.44	13.09.85	3.21	8.10.85	0.0028	NEW SOURCE

Table 3 - Recession constants (cont'd)

District/Village name	1st measurement l/s	Date	2nd measurement l/s	Date	Recession constant $days^{-1}$	Remarks
MBINGA						
MANGO	11.00	19.09.85	8.00	2.11.85	0.0072	
NDUMBI	0.19	21.09.85	0.17	4.11.85	0.0025	
LINDA	1.01	15.09.85	0.97	22.10.85	0.0011	
KIHANGI	0.17	15.09.85	0.16	23.10.85	0.0016	
SILO	0.04	15.09.85	0.03	23.10.85	0.0076	
WUKIRO	3.94	7.09.85	3.92	26.10.85	0.0001	
MAHENGE	0.52	7.09.85	0.20	21.10.85	0.0217	
MYANGAYANGA 1	2.01	13.09.85	1.98	26.10.85	0.0003	
" 2	1.72	13.09.85	1.66	26.10.85	0.0008	NEW SOURCE
SEPUKILA	0.12	10.09.85	0.09	25.10.85	0.0064	
MAPILIPILI LIWIHI	0.03	15.09.85	0.03	24.10.85		
LITEMBO 1	4.64	7.09.85	4.36	21.10.85	0.0014	
" 2	0.20	7.09.85	0.19	21.10.85	0.0012	NEW SOURCE
KWAMBE	19.00	17.09.85	17.00	31.10.85	0.0025	NEW VILLAGE
PUULU	43.00	19.09.85	41.00	1.11.85	0.0011	NEW SOURCE (MANGO II)
TUNDURU						
NANDEMBO 1 (KITANDA)	1.01	2.10.85	0.97	9.11.85	0.0011	
" 2 (NANDEMBO)			2.99	9.11.85		NEW SOURCE
MACHEMBA	(0.76)	23.09.85	1.85	1.11.85		
MISYAJE	1.48	28.09.85	1.26	4.11.85	0.0043	
MARUMBA	1.58	28.09.85	1.37	4.11.85	0.0039	

Table 4 - 10-year minimum flows

District/Village name	Q_1	Recession constant	Reference stream	Time lag	Q_{min} 1985	10-year minimum flow
	l/s	k		t	litre/sec	litre/sec
IRINGA						
ISMANI 1 (MGERA)	80.20	0.0031 L	1KA37 A	33	72.40	38.29
" 2 (MKUNGUGU)	8.73	0.0031 L	1KA37 A	36	7.81	4.13
" 3 (LUGALO)	0.308	0.0031 L	1KA37 A	*	0.31	0.16
NYAMAHANA	167.7	0.0007 L	1KA37 A	27	164.56	87.03
ILULA	17.5	0.0105 L	1KA37 A	35	12.12	6.41
MAGUBIKE 1	24.7	0.0019 L	1KA37 A	31	23.29	12.32
" 2 (KINYANG'AMA)	3.12	0.0019 E	1KA37 A	29	2.95	1.57
ILULA ITUNDA	10.85	0.0262 L	1KA37 A	34	4.45	2.35
IMAGE	31.70	0.01 E	1KA37 A	30	23.48	12.42
MTITU 1 (MTITU)	444.0	0.01 E	1KA22	33	319.20	204.94
" 2 (LUPALAMA)	36.0	0.01 E	1KA22	24	28.32	18.18
" 3 (KIPOLWI)	13.5	0.01 E	1KA22	30	10.0	6.42
IBUMU	4.81	0.0003	1KA37 A	*	4.7	2.49
MUFINDI						
MADUMA	0.76	0.01 E	1KA32 A	33	0.55	0.15
NYAKIPAMBO	6.21	0.0018 L	1KA32 A	38	5.80	1.63
MTAMBULA	0.52	0.01 E	1KA32 A	40	0.35	0.10
LWANG'WA	0.883	0.01 E	1KA32 A	*	0.883	0.25
MBALAMAZIWA	8.50	0.0021 L	1KA32 A	55	7.573	2.13
NJOMBE						
BOIMANDA	8.37	0.0042 L	1KA32 A	41	7.05	1.98
USALULE	327.0	0.025	1KA32 A	6	281.5	79.24
NG'ANDA	150.0	0.015 E	1KA32 A	34	90.07	25.35
IBUMILA	95.0	0.02 E	1KA32 A	50	34.95	9.84
ITIPINDI	429.0	0.03 E	1KA32 A	52	89.52	25.20
NJOOMLOLE	25.56	0.01 E	1KA32 A	49	15.66	4.41
MAKETE						
LUPALILO 1	7.77	0.0005	1RC5 A	*	7.77	5.93
" 2	1.04	0.0107	1RC5 A	*	1.04	0.79
IKONDA 1	0.88	0.0061 L	1RC5 A	27	0.75	0.57
" 2	7.62	0.0061 L	1RC5 A	27	6.46	4.93
INIHO 1 (KIVALE)	5.53	0.0113	1RC5 A	*	5.53	4.22
" 2 (WANGAMI HO)	4.14	0.01 E	1RC5 A	*	4.14	3.15
" 3 (MWELA)	5.79	0.0020	1RC5 A	*	5.79	4.42
KIDOPE	10.76	0.0155	1RC5 A	*	10.76	8.18
IKATA (BULONGWA)	20.36	0.0049	1RC5 A	*	20.36	15.47
LUDEWA						
MAWENGI	2.49	0.0037	1RB2	54	2.04	1.50
ITUNDU (LIPUGU)	5.66	0.01 E	1RB2	*	5.66	4.17
LUFUMBU 1	0.19	0.0158	1RB2	2	0.18	0.13
" 2	0.048	0.01 E	1RB2	3	0.04	0.03
" 3	2.90	0.0050	1RB2	2	2.87	2.11
" 4	0.842	0.0085	1RB2	3	0.82	0.60

