7.13　代替村落リスト

Series No.	Data Sheet No.	Alternative site for	Administration					Population	Pump Type
			District	Division	Location	Sub Location	Village Name		
1	Macha-1	Mukukuni wp (No.167)	Machakos	Kathiani	Mitaboni	Kinyau	Syulunguni	2,250	Motor/Wind Pump
2	Macha-2	Makulumi (No.185)	Machakos	Yathui	Yathui	Kwakola	Kwakavili	1,250	Motor/Wind Pump
3	Macha-3	Kilembwa (No.187)	Machakos	Yathui	Wamunyu	Kyawango	Mwasua	2,250	Motor/Wind Pump
4	Macha-4	Iyuni (No.199)	Machakos	Kalama	Kola	Iyuni	Manzaa	1,800	Motor/Wind Pump
5	Macha-5	Kyawalia Dispensary (No.198)	Machakos	Kalama	Muumandu	Kyawalia	Kyawalia	300	Hand Pump
6	Macha-6	Kakongo Village (No.159)	Machakos	Masinga	Ekalakala	Nzukini	Nzukini	1,750	Motor/Wind Pump
7	Macha-7	Ekalakala (No.150)	Machakos	Masinga	Ekalakala	Nzukini	Wendano	1,800	Motor/Wind Pump
8	Macha-8	Utihini Primary School (No.164)	Machakos	Katangi	Kyua	Kyua	Itithini	800	Hand Pump
9	Macha-9	Kyamutheke (No.200)	Machakos	Kalama	Kathekakai	Kitanga	Kyamutheke	2,400	Motor/Wind Pump
10	Macha-10	Kivandini (No.153)	Machakos	Yatta	Matuu	Katulani	Kivandini	2,400	Motor/Wind Pump
11	Macha-11	Ndalani (No.165)	Machakos	Yatta	Ndalani	Ndalani	Ndalani Centre	2,500	Motor/Wind Pump
12	Macha-12	Ikombe (No.160)	Machakos	Yatta	Ikombe	Ikombe	Ikombe	1,500	Motor/Wind Pump
13	Macha-13	Utihini Primary School (No.164)	Machakos	Mwala	Mwala	Kivandini	Kivandini	4,000	Motor/Wind Pump
14	Macha-14	Masii Girls School (No.176)	Machakos	Mwala	Masii	Mbaani	Kawaa	2,400	Motor/Wind Pump
15	Macha-15	Lema Girls Secondary School (No 186)	Machakos	Mwala	Wamunyu	Mbaikini	Mbaikini	900	Hand Pump
16	Macha-16	Kyawango SHG (No.178)	Machakos	Mwala	Kyawango	Kangii	Kangii	2,000	Motor/Wind Pump
17	Kitui-1	Kwa Mutonga (No.43)	Kitui	Matinyani	Kwa Mutonga	Mutonga	Kithuyiani	500	Hand Pump
18	Kitui-2	Kalindilo (No.40)	Kitui	Matinyani	Kathiva	Kalindilo	Kalindilo	490	Hand Pump
19	Kitui-3	Ikutha (No.47)	Kitui	Ikutha	Ikutha	Ndili	Ndili/Ilaani	1,505	Motor/Wind Pump
20	Kitui-4	Kamutei (No.49)	Kitui	Ikutha	Ikutha	Ikutha	Kithiki	700	Hand Pump

Series No.	Data Sheet No.	Alternative site for	Administration					Population	Pump Type
			District	Division	Location	Sub Location	Village Name		
21	Kitui-5	Kyatune (No.51)	Kitui	Mutomo	Ikanga	Kyatune	Kwa Toma	1,600	Motor/Wind Pump
22	Kitui-6						Kamulambani /Kithumulani	500	
23	Kitui-7	Misewani (No.2)	Kitui	Chuluni	Nzambani	Maluma	Katothya	840	Hand Pump
24	Kitui-8	Mosa (No.6)	Kitui	Chuluni	Mosa	Mosa	Clinics of Care	1,200	Motor/Wind Pump
25	Kitui-9	Katwala (No.7)	Kitui	Chuluni	Nzambani	Misewani	Kilonzo Village	2,800	Motor/Wind Pump
26	Kitui-10	Kazauwu (No.8)	Kitui	Central	Kyangwithya	Mbusyani	Isovya	700	Hand Pump
27	Kitui-11	Kisasi (No.9)	Kitui	Central	Mulango	Kyangunga	Kyangunga	2,800	Motor/Wind Pump
28	Kitui-12	Katika (No.38)	Kitui	Central	Misewani	Misewani	Kwa Ukungu	3,200	Motor/Wind Pump
29	Kitui-13	Kateiko (No.35)	Kitui	Yatta	Kwa Vonza	Mithikwani	Nyumbani Childrens Home	800	Hand Pump
30	Kitui-14	Ikulumbutani (No.34)	Kitui	Yatta	Yatta	Makusya	Ndamukini	1,200	Motor/Wind Pump
31	Kitui-15	Kaseu Secondary (No.18)	Kitui	Mtonguni	Ndulos Corner	Kyamutimba	Kyamutimba	2,000	Motor/Wind Pump
32	Maku-1	Uiini (No.125)	Makueni	Kalama	Kathulumbi	Kathulumbi	Kitoto	3,500	Motor/Wind Pump
33	Maku-2	Kilili Sec School (No.111)	Makueni	Matiliku	Nzaui	Matiliku	Kukui	3,000	Motor/Wind Pump
34	Maku-3	Sakai (No.109)	Makueni	Kisau	Kiteta	Kakuswi	Ndithini	1,600	Motor/Wind Pump
35	Maku-4	Kazokeani (No.103)	Makueni	Kathonzweni	Kanthuni	Kanthuni	Yeembondo	1,800	Motor/Wind Pump
36	Maku-5	Kasikeu Market (No.129)	Makueni	Kasikeu	Kasikeu	Uualeni	Masaani	1,500	Motor/Wind Pump
37	Maku-6	Kiou Village (No.131)	Makueni	Kasikeu	Kiou	Kiou	Ikutani	1,500	Motor/Wind Pump
38	Maku-7	Nguuni (No.134)	Makueni	Kasikeu	Kiou	Kiou	Mvani	600	Hand Pump
39	Maku-8	Kwekolya (No.127)	Makueni	Kilome	Kiimakiu	Ngaamba	Ngondini/Lambati	1,500	Motor/Wind Pump
40	Maku-9	Enzae (No.128)	Makueni	Kilome	Kiimakiu	Ngaamba	Kwa Ilela	2,000	Motor/Wind Pump

