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Abstract:

A Technical survey of 14 water supply schemes has been carried out. Unreliable and insufficient water supply was found at several schemes. A low cost improvement programme has been proposed.

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A WATER PRICING STUDY FOR THE REPUBLIC OF ZAMBIA

Appendix III

SUMMARY OF TECHNICAL FINDINGS

Oslo, May 31. 1984
Torbjørn Damhaug
Svein Stene Johansen

ACKNOWLEDGEMENT

The Norwegian Institute for Water Research (NIVA) would like to thank all the civil servants of Zambia and other persons who have participated in discussing water pricing issues, and who have also made useful information available to us.

We would also thank the NORAD staff in Lusaka who made the safaries and field survey possible, and Mr. Lars Aaby, DWA, for his participitation during the safary in North Western Province.

NORWEGIAN INSTITUTE FOR WATER RESEARCH

Svein Stene Johansen
Project Manager

P R E F A C E

The Norwegian Institute for Water Research (NIVA) was in March 1981 engaged by the Norwegian Agency for International Development (NORAD) to undertake a Water Pricing Study for the Western Province of Zambia.

The report including the recommendation for a new water tariff structure for Western Province was presented in October 1981.

The Department of Water Affairs (DWA), however, felt that a National Study was required in order to establish a National Water Tariff Structure.

NORAD agreed to finance the extension of the Study and a Contract between NORAD and NIVA was signed in September 1982.

The same Project Team as for Western Province was used. However, the team was extended by one water engineer.

The Project Team consisted of:

Mr. David G. Browne, Agricultural and Water Resources Economist
Mrs. Mette Jørstad, Social Anthropologist
Mr. Torbjørn Damhaug, Water Engineer
Mr. Svein Stene Johansen, Project Manager

The two latter are permanently employed by NIVA, the two other persons hired as sub-consultants.

The Project Team visited Zambia in August-December 1982 and had discussions with relevant authorities at central, provincial and local levels. The team also met members of the Department of Water Affairs (DWA) staff as well as many water consumers.

In order to provide data for the main report and NIVA's recommendations to the Zambian Government, socio-economic surveys covering various topics which have a bearing on consumer's ability and willingness to pay were carried out by the economist and the socialanthropologist. Both surveys *are based on the same questionnaires and methodology. These surveys were meant to be independent studies at the responsibilities of the authors. The result of the surveys are presented at Appendix I and II to the main report. Technical Findings are presented as Appendix III in this report.*

Svein Stene Johansen
Project Manager

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RECOMMENDATION

This report gives an overview of the present situation at 14 Township Water supply schemes in Zambia.

In general the schemes are operating at maximum outputs during the whole year, and at most of the schemes there is a remarkable lack of water during the dry season. However, the consultants found that at several supplies minor investment could significantly increase the quality, and/or improve the quality of the water supplied. The major constaints were related to both technical problems and /or inefficient management.

- There is an immediate need for rehabilitation of several township supplies. The Government has limited funds for building new schemes. It is strongly recommended that the rehabilitation programme idea presented this study be further pursued by a donor founded study.

1. INTRODUCTION

The Norwegian Institute for Water Research (NIVA) was commissioned in September 1982 by the Norwegian Agency for International Development (NORAD) to carry out a national Water Pricing Study for The Republic of Zambia. The documentation from the project includes the Main Report, a Summary Report and two appendix reports regarding the willingness to pay survey.

The technical part of the study was mainly meant to serve as a support for the water pricing study. The technical survey, however, identified a number of schemes where the level of supply could be improved significantly by limited upgrading investments. Thus during meetings with the Director of Department of Water Affairs (DWA) and NORAD, NIVA was asked to submit a separate report of the technical aspects from the study.

The major objective of this Appendix Report is to examine the present situation at some of the township supplies visited by the study engineer and to outline an appropriate upgrading program.

2. STUDY SAMPLE AND COLLECTION OF INFORMATIONS

The technical study sample included 14 township water supplies as listed in Table 1. These schemes were all visited by both economical and technical experts of the study team.

Table 1. Study sample.

Township	Province	Run by
Mumbwa	Central	DWA
Chongwe Centre	Lusaka	"
Kitwe	Copperbeet	Council
Mufulira	"	"
Luanshya	"	"
Solwezi	North-Western	"
Mwinilunga	"	DWA
Kasempa	"	"
Kabompo	"	"
Chizela	"	"
Choma	Southern	Council
Kalomo	"	"
Zimba	"	DWA
Mambova	"	Council

As seen from the table the study sample includes both DWA and Council schemes ranging from 2 500 to 130 000 consumers. Due to the limited number of water works included, this study must be regarded as providing examples of the situation at Zambian water works.

The main sources of information were the plant staff, the consultancy reports and the technical and economical questionnaires used. The field survey included one scheme per day.

3. FINDINGS FROM THE VISITED WATER SUPPLY SCHEMES

Some key information from the schemes is presented in Appendix A.

3.1 Water supply capacity versus demand

Correct estimates of water demands and reliable records about the actual water supply are of major importance in order to diagnose the situation.

In estimating water demand a distinction must be made between supply, that is the water entering the distribution system, and consumption, that is the water actually used by consumers. The difference between these represents losses from the distribution system.