Table 4 - 10-year minimum flows (cont'd)

District/Village name	Q_1	Recession constant	Reference stream	Time lag	Q_{min} 1985	10-year minimum flow
	l/s	k		t	litre/sec	litre/sec
MBOZI						
VWAWA GROUP						
IHANDA	0.03	0.0013 L	1KA7 A	31	0.029	0.012
ILEJE						
ITALE 1	17.9	0.01 E	1RC5 A	30	13.3	10.1
IWIJI	0.46	0.01 E	1RC5 A	6	0.433	0.33
MBEYA						
IKHOHO	132.0	0.01 E	1RC5 A	7	123.0	93.7
ISANGALA	4.04	0.0168	1KA7 A	5	3.71	1.55
CHUNYA						
MKWAJUNI/MWAMBANI	3.78	0.0053 L	1KA7 A	34	3.16	1.32
MALEZA	1.52	0.0038 L	1KA7 A	37	1.32	0.55
LUPTINGATINGA	0.22	0.03 E	1KA7 A	*	0.22	0.09
RUNGWE						
NDAGA 1 (MWANZARA)	3.99	0.014 L	1RC5 A	45	2.13	1.63
" 2 (HALOWE)	1.66	0.014 E	1RC5 A	45	0.88	0.67
LYENJE	2.73	0.0093 L	1RC5 A	47	1.76	1.34
SONGEA						
LIBANGO	17.15	0.0063 L	1RB2	16	15.51	11.42
NAMABENGO	3.44	0.0030	1RB2	23	3.21	2.37
MUHUKURU	6.60	0.0182	1RB2	33	3.62	2.67
MAGAGURA 1	0.08	0.01 E	1RB2	26	0.06	0.05
" 2	0.07	0.01 E	1RB2	26	0.05	0.04
NGAHOKORA	2.70	0.0063	1RB2	26	2.29	1.69
MATIMIRA	0.72	0.01 E	1RB2	22	0.58	0.43
NAKAHUGA	0.16	0.003 L	1RB2	27	0.15	0.11
MBINGAMHALULE	0.16	0.0045	1RB2	24	0.14	0.11
HANGA	4.69	0.0026	1RB2	24	4.41	3.25
MLILAYOYO	0.52	0.01 L	1RB2	27	0.40	0.29
MBIMBI 1 (NJIRU)	0.59	0.0060	1RB2	26	0.50	0.37
" 2 (NJIRU)	3.44	0.006 E	1RB2	26	2.94	2.17
KILANGALANGA	1.91	0.0027	1RB2	17	1.82	1.34
NGWINDE 1	0.31	0.01 E	1RB2	20	0.25	0.19
" 2 (NALIHO)	1.59	0.01 E	1RB2	20	1.30	0.96
MDWEMA	0.06	0.0053	1RB2	22	0.05	0.04
NAHATUHI	1.21	0.0126	1RB2	34	0.79	0.58
NJALAMATATA	4.00	0.0062	1RB2	19	3.56	2.62
NAMANGOLE	2.34	0.0086	1RB2	16	2.04	1.50
LILONDO 1 (MATEWELE "A")	0.43	0.0018	1RB2	30	0.41	0.30
" 2 (MATEWELE "B")	0.34	0.0034	1RB2	30	0.31	0.23
" 3 (MADWALA)	3.21	0.0028	1RB2	30	2.95	2.17

Table 4 - 10-year minimum flows (cont'd)

District/Village name	Q_1	Recession constant	Reference stream	Time lag	Q_{min} 1985	10-year minimum flow
	l/s	k		t	litre/sec	litre/sec
MBINGA						
MANGO	8.00	0.0072	1RB2	5	7.72	5.69
NDUMBI	0.17	0.0025	1RB2	3	0.17	0.12
LINDA	0.97	0.0011	1RB2	16	0.95	0.70
KIHANGI	0.16	0.0016	1RB2	15	0.16	0.12
SILO	0.03	0.0076	1RB2	15	0.03	0.02
WUKIRO	3.92	0.0001	1RB2	12	3.92	2.88
MAHENGE	0.20	0.0217	1RB2	17	0.14	0.10
MYANGAYANGA 1	1.98	0.0003	1RB2	12	1.97	1.45
" 2	1.66	0.0008	1RB2	12	1.64	1.21
SEPUKILA	0.09	0.0064	1RB2	13	0.08	0.06
MAPILIPILI LIWIHI	0.03	0.0318 L	1RB2	14	0.02	0.01
LITEMBO 1	4.36	0.0014	1RB2	17	4.26	3.14
" 2	0.19	0.0012	1RB2	17	0.19	0.14
KWAMBE	17.00	0.0025	1RB2	7	16.71	12.31
PUULU	41.00	0.0011	1RB2	6	40.73	30.01
TUNDURU						
NANDEMBO 1 (KITANDA)	0.97	0.0011	1RB2	*	0.97	0.71
" 2 (NANDEMBO)	2.99	0.0011 E	1RB2	*	2.99	2.20
MACHEMBA	1.85	0.0122 L	1RB2	6	1.72	1.27
MISYAJE	1.26	0.0043	1RB2	3	1.24	0.92
MARUMBA	1.37	0.0039	1RB2	3	1.35	1.00

E: Recession constants estimated from calculated recession constants in the same area.