Series No.	Data Sheet No.	Alternative site for	Administration					Population	Pump Type
			District	Division	Location	Sub Location	Village Name		
41	Maku-10	Kithundi (No.98)	Makueni	Wote	Wote	Kamui-Mawe	Kambi-Mawe	4,800	Motor/Wind Pump
42	Maku-11	Utui Wa Wote (No.99)	Makueni	Wote	Wote	Mumbuni	Kathiani	3,500	Motor/Wind Pump
43	Maku-12	Nthangu Pri School (No.101)	Makueni	Wote	Wote	Unoa	Nthangu Village	1,800	Motor/Wind Pump
44	Maku-13	Yindundu (No.141)	Makueni	Mtito Andei	Nzambani	Muthingiini	Manguluku	1,800	Motor/Wind Pump
45	Maku-14	Nthunguni SHG (No.144)	Makueni	Mtito Andei	Nzambani	Muthingiini	Kwa Matundu	2,400	Motor/Wind Pump
46	Maku-15	Kitengei (No.146)	Makueni	Mtito Andei	Kambu	Kitengei	Kilumilo	1,400	Motor/Wind Pump
47	Maku-16	Kikumini (No.138)	Makueni	Nguu	Mweini	Kalii	Yikivumbu	2,500	Motor/Wind Pump
48	Mwin-1	Migwani Market (No.63)	Mwingi	Migwani	Ngutani	Kavoloi	Kavoloi	640	Hand Pump
49	Mwin-2	Ndaluni (No.66)	Mwingi	Migwani	Kyome	Kyome	Ndaluni Secondary	720	Hand Pump
50	Mwin-3	Nzauni (No.62)	Mwingi	Migwani	Migwani	Kitulani	Kitulani	700	Hand Pump
51	Mwin-4	Itumbi (No.59)	Mwingi	Migwani	Nguulani	Kanyaa	Kwambuta	700	Hand Pump
52	Mwin-5	Makengekani (No.58)	Mwingi	Migwani	Nzauni	Kea	Kea	640	Hand Pump
53	Mwin-6	Kavaini (No.61)	Mwingi	Migwani	Thitani	Thitani	Thitani Secondary	1,400	Motor/Wind Pump
54	Mwin-7	Kyanika (No.95)	Mwingi	Kyuso	Mivukoni	Kamula	Kyanika	3,528	Motor/Wind Pump
55	Mwin-8	Twimiwa (No.92)	Mwingi	Kyuso	Mivukoni	Twimilyua	Kwa Kavuri	700	Hand Pump
56	Mwin-9	Muruu (No.88)	Mwingi	Kyuso	Kyuso	Gai	Central Village	660	Hand Pump
57	Mwin-10	Ngungi (No.70)	Mwingi	Mui	Mui	Ngungi	Ngungi Pri. School	2,400	Motor/Wind Pump
58	Mwin-11	Kalitini (No.73)	Mwingi	Mui	-	Itiko	Kalitini Secondary School	3,500	Motor/Wind Pump
59	Mwin-12	Engamba (No.79)	Mwingi	Nuu	Wingemi	Kalawa	Matia	225	Hand Pump
60	Mwin-13	Gankanga (No.84)	Mwingi	Mumoni	Tharaka	Kacigongo	Miramba Ikamba	475	Hand Pump
61	Mwin-14	Ndatha (No.83)	Mwingi	Mumoni	Katse	Konyu	Muvinga	3,220	Motor/Wind Pump
62	Mwin-15	Kanthungu (No.87)	Mwingi	Mumoni	Kawthuwgu	Kawthuongu	Kamwerini	582	Hand Pump

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4. WATER DEMAND

CONTENTS

APPENDIX A

Long term guidelines for the location of infrastructural facilities.

Schedule of principle towns and service centres.

Land potential.

Population growth rates in the districts between 1969-1979.

4.2.2 Service Type

The distribution between individual connection users (IC) and non-individual connection users (NC) i.e. consumers using kiosks or communal water points or share connections for the purpose of the demand projection for new supplies should be assumed to be as shown in the table below.

However, local factors may warrant deviation from the figures in the table which only shall be contrued as indicative. When the designed supply is an extension or completion of an existing supply should the distribution of IC and NC be estimated after the monitoring of the existing situation.

Table 4.1 - Service Type

	IC %			NC %		
	Initial	Future	Ultimate	Initial	Future	Ultimate
Urban Areas						
High and Medium Class Housing	100	100	100	0	0	0
Low Class Housing	10	30	50	90	70	50
Rural Areas						
High potential	20	40	80	80	60	20
Medium potential	10	20	40	90	80	60
Low potential	5	10	20	95	90	80

4.3 LIVESTOCK DEMAND

4.3.1 Population Projections

- The present livestock population should be estimated based on the livestock census usually available from the District Livestock Officer.

- The forecast of the livestock growth should be based on:

  * The historical data from livestock census.

  * Regional physical development plans.

  * District Development Plans.

  * National Master Water Plan.

  * The livestock carrying capacity (see chapter "Definitions and Code Systems").

  * The market study if carried out.

- In livestock projections, grade cattle, local cattle, small stock and other livestock should be estimated separately, poultry need not normally to be considered.

- For the purpose of estimating the water demand for livestock the following conversion factors apply:

1 Grade Cow	-	1 Livestock Unit (LU)
3 Indigenous Cow	-	" "
15 Sheep or Goats	-	" "

4.3.2 Service Level

- It should be assumed that consumers with individual connections water their cattle from the piped water supply except where reliable alternative sources of water are available on the farms.

- Consumers without individual connections will be expected to retain the traditional sources for the watering of cattle except where these sources are seasonal or unreliable.

- The livestock watering situation shall be examined for all rural supplies and detailed proposals for any measures to be taken in this respect shall be included as an integral part of the water supply design. Such special measures may comprise special water holes, dams or water pans for the cattle.

4.4 INSTITUTIONAL DEMAND

4.4.1 Schools

- The development in educational facilities should be based on the existing situation, the plans of Ministry of Education and the projected growth of the population, For rough calculations it may be assumed that 30% of the population attend primary and/ or secondary school.

- Day schools and boarding schools should be studied separately. Also the sanitary standard with regard to WC should be estimated.

4.4.2 Health facilities

The development in health facilities should be based on the existing situation, the plans of Ministry of Health and the anticipated growth of the population. In the long term about 35-40,000 people are planned to be served by one health centre and two to four dispensaries. The number of hospital beds can be assumed to 0.8 beds per 1000 people. Regional and District hospitals should be studied separately.

4.5 COMMERCIAL AND INDUSTRIAL DEMAND

4.5.1 Small shops, workshops, restaurants, bars, etc.

The development of small scale enterprises should be based on the existing situation. It should be anticipated that the future increase in commercial activity will be directly related to the growth of population.

4.5.2 Large enterprises, tourist hotels, military camps, etc.

The development of large establishments should be examined in detail by interviewing relevant bodies. Urban areas marked as industrial areas in the town plan but for which the exact nature of the industry is not known, may be allocated an amount of water per area unit as shown in section "Water consumption rates". However, a realistic time plan over the exploitation of such areas must be proposed.

4.6 OTHER DEMANDS

4.6.1 Irrigation

The water demand projections should not include any provision for irrigation besides for very limited garden watering which is included in the per capita consumption rates.

4.6.2 Fire Fighting

- In urban areas where fire authorities exist should the demands be examined in collaboration with these.

- For urban and rural centres it is recommended that the capacity for fire-fighting should not be less than 10 l/s during 2 hours. Further see chapter "Transmission and distribution lines".

- No provision will normally be necessary in Market and Local centres or in Rural areas.

4.6.3 Internal demand in the water works

- It should be assumed that 5% of the water production is used for backwashing of rapid sand filters where these are part of the treatment.

- Other internal uses than for rapid filtration may be neglected for the purpose of estimating the total water demand.

4.7 WATER CONSUMPTION RATES

4.7.1 General

- The water consumption figures include about 20 % allowance for water losses through leakage and wastage.

- The figures are the consumption rates for which the supply system shall be designed.No additional peak-factors shall be applied to calculate the design demand.

- The rates are proposed as a guide and may be adjusted if different rates are shown to be more appropriate in a particular case. The rates represent the consumption of the average consumer category. Within a consumer category there may be considerable variations.