L: 1984 recession constant.

*: The last reading at the source was taken later than the date for measured minimum flow at the nearest hydrological station. Therefore, the 1985 minimum flow of the source cannot be calculated by the normal procedure, and the last reading at the source has been estimated to be the 1985 min. flow for the source.

4. DEMAND VERSUS AVAILABILITY AND DESCRIPTION OF PROBLEMS AND DATA RELIABILITY

The village water demand has been calculated during the water master plan study for each water supply scheme, based on the projected population in the year 2006. It has been observed that in-depth analyses are being made on existing and future population, expected to be served from a planned scheme. Therefore, no source with a capacity near to the calculated water master plan demand should be either rejected or approved, until these analyses have been performed.

In Table 5 below is shown a list of water demand versus availability. As was the case in the 1984 low flow programme many sources continue to have insufficient capacity to meet the demand. A few additional sources for supplementing existing sources and alternative new ones, sighted before and during the programme, have very much improved the supply to the respective villages. Such procedure should be exercised in all villages with deficient water supply before other alternative methods of supply - e.g. shallow wells - are considered. A few more villages have been added to the list, since the 1984 list, and the sources of all these villages, except for two in Mbeya region, have sufficient water to meet the demand.

All sources in Ruvuma have been related to one hydrological station only at Ruhuhu river as it is the only one with an estimated 10-year minimum flow. The Ruvuma region was restricted area up to the mid-1970s, and therefore only 1-2 gaugings from the major rivers existed during the water master plan study, and no 10-year minimum flow was estimated. Today gaugings are available from a period of 7-8 years, and a 10-year minimum flow should be estimated to give a more reliable picture of the sources, especially in the eastern and southern parts of Songea district and Tunduru district.

Another problem is the accuracy of the rating curves for the hydrological stations. These curves were made 6-7 years ago, and very few river cross-sections remain constant over time, particularly if there is a big sediment transport. Also, the way the field work was

planned and implemented has caused problems. In general, the field work was started too late, and many of the second source gaugings could not be made as the rains had started. Even many of the readings that were taken were affected by rain, and many of the calculated recession constants may be too low, giving too optimistic low flow estimates.

Selection of gauging sites should be very carefully done so that well defined cross-sections and flows exist. In some cases, sources, likely to have capacity enough to meet the demand, have been rejected - as a wrong gauging method was used. Good examples are Nandembo single scheme and Machemba group in Tunduru district, where the proposed sources for both schemes are small lakes with an estimated area of 0.1 km^2 and with small streams flowing out of the lake. The water table in the lakes is estimated to be part of the groundwater table, and instead of measuring one of the small outflows, a more reliable way to investigate whether the capacity is sufficient is to test pump from the lake with the same amount of water as the demand - or more - until the water table stabilizes (if it stabilizes). A good example of a seepage source is the Namagole group in Songea district. The seepage area is a 50-100 m wide valley several hundred metres long. As the intake structure is likely to be an infiltration gallery the test pumping shall be made from a dug hole or a dug trench to find out how long the trench for the infiltration drain shall be, if the sources are sufficient.

A wrong gauging method is not only untimely for a certain water supply scheme where a good source can be rejected in favour of a doubtful one. But also when possibly the hydrological model will be calibrated to actual gaugings it may give a wrong picture of the reliability of the model. It is recommended that the regional hydrologist together with the implementation engineer visit all the sources for approval of all gauging sites before starting field work.

In Table 6 is given a list of all problematic villages, and as they are almost all commented on in Appendix 1, only the ones not included - and where there are some additional comments - will be mentioned below. For the other villages reference is made to Appendix 1.

Iringa Region, Mufindi District

Maduma

An additional or alternative source(s) is necessary in order to supply the required amount of water.

Mbeya Region, Mbozi District

Vwawa Group

The gravity source is sufficient for the group if Vwawa town is excluded. Vwawa town has a pumped scheme, at present out of order. An additional or alternative source has to be found if Vwawa town is to be served from the gravity scheme.

Mbeya Region, Ileje District

Iwiji

The source has insufficient water and additional sources should be found.

Mbeya Region, Chunya District

Luptingatinga

The source is much too small and it is recommended to find another.

Ruvuma Region

All the villages with problems shown in Table 6 have already been mentioned in the 1984 report, and the recommendations from then are still valid.

Table 5 - Water demand and availability (cont'd)