4.7.2 Rates

Table 4.2

CONSUMER	UNIT	RURAL AREAS			URBAN AREAS		
		High Potential	Medium Potential	Low Potential	High Class Housing	Medium Class Housing	Low Class Housing
People with individual connections	l/head/day	60	50	40	250	150	75
People without connections	l/head/day	20	15	10	–	–	20
Livestock unit	l/head/day	50			–		
Boarding Schools	l/head/day	50					
Day schools with WC without WC	l/head/day	25 5					
Hospitals Regional District other	l/bed/day	400) 200) 100) +20 l per outpatient and day (minimum 5000 l/day)					
Dispensary and Health Centre	l/day	5000					
Hotels High class Medium class low class	l/bed/day	600 300 50					
Administrative offices	l/head/day	25					
Bars	l/day	500					
Shops	l/day	100					
Unspecified industry	l/ha/day	–			20,000		
Coffee pulping factories	l/kg coffee	25 (when recirculation of water is used).					

4.8 CONSUMPTION PATTERN

4.8.1 Rural Areas Inclusive Rural, Market and Local Centres

- It should be assumed that all water is drawn between 7 a.m. and 7 p.m. The same pattern applies for NC (CWP, Kiosk), IC and for livestock consumption.

- When the number of water users exceeds 1000 should it be assumed that the draw-off is constant through the 12 hour consumption period.

- For fewer than 1000 water users should a peak factor as shown in Figure No. 4.1 be applied to determine the design flow.

- Large institutions, industry etc.. may have their own balancing reservoirs which may reduce the peak demand. Such balancing reservoirs should be encouraged and considered when determining the design flow.

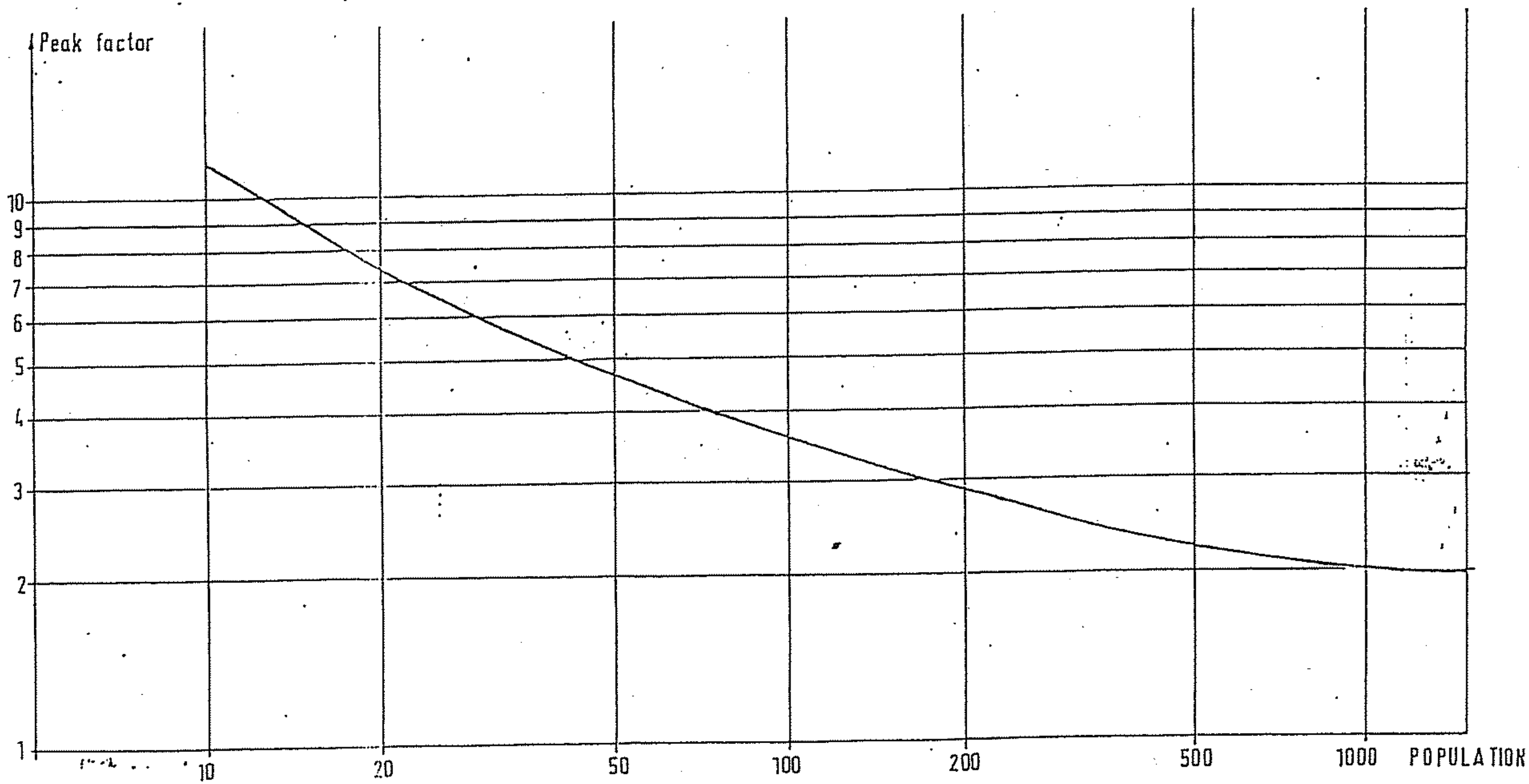
4.8.2 Principal Towns and Urban Centres

- The assumed consumption pattern should be based on the analysis of records from the existing supply. If such records are not available consumption patterns from equivalent towns may be used. It should be assumed that most houses have individual roof tanks which will reduce the peak factors considerably.

- Institutional, commercial and industrial water consumption pattern should be analysed separately.

FIGURE NO. 4.1

PEAK FACTORS FOR INDIVIDUAL CONNECTIONS CWP's AND KIOSKS IN RURAL AREAS



5. WATER QUALITY

CONTENTS

5. WATER QUALITY

5.1 GENERAL

5.1.1 Basic Requirements

The basic requirements for drinking water are that it should be:

- Free from pathogenic (disease causing) organisms.
- Containing no compounds that have an adverse acute or long term effect on human health.
- Fairly clear (i.e. low turbidity little colour).
- Not saline (salty)
- Containing no compounds that cause an offensive taste or smell.
- Not causing corrosion or encrustration of the water supply system not staining clothes washed in it.

5.2 BACTERIOROLOGICAL QUALITY

5.2.1 General

- The bacteriological quality is very essential and should be tested before the selection of the source and during the operation of a supply. In this regard microbiological quality should not be confused with aestetically pleasing water.
- A good bacteriological quality is best obtained by selecting a source without contamination (see chapter "Water sources"), by protecting the intake (see chapter "Intake structures" and by adequate treatment (see chapter "Water Treatment").

5.2.2 Guideline values for distributed water

- The values are virtually the same as those which will be published in the new WHO guidelines shortly.
- Large supplies can in this contextbe defined as those supplying over 50,000 people.
- Remedial action has to be taken if deficiencies of the quality is detected. Such actions may be temporary such as issuing recommendations to boil the water or/and long term such as localizing and eliminating the source of contamination and improving the treatment.

Parameter	Unit	Guideline Value	Remarks
A. Piped Water Supplies			
A.1 Treated water entering the distribution system			
Faecal Coliforms	number/ 100 ml	Zero	Turbidity 1 NTU; for disinfection with chlorine, PH preferably < 8.0, free chlorine residual 0.2-0.5 mg/1 following 30 minutes (minimum) contact.
Coliform Organisms	number/ 100 ml	Zero	
A.2 Untreated water entering the distribution system			
Faecal coliforms	number/ 100 ml	Zero	
Coliform Organisms	number/ 100 ml	Zero	In 98% of samples examined throughout the year for large supplies with sufficient samples examined.
Coliform Organisms	number/ 100 ml	3	In occasional sample but not in consecutive samples.
A.3 Water in the distribution system			
Faecal coliforms	number/ 100 ml	Zero	
Coliform Organisms	number/ 100 ml	Zero	In 95% of samples examined throughout the year for large supplies with sufficient samples examined.
Coliform Organisms	number/ 100 ml	3	In occasional samples but not in consecutive samples.
B. Unpiped water supplies			
Faecal coliforms	number/ 100 ml	Zero	
Coliform organisms	number/ 100 ml	10	Not occuring repeatedly. Repeated occurrence and failure to improve sanitary protection, alternate source to be found

5.2.3 Guideline values for raw water

The following tables gives indication as to the treatment required for raw water

coliform organisms 1).
number/100 ml

0-50	Bacterial quality requiring disinfection only.
50-5000	Bacterial quality requiring full treatment (coagulation, sedimentation, filtration and disinfection).
5000-50000	Heavy pollution requiring extensive treatment.
greater than 50000	Very heavy pollution unacceptable as source unless no alternative exists. Special treatment needed.