Village/Group	Pres./future population	Water demand m^3/d	Water availability 2-year min.	Water availability 10-year min.
IRINGA				
ISMANI GR. 1+2+3	36,800/66,300	1,764		3,679 A
NYAMAHANA GR.	4,132/13,830	336		7,517
ILULA GR.	16,211/40,245	1,002	740	554
MAGUBIKE GR. 1+2	5,325/10,465	259		1,064
ILULA ITUNDA	4,244/9,209	230	271	203
IMAGE GR.	8,708/21,989	547		1,073
MTITU GR. 1	64,782/99,860	2,480		17,707
IBUMU	1,725/3,470	86		218
MUFINDI				
MADUMA	2,912/5,824	145	25	13
NYAKIPAMBO	1,082/2,835	70		141
MTAMBULA				8 *
LWANG'WA				22**
MBALAMAZIWA	10,300/20,600	520	347	184 A
NJOMBE				
BOIMANDA (hydram)	541/1,278	31		171
USALULE GR.	89,501/195,602	5,209		6,846
NG'ANDA	527/ 916	22		2,017
IBUMILA	2,131/5,225	130		850
ITIPINGI	1,167/2,602	65		2,177
NJOOMLOLE (hydram)	843/1,180	29		381
MAKETE				
LUPALILO GR. 1+2	3,306/ 5,290	131		581 A
IKONDA 1+2	888/ 1,420	35		475 A
INIHO 1+2+3	931/ 1,071	26		1,019
KIDOPE GR.	10,311/15,232	376		707
IKATA (BULO. group)	8,704/12,339	304		1,337

Table 5 - Water demand and availability (cont'd)

Village/Group	Pres./future population	Water demand m^3/d	Water availability 2-year min.	Water availability 10-year min.
LUDEWA				
MAWENGI	2,371/5,572	139	159	130
ITUNDU	2,709/6,366	159		360
LUFUMBU 1+2+3+4	1,249/2,935	73		248
MBOZI				
VWAWA GR.	18,037/31,601	1,042		778***
IHANDA	2,959/6,421	160	1.2	1.0
ILEJE				
ITALE 1	3,187/6,690	167		873
IWIJI	1,927/2,628	65	33	29
MBEYA				
IKHOHO	1,262/1,767	44		8,096 N
ISANGALA	3,485/5,151	128		134 N
CHUNYA				
MKWAJUNI/MWAMBANI	5,032/15,126	377	252	114
MALEZA	2,199/6,597	164	105	48
LUFTINGATINGA	3,112/15,902	397	16	8
RUNGWE				
NDAGA 1+2	6,273/10,532	269	232	199 A
LYENJE	1,058/1,442	36		116

Table 5 - Water demand and availability (cont'd)

Village/Group	Pres./future population	Water demand m^3/d	Water availability 2-year min.	Water availability 10-year min.	
SONGEA					
LIBANGO GR.	12,863/22,730	566		987	
NAMABENGO GR.	5,368/13,130	327	251	205	
MUHUKURU GR.	6,192/14,860	370	283	231	N
MAGAGURA 1+2	2,531/6,190	154	9	8	
NGAHOKORA	1,629/3,990	99		146	N
MATIMIRA	2,591/6,560	163	45	37	
NAKAHUGA	1,527/3,740	93	12	10	
MBINGAMHALULE	2,180/5,700	142	11	10	
HANGA	2,426/6,140	153		281	
MLILAYOYO	1,032/2,520	62	31	25	
MBIMBI 2	1,379/3,200	79		187	N
KILANGALANGA	1,370/3,350	83		116	
NGWINDE 2	1,039/2,750	68		83	N
MDWEMBA	719/1,880	46	4	3	
NAMATUHI	1,331/3,260	81	62	50	
NJALAMATATA GR.	7,679/18,780	467	275	226	
NAMANGOLE GR.	3,649/9,120	227	159	130	
LILONDO 3	1,747/4,280	106		187	N
MBINGA					
MANGO GR.	5,474/8,300	206		492	
NDUMBI	2,518/3,700	92	13	10	
LINDA	2,044/5,212	130	74	60	
KIHANGI	1,607/4,100	102	12	10	
SILO	2,256/4,855	121	2	2	
WUKIRO	2,720/6,490	162		249	
MAHENGE	1,579/3,770	94	11	5	
MYANGAYANGA GR.1+2	6,595/15,960	397	282	230	A
SEPUKILA	1,569/3,190	79	6	5	
MAPILIPILI LIWIHI	2,455/6,260	156	2	1	
LITEMBO 1+2	2,784/6,640	165		283	A
KWAMBE	1,600/2,360	58		1,064	
PUULU GR.(MANGO II)	5,999/10,121	226		2,593	

Table 5 - Water demand and availability (cont'd)

Village/Group	Pres./future population	Water demand m^3/d	Water availability 2-year min.	Water availability 10-year min.
TUNDURU				
NANDEMBO 2	2,873/6,790	169		190 N
MACHEMBA GR.	3,938/6,970	172	134	110
MISYAJE	1,183/2,700	67		79
MARUMBA GR.	4,020/8,139	202	105	86

Note:

A : initial source + additional source(s)

N : new intake

* : the village will be served from shallow wells

** : the source was not meant for Lwang'wa but as a supplement to former Mtambula group

***: data from 1984, but with recession constant on 0.005 and only from gravity source

5. CONCLUSIONS AND RECOMMENDATIONS

Additional or completely new sources for the villages which were found to have problems in the 1984 study have improved their water supply considerably. However, still many of the sources have insufficient water. During the 1984 and 1985 low flow programme a total of 53 sources in Iringa, 41 in Mbeya and 51 in Ruvuma regions have been measured, and out of these 18, 9 and 20 sources in the three regions, respectively, are giving insufficient water to meet the year 2006 demand, if the 10-year estimated minimum flow is used.

Comparison of the results from 1984 and 1985 shows that out of twelve comparable recession constants six are considerably smaller in 1985 than they were the year before. A possible reason for the difference is that the last reading in 1985 may have been influenced by rain as described in Chapter 4. Only the recession constant for the Usalule source in Njombe district has increased. The 10-year minimum flow can be compared for 50 sources, and out of these, only 15 have changed considerably, and are almost all giving more water in 1985. The change for 80% of these sources is due to a very pessimistic estimate of the recession constant in 1984 of 0.03 for sources where it was not possible to calculate the recession constant. Only in three cases it has not been possible to explain the difference, but likely reasons could be reading errors or physical changes of flow conditions. The three villages are Ilula Itunda in Iringa district, Nyakipambo in Mufindi district and Kilangalanga in Songea district.

In Chapter 4 were mentioned some of the problems that the hydrologists have faced when estimating a 10-year minimum flow. It was also mentioned how difficult it is to make a reliable population projection. However, as the socio-economic team is taking care of the analysis of the population growth for villages planned to have water supply it will not be mentioned further in this report.

For the hydrological part of the water supply planning it is recommended to perform a study including the following items:

- Low flow gauging programme for at least the problematic villages shown in Table 6, but better for all previously measured sources.
- Estimate of 10-year minimum flows for major rivers in Ruvuma.
- Reconsideration of the accuracy of rating curves for reference gauging points.

Table 6 - Villages with too little water at 10-year minimum flows in the year 2006

IRINGA REGION:				
Iringa district	Mufindi district	Njombe district	Makete district	Ludewa district
Ilula group	Maduma	Moronga group	Matamba group	Madunda
Ikungwe	Mbalamaziwa group		Iwawa group	Madilu
Ilula Itunda	Igomaa		Ukwama	Lugarawa
			Masisiwe	Luilo group
			Mbalatse	
			Igolwa	
			Ukange	

MBEYA REGION:			
Mbozi district	Ileje district	Chunya district	Rungwe district
Vwawa group	Iwiji	Mtanila group	Ndaga group
Ihanda		Mkwajuni/Mwambani	
		Maleza	
		Namkukwe	
		Luptingatinga	

RUVUMA REGION:		
Songea district	Mbinga district	Tunduru district
Namabengo group	Ndumbi	(Machemba group)
Muhukuru group	Linda	Marumba group
Magagura	Kihangi Mahuka	
Matimira	Silo	
Lipokela	Mahenge	
Mbingamhalule	Myangayanga	
Mlilayoyo	Sepukila	
Mdwemba	Mapilipili Liwihi	
Namatuhi		
Njalamatata group		
(Namagole group)		
Nakahuga		

( ) estimated to have enough water as mentioned in Section 4

It is recommended not only to make a low flow programme including the villages shown in Table 6, but for all 145 villages investigated during 1984/85, and not only before construction of the water supply scheme but also after construction. This is to follow the low flow in the future and to have good statistics of the used streams. Then it can also be seen whether the used hydrological model is useful for the three regions, or whether it has to be modified for the benefit of future schemes. As mentioned earlier, all gauging sites ought to be approved by the regional hydrologist and the implementation engineer as it is very important to find the right sites.

The only river in Ruvuma region with an estimated 10-year minimum flow is Ruhuhu which is not even a real Ruvuma river as it is the boundary river between Iringa and Ruvuma regions. However, it can be used for the northern part of Mbinga and Songea districts. For the southern part of Mbinga district and the southwestern part of Songea district it is recommended to use Ruvuma river. For the eastern part of Songea district it is recommended to use Likonde river and for Tunduru district e.g. the Muhuwesi river. According to the regional hydrologist in Ruvuma, low flow measurements have been performed for the mentioned rivers during the past 7-8 years. An estimate of the 10-year minimum flow could therefore be made, and it is recommended to use the CCKK computer in Copenhagen for the calculation using a 3-parameter Weibull distribution. The 3-parameter Weibull distribution was used in the Water Master Plan study as it has proven to give good estimates for extreme low flow events.

CHAPTER 4 FROM 1984 LOW FLOW CAUGING REPORT INCLUDING A BRIEF DESCRIPTION OF EACH PROBLEMATIC VILLAGE WITH RECOMMENDATIONS FOR THE 1985 PROGRAMME.

4. VILLAGE WATER DEMAND VERSUS AVAILABILITY

The village water demand has been calculated during the Water Master Plan of Iringa, Mbeya and Ruvuma for each water supply scheme and has been based on the expected population in the year 2006, multiplied by the amount of water needed per capita per day. Some of the future populations seem to have been estimted rather too high, especially for the arid ares, and it may be advisable to look into this matter. The populations in question are marked by an asterix in Table 4.

Below is a list of water demands versus availability - from which it can be seen that 49% of the village water supply schemes measured will have sufficient water in the year 2006.

In 51% of the schemes the water available is less than what will be needed, and in these schemes it is very important to locate other sources with large enough minimum flows, either to supply all the water needed, or at least enough to supplement the proposed source. Should this not be possible, then an alternative solution, i.e. shallow wells, must be considered.

At some sites it has been difficult to measure the water available, either because of seepage over a large area, or because of water collects underground, resulting in little or no surface flow. Therefore, some of the measurements do not reflect the actual amount of water available. A brief description of each site at which there was a deficit is therefore needed.

Iringa Region, Iringa District

Ilula, Group:

Additional sources may be needed to supply the proposed amount of water. Reconnaissance will be needed.

Ikungwe, Single:

Several streams run through the village, and intakes could be constructed on one or more of these streams. Measurements on these streams will determine how many intakes are necessary.

Ilula Itunda, Single

The measurements were made 100 m upstream of the intake structure, but even so, it is necessary to provide additional water, which may be found in nearby streams.