1) When more than 40% of the number of coliforms are found to be of the Feacal coliform group, the water source should be considered to fall into the next higher category with respect to the treatment required.

5.3 CHEMICAL QUALITY

5.3.1 Constituents of health significance

The following constituents have some health significance and the guideline values given should generally not be exceeded in drinking water (WHO Guidelines).

Inorganic constituents of health significance

Parameter	Unit	Guideline Value	Remarks
Arsenic	mg/l	0.05	
Asbestos	-	No guideline value set	
Barium	-	No guideline value set	
Beryllium	-	No guideline value set	
Cadmium	mg/l	0.005	
Chromium	mg/l	0.05	

Inorganic constituents of health significance, contd.

Parameter	Unit	Guideline Value	Remarks
Cyanide	mg/l	0.1	
Fluoride	mg/l	1.5	Natural or deliberately added. Local or climatic conditions may necessitate adaption.1)
Hardness	-	No health-related guideline value set	
Lead	mg/l	0.05	
Mercury	mg/l	0.001	
Nickel	-	No guide-line value set	
Nitrate	mg/l (N)	10	
Nitrite	-	No guide-line value set	
Selenium	mg/l	0.01	
Silver	-	No guide-line value set	
Sodium	-	No guide-line value set	

1) In exceptional cases a Fluoride content of 3 mg/l may be accepted in Kenya.

Organic constituents of health significance

Parameter	Unit	Guideline Value	Remarks
Aldrin & Dieldrin	μg/l	0.03	
Benzene	μg/l	10	
Benzo-a-pyrene	μg/l	0.01	
Carbon tetrachloride	μg/l	3	Tentative guideline value
Chlordane	μg/l	0.3	
Chlorobenzenes	μg/l	No health related guideline value set	Odour threshold concentration between 0.1 and 3 μg/l
Chlorophenols	μg/l	No health related guideline value set	Odour threshold concentration 0.1 μg/l
Chloroform	μg/l	30	Disinfection efficiency must not be compromised when controlling this parameter
2,4,D	μg/l	100	
DDT	μg/l	1	
1,2 Dichloroethane	μg/l	10	
1,1 Dichloroethylene	μg/l	0.3	
Heptachlor and Heptachlor epoxide	μg/l	0.1	
Hexachlorobenzene	μg/l	0.01	
Lindane	μg/l	3	
Methoxychlor	μg/l	30	
Pentachlorophenol	μg/l	10	
Tetrachloroethylene	μg/l	10	Tentative guideline value
Trichloroethylene	μg/l	30	Tentative guideline value
2,4,6 Trichlorophenol	μg/l	10	Odour threshold concentration is 0.1 μg/l
Trihalomethanes		No guideline value set	See chloroform

5.3.2. Desirable aesthetic quality

Common constituents which do not affect health in concentration in which they normally are present in water may however affect the aesthetic quality of the water.

The following quality is desirable for a water which should be generally accepted for human consumption and for all usual domestic purposes (WHO Guidelines).

Desirable aesthetic quality

Parameter	Unit	Guideline Value	Remarks
Aluminium	mg/l	0.2	
Chloride	mg/l	250	
Chlorobenzenes and Chlorophenols	mg/l	No guide-line value set	These compounds are capable of affecting taste and odour
Colour	True Colour Units (TCU)	15	
Copper	mg/l	1.0	
Hardness	mg/l (as $CaCO_3$)	500	
Hydrogen sulphide	–	Not detectable by consumers	
Iron	mg/l	0.3	
Manganese	mg/l	0.1	
Oxygen(dissolved)	–	No guide-line value set	
pH	–	6.5 to 8.5	
Sodium	mg/l	200	
Solids (total dissolved)	mg/l	1000	
Sulphate	mg/l	400	
Taste and odour	–	Inoffensive to most consumers	
Temperature	–	No guide-line value set	

Desirable aethetic quality, contd.

Parameter	Unit	Guideline Value	Remarks
Turbidity	Nephelometric turbidity units (NTU)	5	Preferably <1 for disinfection efficiency
Zinc	mg/l	5.0	

5.3.3 Permissible aesthetic quality

Under certain circumstances when it is not practicable to produce a water of the desirable aesthetic quality it may be permissible to raise certain guideline values as shown below. Further see chapter "Water Treatment".

Permissible aesthetic quality

Parameter	Unit	Guideline Value	Remarks
Chloride	mg/l	600	
Colour	TCU	50	
Copper	mg/l	1.5	
Iron	mg/l	1.0	
Manganese	mg/l	0.5	
pH	-	6.5-9.2	
Solids	mg/l	1500	
Turbidity	NTU	25	
Zinc	mg/l	15	
Other constituents	-	As in table "Desirable aesthetic quality"	

5.3.4 Substances and Characteristics Affecting Building and Pipe Material

The materials usually applied in water supply are cement products, steel, iron and plastic. The various factors which affect the different materials are described below. Plastic is generally unaffected by water.

Aggressive substances either have to be removed or materials chosen which can best resist the aggressivity of water.

In this connection it should also be mentioned that attention should always be paid to the fact that the attack can be also from outside. (Groundwater, swampy areas, or just humid acid soil, especially peat and those soil containing calcium sulphate). Further see chapter "Transmission and distribution lines".

Cement products

- Acid Water (pH value below the neutral line, Fig. 5.1 must be regarded as harmful to concrete. It becomes very harmful if the pH value is more than 1 to 2 points below the neutral line.

- As it can be seen from Fig. 5.2, soft water (with low carbonate hardness) becomes always very aggressive if it contains free carbon dioxide. This aggressive CO_2 dissolves the calcium salts of the concrete and mortar and it destroys gradually these cement products. Flowing water with such properties performs this very rapidly.

- Moor Water is often very harmful.

- Alkaline water (Fig. 5.1, pH above the neutral line) can also cause damage to cement products if the sulphate content is above 300 mg/l in standing or 100 mg/l in flowing water. Calcium and magnesium sulphates and, to a small extent also the corresponding chlorides, destroy concrete.

- Harmful to concrete is also water containing hydrogen sulphide and larger amounts of ammonium salts (e.g. waste).

- Concrete is attacked by water containing sodium hydrogen carbonate (especially in coastal areas).

- AC-pipes contain calcium carbonate and show high internal and external resistance to concentrated salt solutions. Experiments have proved that asbestos pipes are not corroded by water containing 2000 mg $CaSO_4$ liter and 5000 mg Na_2SO_4/liter and $MgSO_4$.

- AC-pipes are also resistant to electric currents.

- But larger amounts of aggressive carbon dioxide occuring with low carbonate hardness cause damage (see Fig. 5.2) of AC-pipes internal linings of bitumen and external coal-tar coats improve the resistance of asbestos pipes to the limit "very aggressive" in Fig. 5.2.

Steel and Iron Products

- Standing water effects greater corrosion in the pipes than flowing water. Therefore an aggressive water has a specially evil influence in the terminal parts of the piping system.

- Water of hardness above 35 mg/l $CaCo_3$ and of an oxygen content of at least 6 mg/l if $v<0.5$ m/s or 2 mg/l if $v>0.5$ m/s (but without aggressive carbon dioxide) form a protective layer of calcium and magnesium compounds named anti-rust layer on the internal surface of the pipe.

- Every water attacks the iron pipe if the oxygen content is insufficient, even if the other corrosion factors do not favour attack. The oxygen concentration should never be below 4.0 mg/l (respectively 2.0 mg/l in case of v>0.5 m/s).

- Iron is always attacked and dissolved by water containing aggressive carbon dioxide which prevents the formation of a protective layer against rust (see above and fig. 5.3).

- The pH-value should always be equal to or just below the equilibrium for unprotected iron pipes: -0.5 points for galvanized steel pipes (see Fig. 5.1).

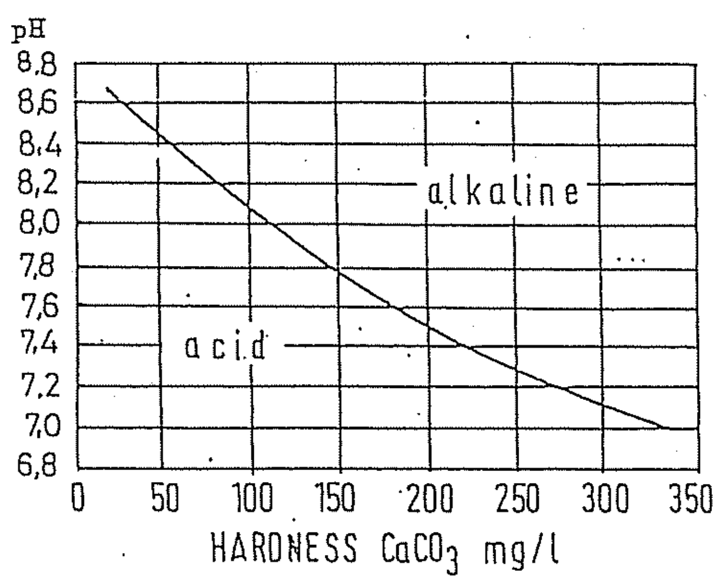
- Unprotected iron pipes are attacked by hydrogen sulphide (e.g. in moor-soils).

- Water with a high chloride content (e.g. brakish water) attacks iron pipes strongly. The limit for unprotected iron pipes is 150 mg/l in soft water.

- Special attention has to be given to the external attack.

- Steel pipes are more susceptible to chemical attacks than cast iron pipes. Cast iron pipes are more resistant than steel pipes against soft water of high oxygen content and aggressive properties.

Fig. 5.1



PH-value for neutral water depending on the calcium salt content

Fig. 5..2 Aggressivity towards cement products (concrete, mortar, AC pipes) depending on the hardness and the free CO_2.

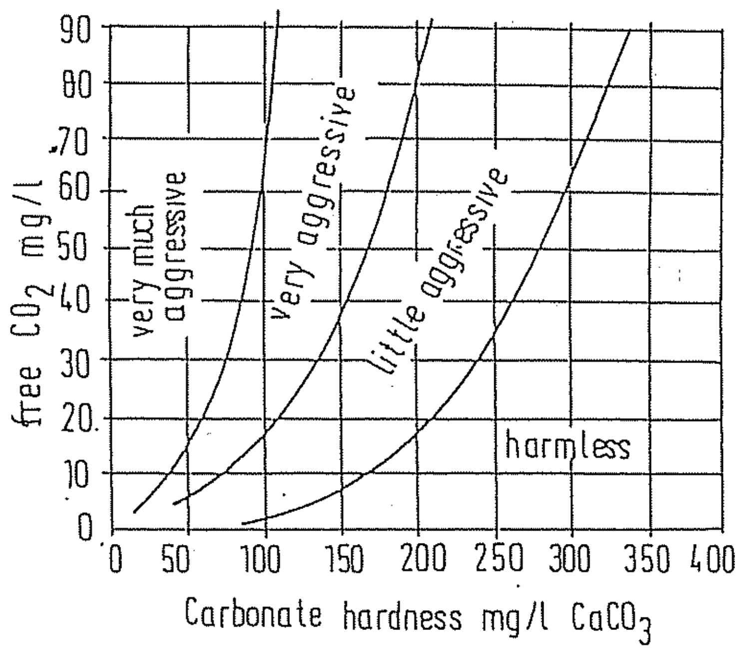
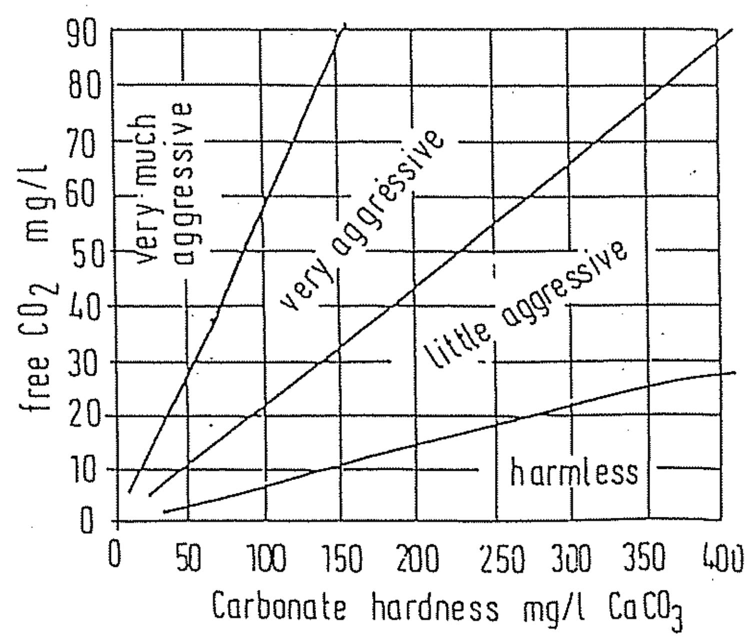


FIG. 5.3 Aggressivity towards iron products (steel pipes) depending on the hardness and the free CO_2



5.4 WATER SAMPLES

5.4.1 Sampling for selection of source and treatment

- The selection of source and treatment method will require the collection and analysis of water samples from the alternative sources which may be considered for a supply.

- The samples shall cover all regimes of a river, and be taken in a sufficient number, minimum 4, of which at least 3 shall be taken in the rainy seasons.

- Samples from new wells and boreholes should be taken after at least 24 h pumping.

- Both chemical and bacterialogical analysis should generally be made unless it is clear that only one of the two is of interest in a particular case.

- Whenever the result of the analysis leaves doubt as to the selection of source or treatment method additional samples should be collected and analysed.

6. WATER SOURCES

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APPENDIX B

Mean annual rainfall in Kenya.

90% probability map of annual rainfall in Kenya.

Month to month variation of rainfall in Kenya.

6. WATER SOURCES

6.1 GENERAL

6.1.1 General selection considerations

In selecting a source of drinking water, there are a number of factors that must be considered e.g.:-

- Quantity: Is the quantity of water available at the source sufficient to meet future development?

- Quality: Is the raw water quality such that, with appropriate treatment water can be supplied that meets or exceeds the quality specified in the "Water Quality Chapter"?

- Protection: Can the water, today and in the future, be protected from human excreta, from industrial discharges and from agricultural run-off? Can the catchment area, e.g. a forest, be protected efficiently to ensure sustained quantity and quality of the raw water?