Image, Group

Since only one measurement was valid here it is difficult to say if the the amount of water available is too small. Additional measurements are necessary here.

Mtitu, Group

There may be enough water available here, but since only one measurement is valid it is difficult to say. Additional measurements are needed to ascertain the quantities of water.

Iringa Region, Mufindi District

Mbalamaziwa, Group

Additional sources are necessary in order to supply the needed amount of water.

Nyakipambo, Group

This group scheme consists of Nyakipambo, Mtambula and Ihegele villages, which in the Water Master Plan were single schemes. It would be an idea either to go back to the original proposal, or to make an additional intake on Msolwa river if enough water is available here.

Igomaa, Single

A new source has to be found here as the proposed source runs dry. Several rivers run parallel to the proposed source, and intakes could be constructed on these when measurements have shown if there is enough water.

Iringa Region, Njombe District

Moronga, Group

It is possible that enough water is available here, but as there is only one valid measurement it is difficult to estimate an exact 10-year minimum.

Iringa Region, Makete District

Bulongwa, Group; Iwawa, Group; Ukwama, Single; Mbalatse, Single; Ukange, Single

At all these villages there may be enough water available, but because only one valid measurement is available it is difficult to be certain, and additional measurements are recommended.

Lupalilo, Group

Several sources run parallel to the proposed source so that intakes could be established on one or more of these, if additional measurements prove the necessity.

Ikonda, Single

Additional intakes should be possible on sources either parallel to the proposed village or southeast of the village.

Matamba, Group

Additional sources are available in the vicinity to augment the supply of the existing, but measurements should be made before selecting the source or sources.

Masisiwe, Single

Several additional sources are available in or near the village, but it may be a problem to get enough head as the village is situated on the watersheds.

Igolwa, Single

This village is also located on the watershed so, even though there are plenty of sources in the vicinity, there is a problem of enough head.

Iringa Region, Ludewa District

Mawengi, Single

Additional sources are needed to supply the necessary amount of water. A reconnaissance must be made to find a suitable supply.

Itundu, Group

Only the proposed sources were measured, therefore it is very likely that the three existing intakes can supply the remaining water, only measurements here can ascertain this.

Madunda, Single

An additional source should be found in order to supply adequate amounts of water.

Madilu, Single

This village is situated on the watershed, so even though plenty of sources are available, not enough head can be found.

Lugarawa, Single

Several additional sources are available here so that intakes on one or more of them could solve the problems of too little water.

Luilo, Group

The potential intake sites should be measured and if enough water is available they should be developed to supplement the proposed sites.

Mbeya Region, Mbeya District

Isangala, Group

The proposed source runs dry here, therefore another source should be found if possible, otherwise alternative supply must be sought.

Mbeya Region, Mbozi District

Ihanda, Single

If enough head is available the proposed intake may be moved downstream to the confluence of the tributary from the south, but measurements should be made beforehand to make sure this is a viable solution.

Mbeya Region, Chunya District

Mtanila, Group

The proposed year 2006 population seems unrealistic, it is doubtful that the soil can support such a population expansion. The source runs dry so that additional sources must be found or shallow wells proposed.

Mwambani/Mkwajuni, Single

Additional sources are needed if the future population has to be supplied. The population increase does seem unrealistic.

Maleza, Single

The population increase seems somewhat unrealistic in such a dry area, but possibly additional sources could be found.

Namkukwe, Single

Additional sources are necessary here as the proposed source runs dry, shallow wells may be a possibility.

Mbeya Region, Rungwe District

Lyenje, Single

This is a spring source and very difficult to measure accurately. Seepage around the source was noticed, therefore it is possible that enough water is available. Additional measurements downstream may give better results.

Ndaga, Group

Additional intakes will be necessary if the proposed supply shall be met, and several sources flowing parallel to the proposed source could supply the required water. Measurements of the amounts will determine the number of necessary additional intakes.

Ruvuma Region, Songea District

Namabengo, Group

The water available is sufficient at present, but cannot supply a future larger population. However, there are several streams to the west and south of the village which could supply the required water, and additional intakes could be constructed there.

Mpitimbi, Group

Mpitimbi already has a source that supplies part of the group. Only one intake was measured although there are two; therefore the yield should be higher. The measurements are very difficult to perform as the water is collected by infiltration wells. The supply here is considered sufficient.

Muhukuru, Group

It is necessary to locate an additional source here as the supply is inadequate.

Magagura, Single

The measurements seem to have been made on another source than the one proposed. The proposed source could later be developed to supplement the one MAJI has selected.

Ngahokora, Single

This source was measured close to its spring source. The intake could be moved downstream and then possibly supply the whole village.

Matimira, Single

The intake site here is very wet but difficult to measure. If the amount of water proves to be too small there will be several possibilities of additional sources nearby; however, they will probably be too low for gravity schemes.

Nakahuga, Single

Several additional sources exist to supplment the proposed source but measurements must take place in order to select the best suited.

Peramiho, Group

It was not possible to perform any measurements here as the water is collected by infiltration galleries, but there seems to be a sufficient supply.

Lipokela, Group

There is an existing bamboo scheme here, which could be supplemented by other sources.

Mbingamhalule, Single

The intake could be moved some distance downhill, but will probably have to be supplemented by other sources.

Lilondo, Single

There are probably no additional sources, therefore other alternatives must be considered if the proposed amount of water shall be supplied.