- Feasibility: Is the source available at reasonable cost considering both capital and O&M costs? Can the source be exploited using simple and reliable treatment and transmission technology?

6.1.2 Specific selection considerations

- Sources which require little or no treatment of the water should be chosen in first instance provided the required quantity of water can be obtained. Hence springs and ground water resources should always be exploited in the first hand.

- For household and small-scale community supplies rainwater harvesting may serve well in most medium and high potential areas in Kenya.

- Surface water from river streams and lakes will almost always require some treatment to render it safe for human consumption. However, for large supplies surface water will often still be the most economical alternative. Rivers which have the bulk of their catchment in forest areas should be preferred.

- Sub-surface water drawn from a riverbed or river bank can sometimes be a viable alternative in dry areas with only seasonal flow in the river, or in rivers with a high silt load.

- It should be studied whether a combination of sources may give a more economical and reliable water supply than a system based on only one source. Mixing can also be used to reduce the content of certain constituents, eg. fluoride, to acceptable levels.

- Sources from which water can be supplied by a gravitational system are particularly favourable.

6.2 RIVERS AND STREAMS

6.2.1 Safe Yield for Principle Towns and Urban Centres with a population over 10,000

The 96% - probability daily low flow shall be regarded as the safe yield of a river. The flow - frequency analysis shall be made by using the lowest recorded daily flow of each calender year for which records are available for the dry season.

6.2.2 Safe yield for Rural Areas including Urban Centres with a population under 10,000 and Rural, Market and Local Centres

The 96% - probability monthly low flow shall be regarded as the safe yield of a river. The flow-frequency analysis shall be made by using the recorded lowest average flow during one calender month for each year for which records are available for the dry season.

6.2.3 Flood flow

Small dams (in this context taken as dams with a height less than 4m), spillways and intake structures shall be designed for the 100 year flood unless an economic-statistical analysis is used to determine the optimal design flow.

6.2.4 Flow Analysis

- For rivers with no or few observation records, shall full use be made of flow records from adjacent rivers and of rainfall data to construct a probable flow-frequency curve.

- Rivers and streams which lack installations to measure the flow but which have been identified as potential sources of a water supply should be provided with permanent or temporary gauging stations as early as possible in the planning process.

- The draw-off for other water supplies from the same river should be considered in the flow analysis and when determining the available water.

6.3 SPRINGS

6.3.1 Location and reliability

The best way to locate adequate springs and to get information about their reliability during dry spells is to interview people resident in the area.

6.3.2 Yield

There are seldom records of the flow from springs. Simple overflow weirs, V-notches etc. should be installed for gauging the flow as early as possible in the planning process.

The flow from an artesian spring often fluctuate less than that of a gravity spring. As also the bacteriological quality of the water from an artesian spring is better this type of spring is preferred.

6.4 BOREHOLES AND WELLS

6.4.1 General

Except for shallow wells for one or a few families the safe yield should be determined by a hydro-geologist.

6.4.2. Fully exploited aquifers

- Testpumping should be done to determine both the hydraulic characteristics of the boreholes and that of the aquifer.
- The borehole characteristics should be determined by a step testpumping with 3-5 different pump capacities each step taking about one hour.
- The characteristics of the aquifer should be determined through medium terms testpumping and observation of the water levels in adjacent production or special observation boreholes.

The required testpumping period will depend on the aquifer and should be decided by a hydrogeologist.

Generally a pumping period of 1-3 days will be adequate for an artesian reservoir whereas a reservoir with a free water table will have to be pumped for a longer period.

The pump capacity should be kept as constant as possible and also as big as possible during the testpumping.

6.4.3 Only partly exploited aquifers

- When the draw-off from a borehole is going to be considerably lower than the expected yield, then a simplified test-pumping programme may be followed.

  In this case observation boreholes will not be required and the test-pumping period should be 1-3 days with a pump capacity which exceeds the future draw-off with about 50%.

- Survey boreholes for shallow wells (0-20m) may be test-pumped for only 1 hour (50 min. with approximately the future draw-off 10 min. with twice this capacity). This test method is allowed only for wells to be equipped with handpumps and which are to serve as point supply for maximum 500 people.

6.4.4 Manual Water Level Observations

The water levels in the test boreholes and the observation boreholes should be read with the following frequencies during the test-pumping and during the recovery after the pumping has been stopped.

Time after start or stop of pumping	Gauging interval
0 - 10 min.	1 min.
10 - 20 min.	2 min.
20 - 40 min.	5 min.
40 - 60 min.	10 min.
60 - 90 min.	15 min.
90 - 180 min.	30 min.
180 - 360 min.	60 min.
360 - 600 min.	120 min.
10 - 24 hours	4 hours
1 - 3 days	6 hours
over 3 days	12 hours

6.4.5 Yield Records From Existing Boreholes

Information about the yield of existing boreholes shall be used with great care.

The yield may have changed after many years of use or what is reported as the yield may very well be the capacity of the pump once used for the test pumping.

Fresh test pumping is recommended unless the background of the reported yield is very well documented.

6.5 SUB-SURFACE DAMS

6.5.1 General

In rivers with only seasonal flow it is often possible to abstract water from the river bed also in the dry season if a structure is built across the river bed under the surface to retain the sub-surface flow. This method is particularly suitable in areas where the groundwater is generally saline or has a high fluoride content.
The water is generally withdrawn through infiltration drains up-stream the sub-surface dam.

6.5.2 Withdrawal of stored water

The river bed sometimes can store considerable amounts of water which can be drawn during the dry seasons.
The bed is then recharged during the rainy seasons.
The available water can be estimated using the specific yields as given in Section 6.6.3
The depths of and the material in the river bed should be investigated before any accurate estimate of the available water can be done.
It is sometimes possible to find a natural barrier in form of a rock outcrop or impervious material in the river bed.
Behind such barriers large amounts of water may be stored. This type of sub-surface dams has proven very successful in dry areas like Turkana District.

6.5.3 Withdrawal of sub-surface flow

The total sub-surface flow can be estimated from:-

$$Q_t = KAI$$

Where: Q_t = total sub-surface flow, m^3/s
K = permaability, m/s (see table).
A = cross-sectional area, m^2
I = hydraulic gradient, dimensionless.

Coefficient of permeability, m/s at unit hydraulic gradient.

$1 \quad 10^{-1} \quad 10^{-2} \quad 10^{-3} \quad 10^{-4} \quad 10^{-5} \quad 10^{-6} \quad 10^{-7} \quad 10^{-8} \quad 10^{-9} \quad 10^{-10} \quad 10^{-11}$

Nature of soils	Clean gravel	Clean sands; mixtures of clean sands and gravel	Very fine sands; silts; mixtures of sand, silt, and clay; glacial till; stratified clays; etc.	Unweathered clays
Flow characteristics	Good aquifers		Poor aquifers	Impervious
Retention characteristics	Good drainage		Poor drainage	Non-draining
Use in dams and dikes	Pervious parts of dams and dikes		Impervious parts of dams and dikes	

In practice seldom more than 60 to 75 % of the total sub-surface flow can be intercepted.

6.6 ARTIFICIAL RECHARGE

6.6.1 General

Ground water usually has the great advantages over surface water from rivers and lakes in that it is free from organisms and bacteria causing illness and also that the turbidity and the colour is usually not a problem.

Where the groundwater yield is inadequate it should therefore be investigated whether it can be supplemented by artificial recharge from an adjacent surface-water source.

6.6.2 Bank Infiltration

The horizantal distance between the river or lake and the recovery point should be a minimum of 20m and preferably 50m or more in order to guarantee the desirable bacteriological quality. However often it will not be practicable to place the recovery point so far away from the stream or lake because of the ground conditions. In this case provision should be made for chlorination of the water.

6.6.3 Artificial aquifer

An artificial aquifer should be designed for a retention time of the water underground of 60 days. If the retention time is shorter chlorination may be required.
The specific yield, or storage capacity, of different materials is shown below. It must be understood that large variation can be expected and that soil investigations are required to determine the specific yield accurately.

Material	Specific Yield (%)
Clay	3
Sand	25
Gravel	22
Gravel and sand	16

Thus a rough estimate of the required volume 'V' of a gravel and sand aquifer can be made by using the formula $V = 400\ D\ m^3$ which will give a retention period of approximately 60 days.

D is the water demand in m^3/day.

The intake of water to the infiltration basin should be arranged so that the flow can be stopped when the river is polluted or otherwise of poor quality.

6.6.4 Sand Dams

Sand dams are particularly approriate in semi-arid areas where the flood water often carry high silt load and the evaporation from a free water surface is high. The dam across the river should be built in stages to ensure that mainly sand and gravel are deposited. The first stage should be a dam about 2mm high. Later the wall should be raised as the sand and gravel builds up until the full height, often 6-12 is reached.

6.7. RAINWATER HARVESTING

6.7.1 Rainfall Data

The 90 % - probability annual rainfall should be regarded as the dependable rainfall for the purpose of rain water harvesting for domestic use. Maps showing the 90 %-probability annual rainfall and the average annual rainfall in Kenya can be seen in Appendix B. The maps can be used for rough estimates of available water for a certain location. However specific rainfall data for the location in question should be obtained for each individual case.

6.7.2 Run-off Coefficients

The following run-off coefficients should be used for calculating the fraction of the rainfall which can be harvested.

	Run-off coefficient
Roof tiles, corrugated sheets, concreted bitumen, plastic sheets	0.8
Brick pavement	0.6
Compacted soil	0.5
Uncovered surface, flat terrain	0.3
Uncovered surface, slope 0-5%	0.4
Uncovered surface, slope 5-10%	0.5
Uncovered surface, slope >10%	>0.5

6.7.3 Collection Tank

The required capacity of the collection tank should be calculated using available meteorological data showing the rainfall pattern of the area.

However, for rough calculations the tank capacity may be calculated by the formula:

$$C = 0.03 \times D \times (T + 2)$$

Where C = Tank capacity in m^3

D = Total water demand in litres/day

T = Longest dry spell in months, average year

In this connection a dry spell may be defined as the period when the average monthly rainfall is less than 50 mm. The length of the dry spell in different areas in Kenya can be found in Appendix B.

6.7.4 Roof Catchment

A rough estimate of the required minimum roof area can be made by using the following formula.

$$A = \frac{450 \times D}{R}$$

Where A = Minimum roof area in m^2

D = Total water demand in litres/day

R = The 90% - probability annual rainfall in mm

PART I

RURAL AND URBAN WATER SUPPLY

7. INTAKE STRUCTURES

CONTENTS

7. INTAKE STRUCTURES

7.1 RIVER INTAKES

7.1.1 Location

Whenever practicable an intake should be positioned:

- On a river whose main catchment area is in the forest.
- On a level that allows the water to be gravitated to the consumers.Further see "Transmission and distrubution lines".
- Up-stream populated areas and farming areas.
- Up-stream of bridges, cattle watering,laundry washing and sewerage outlet points.
- At a location where the area immediately up-stream the intake is not easily accessible to people and cattle.If it is, fencing should be provided.
- Where the ground is rocky (firm) and does not get flooded.
- At the outside of a river bend.
- Where the flow is adequent to cater for the ultimate water demand. Further see chapter "Water Sources."

7.1.2 STRUCTURES

- Small streams and rivers may require that a dam is built across the watercourse so that the water depth remains sufficient also during low flows.
- The dam should be designed with a stepped weir with the lowest part of the weir next to the actual draw-off point in order to prevent siltztion. The velocity at this point should be at least 1 m/s for all regimes of the river.The area immediately upstream and downstream the dam should be protected against erosion.
- The draw-off should be perpendicular to the direction of the flow of the river.The bottom of the intake should be positioned some distance above the river, if possible at least 1m. The water should flow towards the intake at a velocity less than 0.1 m/s.
  Once the water has passed the screeens the velocity should be at least 0.5 m/s. This minimum velocity must be upheld in intake chambers, canals and intake pipes also during the initial phases of a water supply when the water demand is low. There should be a possibility to clsoe the intake with stop logs or similar.
- A floating intake may be a viable alternative in relatively large rivers with variable water levels.

7.1.3 Screens

The intake should be equipped with a course screen and a fine screen, both removable.

- The course should have an open spacing of 30 - 50 mm between the bars.
- The fine screen should have a spacing of 5 - 10 mm.
- The screens should be possible to clean with a rake, which should be supplied together with the screens. Thus, the mesh type of screen is not permitted.
- The screens should be designed with a maximum velocity, V_s, in the openings between the bars of 0.7m/s even if the screen is clogged to 50%.
- The head loss through the screen can be calculated with the following formula.

$$h = 1.1 \times \frac{V_a^2}{2g} \left[\left(\frac{L_2}{0.8\, L_1} \right)^2 - 1 \right] \text{m} \quad \text{in which}$$

h= loss of head in the screen, m
V_a= Actual approach velocity, m/s
L_2= Total width of the screen, m
L_1= Total width between the bars, m

Example

Q= 0.1 m^3/s. Screen area 0.5m^2, screen width 0.5m. Distance between bars 15mm (centre) Thickness of each bar 5mm.

Hence, the velocity between bars when the screen is clogged to 50% will be

$$V_s = \frac{Q}{A} = \frac{0.1}{0.5 \times \frac{10}{15} \times 0.5} = 0.6 \text{ m/s} \quad ; \quad V_s \angle 0.7 \text{ m/s}$$

The head loss will be

$$h = 1.1 \times \frac{\left\{\frac{0.1 \times 2}{0.5}\right\}^2}{2g} \times \left[\left(\frac{0.5}{0.8 \times \left(\frac{10}{15} \times 0.5\right)} \right)^2 - 1 \right] = 0.023\text{m}$$

- The intake should generally be equipped with a platform and handrails. The platform should cover at least one meter round the screens. Equipment to lift the screens should be provided when the weight of each screeen exceeds 30 kg.

7.2. INTAKE IN LAKES

7.2.1 Location

- The intake should preferably be 3-5m below the surface but at least 1 m above the lake bottom.
- In lakes with bilharzia the intake point should be a minimum of 100m from the shore.

7.2.2 Design Details

- The underwater pipe should be laid with an even slope without any peaks where airpockets can form. If peaks cannot be avoided the pipe should be punctured at these points.
- Lifting of the underwater pipe when empty should be prevented through adequate anchorage.
- The underwater pipeline should usually be flexible. Either the pipe material itself or the joints should give the required flexibility.
- The cleaning of the intake screen should be considered in the design. When feasible a connection should be made from the discharge pipe to the underwater pipe to make back-washing of the intake pipe possible.
- The intake level should be adjustable in lakes with widely fluctuating water levels (e.g. Lake Victoria)
- The water should flow towards the intake at a velocity less than 0.1 m/s.

7.3 BOREHOLE INTAKES

7.3.1 Setting of the intake

- The intake of a borehole pump should be set at least 2m above the bottom of the borehole.
- The exact setting of the borehole intake will be controlled by the characteristics of the borehole and the ground-water reservior as obtained through long term test pumping.
  Further see chapter "Water Sources".
- If only results from short time test pumping are available then the intake should be placed between 2m and 5m above the borehole bottom unless the draw-off from

the borehole is shown to be much lower than the potential yield.