Mlilayoyo, Single

The measurements made here are not exact as the area is very swampy, and therefore the discharge is very difficult to measure. The amount of water available is considered sufficient.

Mbimbi, Single; Ngwinde, Single; Mdwema, Single; Namatuhi, Single

Additional sources have to be found and measured as the proposed source cannot meet the demand.

Njalamatata, Group

This is a Danida scheme built on MAJI recommendation. In order to supply the future demand an additional source will have to be found.

Namangole, Group

The area is very swampy and therefore very difficult to measure, but the available supply seems to be sufficient.

Kilangalanga, Single

The measurement here seems unrealistic, and the source ought to yield more. Additional measurements are recommended.

Mbinga District

In the mountainous regions of Mbinga District the population tends to be very scattered within the villages and to a large extent to inhabit the watershed areas. As such, it is very difficult to find sources that originate from higher elevations than the habitation. The area is supplied by water through thousands of small streams, all perennial and all with small yields near their spring source. In fact, most houses have their own little furrow that leads water past their house. It is therefore a diffcult task to better their supply through one intake, as parts of the village will always be situated too high for such a supply. A solution, however, would be to construct several small intakes and thereby supply the whole village. Villages with such problems are Linda, Kihangi Mahuka, Silo, Wukiro, Mahenge, Myangayanga, Sepukila and Mapipili Liwihi.

Ndumbi, Single

Plenty of additional sources exist so that adequate water supply should not be a problem. Measurements should be made before selecting an additional source.

Mpepai, Single

Measurements are very difficult here as water is collected in an infiltration well, but the amount is considered sufficient.

Tunduru District

Nandembo, Single; Machemba, Group

Measurements are difficult here as the intake is situated in a pond. The supply should be adequate.

Misyaje, Single; Marumba, Group

An additional source should be found, or an alternative supply considered for both these supplies.

Table 4 - Water demand and availability

Village/Group	Present/future population	Water demand m^3/day	Water availability m^3/day 2-year min.	Water availability m^3/day 10-year min.
Iringa District				
Ismani Group	28,014/42,432	1,051		2,998
Tungamalenga Group *	4,529/13,587	388		4,052
Nyamahana Group *	4,132/13,830	336		5,988
Ilula Group	16,211/40,245	1,002	665	432
Tanangozi Group	20,615/28,830	865		1,037
Magubike Group	5,325/10,465	259		1,236
Ikungwe, Single	1,443/ 1,905	47	14	9
Mfukulembe, Single	1,352/ 1,785	44		78
Idonda, Single	1,334/ 2,588	64		86
Ilula Itunda, Single	4,244/ 9,209	230	160	104
Image Group	8,708/21,989	547	413	268
Mafuluto, Single *	826/ 2,478	61		1.000
Mtitu Group	64,782/99,860	2,480	2,781	1.806
Ibumu	1,725/ 3,470	86		130
Mufindi District				
Maduma, Single	2,912/ 5,824	145		
Mbalamaziwa Group	7,419/14,910	368	451	293
Ihegele	1,295/ 2,590			
Nyakipambo Group	1,082/ 2,835	259	18	12
Mtambula	2,506/ 5,012			
Igomaa, Single	1,291/ 3,382	84		0
Kiliminzowo, Single	1,144/ 3,016	75		2,868
Wambi Group	13,626/28,245	949		1,391
Njombe District				
Ujindile, Single	1,834/ 2,764	69		78
Boimanda, Single	541/ 1,278	31		259
Usalule Group	89,501/195,602	5,209		5,953
Moronga Group	14,962/24,113	598	146	95
Makete District				
Bulongwa Group	17,498/25,481	629	413	268

Table 4 (cont'd)

Village/Group	Present/future population	Water demand m^3/day	Water availability m^3/day 2-year min.	Water availability m^3/day 10-year min.
Makete District				
Lupalilo Group	3.306/ 5.290	131	80	52
Ikonda, Single	888/ 1.420	35	14	9
Matamba Group	7.001/10.100	250	172	112
Iwawa Group	5.779/ 9.245	273	278	181
Kisinga, Single	855/ 1.368	34		311
Ihanga, Single	1.290/ 1.457	36		78
Ukwama, Single	1.327/ 2.672	66	80	52
Masisiwe, Single	900/ 1.359	33	14	9
Mbalatse, Single	1.744/ 1.970	49	26	17
Igolwa, Single	1,570/ 1.805	45	14	9
Ukange, Single	1,316/ 1.842	46	66	43
Ludewa District				
Mawengi, Single	2.371/ 5.572	139	92	60
Itundu Group	3.958/ 9.301	232	54	35
Madunda, Single	1.485/ 3.490	87	54	35
Madilu, Single	2.504/ 5.884	147	26	17
Lugarawa, Single	5.705/13.407	355	26	17
Luilo Group	11.198/27.654	689	97	63
Mbozi District				
Mbosi West Group *	28.056/97.669	2.432		6.912
Myovisi Group	10.682/23.362	580		1.719
Vwawa Group *	18.037/31.601	1.042		1.581
Katete, Single *	2.110/ 8.060	201		328
Ihanda, Single	2.959/ 6.421	160	40	26
Isandula, Single	2.441/ 5.757	143		864
Senjele, Single	2.867/ 6.221	155		4.156
Hezya, Single	2.436/ 5.286	132		12.122
Ileje District				
Isoko Group	5.140/ 9.012	224	347	225
Itale, Single	3.187/ 6.690	167		3.050