7.3.2 Design details

- Screen, pump and pipe material which can sustain the agressiveness of the water has to be selected. Further see chapter "Water Quality".
- For pump selection, see chapter "Pumps and Power Sources"
- All boreholes should be equipped with level indicator of simple design eg the air type with foot pump and manometer.

7.4 SPRING INTAKES

7.4.1 Protection

Where the spring is tapped with drains placed in a gravel pack the top of the gravel pack should be at least 3m below the ground surface.
An area extended along the drain gallery over its full length plus 10m at each side and in the other direction to a distance of at least 50m upstream should be protected against contamination from cesspools, manure and pits and should be fenced in.

Above the fenced-in spring site there should be a drainage ditch to divert any surface water.

7.4.2 Storage Chamber

The drains should discharge into a storage chamber (spring box) which should be equipped with a lockable manhole cover. Any air vents, overflow pipes and scour pipes must have screened openings.

7.5 ROOF CATCHMENTS

7.5.1 General

Regarding available rainwater, roof area and capacity of the storage tank see chapter "Water sources"

7.5.2 Roof

Water can be collected from house roofs made of tiles, slates (corrugated) galvanised iron or aluminium. Thatched roofs are not suitable because of health hazards.

Plastic sheeting is often not durable. Painting the roof for water-proofing may impart taste and colour and should be avoided.

7.5.3 Roof Guttering

The roof guttering should slope evenly towards the downpipe to prevent the formation of breeding pools for mosquitoes.
New houses should be carefully planned so that the length of guttering and pipes will be as short as possible and so that the water can be tapped by gravity.

7.5.4 Foul Flush

There should be arrangements to prevent the first water from each shower from being collected in the clear water container in order to prevent pollution by dust, leaves and bird droppings which accumulate during the dry periods.

This can be accomplished simply by arranging the downpipe so that the foul flush can be diverted or by having a small vessel which collects the foul flush before the water overflows to the clear water tank. A foul flush vessel with a capacity of 100 - 200 liters should be adequate for an ordinary roof.

7.5.5 Storage Tank

- Regarding tank capacity see section 6.7.3
- The inlet pipe should be equipped with a sieve or net to trap any foreign materials.
- The tank shall be covered to reduce evaporation and contamination.
- The outlet pipe should be placed 0.2m above the floor of the tank.
- The tank should have a scour or be constructed in a manner that facilitates removal of sediments and cleaning.
- The tap area should be drained and have a concrete apron to keep it dry and clean.
- The tank should be well raised to allow easy tapping.
- Corrugated steel tanks should be laid on wooden supports placed on raised concrete platforms to ensure that the outer bottom surface is kept dry to reduce corrosion.

7.6. DUG WELLS

7.6.1 Diameter and depth

- The diameter of a dug well should be at least 1.2m to allow two men to work together during the digging. Slightly smaller diameter may be used if the digging is to be done by one man only.
- Well for a large community should usually have a diameter of 2 - 3m

- The well should be dug at least 3m below the expected lowest water level.

7.6.2 Lining

- Most dug wells need an inner lining of materials such as brick, stone masonry, concrete rings cast insitu or precast concrete rings. Back filled dug wells with a 100 -150mm tube can also be a good solution.

- Sinking a dug well by excavation from the inside is very often a good and safe technique, however, in very loose soil (fine or medium sand) in thick layers (over 3m) other methods eg. hand-drilling should be used.

- In consolidated ground (eg.rock) the well may stand unlined but the upper part should always have a lining.

- The section of the well penetrating the aquifer requires a lining with openings or perforations to allow the groundwater to enter. Any backfilling at the same level as the aquifer should be made with gravel.

- However in fine sand aquifers the lining should be without perforations and the groundwater should enter only through the bottom of the well. The bottom should be covered with graded gravel e.g. three layers each 150mm thick with grain sizes 1 - 2mm for the deepest layer, then 4 - 8 mm, and 20 - 30 mm effective size at the top.

7.6.3 Protection

- The space between the walls of the dug hole and the lining should be sealed with puddled clay or with cement grout. The sealing should be between the ground surface and the aquifer or down to at least 2m below the ground surface.

- The wall lining should be extended approximately 0.5m above the ground to form a wall round the well.

- A concrete apron should be constructed on the ground surface extending about 2 m all round the well.

- The well top should be sealed with a watertight slab. A manhole that can be tightly and securely locked should be provided for inspection and disinfection.

7.7. DRILLED WELLS

7.7.1 Hand-drilled wells

Hand drilling of 250-300 mm diameter wells down to a depth of 15-20m is particularily feasible in clay and sandy ils

If gravel and small stones are found and in semi-cemented layers such as soft sandstone, weathered granite and weathered laterite, hand-drilling is still possible, though rather time consuming.

- A filter pipe of at least 6m length and 100-150mm diameter and a sand filter should be put in the well.

- Protection should be made as described under "Dug Wells".

7.7.2 Mechanical well drilling

- Mechanical well drilling (digging) has to be used in layers with big stones and boulders and in heavily cemented soils.

- Regarding filter and protection see above.

7.8 INFILTRATION GALLERIES

7.8.1 Gallery in slowly permeable material with minimum depth of water above streambed, channel or lakebed

The length of the screen should be at least:

$$L = \frac{Q\,d}{K\,H\,B}$$

Where:

L = length of screen required, m
Q = desired discharge, m^3/s
d = vertical distance between riverbed and centre of screen, m
K = permeability of gravel backfill, m/s (see 6.5.3).
H = head acting on centre of the pipe (distance between minimum water surface elevation and centre of the pipe), m
B = average width of the trench backfill with gravel.

The screen should be placed at a depth as great as physically possible and economically practical beneath the minimum water surface.

7.8.2 Gallery in permeable riverbed or lakebed with minimum depth of water above the bed. See figure

The length of the screen should be at least:

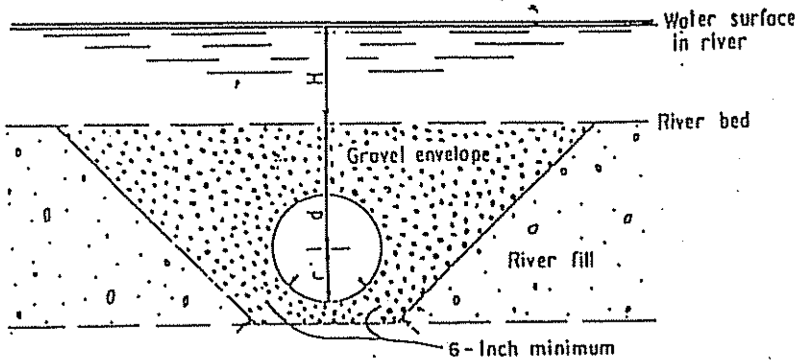
$$L = \frac{Q \ln\frac{2d}{r}}{2\pi\,K\,H}$$

Where:

L, Q, K and H are as in 7.8.1 above

ln = natural log

r = radius of pipe, m.



7.8.3 Gallery in an ephemeral or intermittent stream channel filled with permeable material through which a perennial sub-surface flow is moving

The calculations for this case is complicated why special manuals e.g. Groundwater Manual (1977) should be consulted.

7.8.4 Collection pipes (screen)

- The pipes should be designed for a velocity of 0.5 to 1.0 m/s in order to be self-cleaning.

- The average entrance velocity through the holes or slots of the screeen should not exceed 0.03 m/s.

- The diameter of the holes or width of the slots should normally be 3 - 4 times d60 of the gravel pack.
  (d_{60} is the sieve diameter through which 60 % of the soil material can pass).

  Hovever the holes must never be bigger than d_{85} of the gravel pack.