Table 4 (cont'd)

Village/Group	Present/future population	Water demand m^3/day	Water availability m^3/day 2-year min.	Water availability m^3/day 10-year min.
Ileje District				
Sheyo, Single	1.632/ 3.084	77		95
Mbeya District				
Ilongo Group *	14.027/46.244	1.152		1.607
Mbuyuni Group *	11.009/36.485	907		9.504
Utengule Group *	7.703/30.658	766		4.406
Ikhoho, Single	1.262/ 1.767	44		354
Ihombe Group	4.555/ 6.211	144		1.028
Uyole Group	9.618/13.271	332		492
Iwindi Group	13.191/18.256	422		3.421
Isuto Group	8.342/11.250	279		829
Itimba, Single	1.605/ 2.188	54		5.944
Rujewa Group *	20.981/86.470	2.779		201.053
Ijumbi Group *	4.843/19.730	522		536
Isangala Group	3.485/ 5.151	128		0
Chunya District				
Mtanila Group *	7.007/34.964	874		0
Ngwala, Single	1.039/ 2.881	72		406
Mkwajuni, Single *				
Mwambani, Single *	5.032/ 15.126	377	226	147
Maleza, Single *	2.199/ 6.597	164	80	52
Namkukwe, Single	3.680/11.040	275		0
Ifyenkenya Group	4.342/10.464	260		8.640
Rungwe District				
Nsigara Group	2.900/ 3.354	83		717
Kasiabone, Single	1.232/ 1.626	24		9.366
Ndaga Group	6.273/10.532	269	245	159
Kanyelele Group	4.730/ 5.020	125		164
Ngopyolo Group	6.797/ 8.973	224		1.063
Lyenje, Single	1.058/ 1.442	36	5	3
Nditu, Single	2.400/ 3.168	79		138

Table 4 (cont'd)

Village/Group	Present/future population	Water demand m^3/day	Water availability m^3/day 2-year min.	Water availability m^3/day 10-year min.
Kyela District				
Ngana Group	25.127/34.740	861		1.123
Ngamanga Group	12.747/19.336	479		3.024
Sinyanga Group	7.325/10.314	255		346
Songea District				
Libango Group	12.863/22.730	566		1.633
Namabengo Group	5.368/13.130	327	386	251
Mpitimbi Group	4.167/10.430	260	26	17
Muhukuru Group	6.192/14.860	370	40	26
Magagura, Single	2.531/ 6.190	154	14	9
Ngahokora, Single	1.629/ 3.990	99	14	9
Matimira, Single	2.591/ 6.560	163	66	43
Peramiho Group	4.555/ 6.882	149		
Lipokela Group *	2.402/ 7.162	117	26	17
Mbingamhalule, Single	2.180/ 5.700	142	14	9
Limamu, Single	2.035/ 5.330	133		268
Lilondo, Single	1.747/ 4.280	106	54	35
Hanga, Single	2.426/ 6.140	153		268
Mlilayoyo, Single	1.032/ 2.520	62	40	26
Mbimbi, Single	1.379/ 3.200	79	26	17
Ngwinde, Single	1.039/ 2.750	68	26	17
Mdwemba, Single	719/ 1.880	46	14	9
Namatuhi, Single	1.331/ 3.260	81	66	43
Njalamatata Group	7.679/18.780	467	132	86
Namangole Group	3.649/ 9.120	227	146	95
Kilangalanga, Single	1.370/ 3.350	83	26	17
Nakahuga, Single	1.527/ 3.740	93	14	9
Mbinga District				
Lundo Group	2.721/ 3.775	93		562
Mango Group	5.474/ 8.300	206		259
Ngindo, Single *	573/ 1.925	48		34.560
Litembo, Single	2.784/ 6.640	165		510

Table 4 (cont'd)

Village/Group	Present/future population	Water demand m^3/day	Water availability m^3/day 2-year min.	Water availability m^3/day 10-year min.
Mbinga District				
Ndumbi, Single	2.518/ 3.700	92	14	9
Kindimba chini/juu, Single	1.721/ 3.320	82		181
Linda, Single	2.044/ 5.212	130	80	52
Kihangi Mahuka, Single	1.607/ 4.100	102	14	9
Silo, Single	2.256/ 4.855	121	42	27
Wukiro, Single	2.720/ 6.490	162	172	112
Mahenge, Single	1.579/ 3.770	94	14	9
Myangayanga Group	6.595/15.960	397	54	35
Miyao Group	4.364/11.570	288		570
Sepukila, Single	1.569/ 3.190	79	14	9
Malindindo, Single	2.053/ 5.235	130		302
Mikalanga, Single	2.294/ 5.850	146		216
Mpepai, Single	3.000/ 7.150	178		
Mbamba Bay Group	5.742/ 8.620	214		22.896
Mapipili Liwihi, Single	2.455/ 6.260	156	11	9
Nangombo, Single	1.770/ 2,650	66		24.192
Tunduru District				
Matemanga Group	4.625/ 8.100	200		492
Nandembo, Single	2.873/ 6.790	169	26	17
Machemba Group	3.938/ 6.970	172	200	130
Naluwale Group	1.415/ 2.560	63		173
Amani Group	3.781/ 9.380	232		1.045
Kindamba, Single	560/ 1.000	24		173
Misyaje, Single	1.183/ 2.700	67	67	43
Njenga, Single	1.625/ 3.900	97		1.382
Marumba Group	4.020/ 8.139	202	40	26