In this part of the study the term "demand" refers to the amount of water used if it is freely available.

From a design point of view one also has to consider the losses from the distribution system and losses at the consumers' premises. For projection of water demand, figures based upon long term observations have been developed.

The procedure in the design of water supply systems also includes seasonal, daily and hourly peak demand factors.

Due to the lack of detailed records of water production and demand this study is based on average data as shown in table 2.

The actual production figures are generated by combining and cross checking of information from the following sources:

- Number of pumping hours multiplied by capacity.
- Measurements made by the study team. (Weir measurements and flow diagrams or bucket and stop watch).

- Records from feasibility studies.
- Information from the interviews.
- Time of filling or emptying storage basins.
- Bulk flow meter readings.

The demand data are collected from the feasibility studies and the table also presents "guesstimates" made during the interviews.

The feasibility study records are net annual demand excluding losses, while the questionnaire figures are net demands during the dry and the rainy season.

Even if the questionnaire records are guesstimates there seems to be a good correspondance between these data and the feasibility study records at most of the schemes. The average ratio between dry and wet season demand based on the guesstimates is about 1.5.

Despite losses and peak demands being unknown elements in this survey, Table 2 gives an indication of the present situation at different schemes.

In general most of the schemes are operating at maximum possible outputs during the whole year, thus the number of hours of supply per day reflects the supply situation. On an average basis most of the schemes are slightly undersupplied during the rainy season (October - April) while there is a remarkable lack of source/supply water during the dry months (May - September).

If the schemes should meet the "normal" design criteria the maximum output of the water works should be about 1.9 times the net average demand pointed out in Table 2. In this case the state of insufficient supply would be even more accentuated.

However, the consultants found that at several supplies minor investments could significantly increase the quantity, and/or improve the quality, of the water supplied. In some cases the increase in capacity may still fail to supply today's peak requirements, but the level of supply could be improved by investing a limited sum of money.

Table 2. Number of consumers, present production and estimated demands.

		PRODUCTION			DEMAND			
					From Feasibility Studies		From Questionnaries 1982	
Township	Number of Consumers	Average		Over all specific	Average		Wet season	Dry season
		m^3/annum	m^3/d	l/c·d	Year	m^3/d	m^3/d	m^3/d
Mumbwa	6.239	657.000	1.800	289	83	1.190	1.497	2.500
Chongwe Centre	4.000	41.060	114	28				
Kitwe	130.000	20.430.000	56.000	431	85	358.800	50.050	127.010
Mufulira	65.000	7.117.500	19.500	300	85	29.300	19.500	22.685
Luanshya	90.000	6.205.000	17.000	189	85	19.286		17.010
Solwezi	15.000	663.570	1.818	121	90	4.444	3.645	4.545
Mwinilunga	3.350	146.000	400	119	90	1.156	754	1.200
Kasempa	3.063	182.500	500	163	90	923	970	1.127
Kabompa	5.357	255.500	700	131	90	1.320	2.000	2.700
Chizela	2.000	65.700	180	90	90	316	722	962
Choma	3.500	503.700	1.380	394	88	13.350		
Kalomo	11.000	755.550	2.070	188	88	1.807	2.070	2.904
Zimba	3.200	62.050	171	53	86	466		
Mambova	2.500	?		?	88	545		

3.2 Resources and water quality

Water may be obtained either from surface- or groundwater sources. Where surface water is uncontaminated and continuous, it is the least costly option. However, in most of the developing world surface water is subject to seasonal availability; a continuous supply can be ensured only by constructing a reservoir and proper treatment facilities.

Ground water sources are more protected against contamination but after a period of time the yield from the wells and boreholes may decline due to collapse of linings or accumulation of silt.

All of the investigated schemes except Chizela were based on surface water sources. This section therefore concentrates on the quality of surface waters.

Among all the conflicting interests in the use of water this section will deal with the water supply aspects.

In terms of hydrology, the natural water run-off exhibits a variation on a regular seasonal cycle oscillating above and below a long term mean. Practical water resource assessment thus requires a basis of hydrological data for the actual sources.

The main complication in engineering water supply is that demand and natural supply cycles are usually out of phase and also in conflict with other demands such as power, flood control and irrigation. This situation leads to the requirement to regulate the supply with storage reservoirs.

The present study does not include hydrological assessments of the water sources, but this must be paid more attention during an upgrading programme.

Raw water quality is a major factor in the selection of treatment methods.

Despite this fact there was a lack of relevant raw water analyses from the schemes visited. From a public health point of view the hygienic standard is by far the most important factor. Many of the rivers are recipients of sewage from the adjacent townships and the risk of water borne diseases is absolutely present. Water borne diseases include typhoid, cholera, various enteric infections including dysentery and diarrhoea. These diseases develop after ingestion of bacteria, viruses and amoeba which may be in a polluted water supply.

In general the presence of harmful organisms in raw river water should be taken for granted and it is essential that these should not exceed certain concentrations.

Chlorination in some form or other is the universal method used for desinfection of water supply in developing countries. Other important water quality characteristics are colour and turbidity.

Colour is caused by dissolved organic solids in water while turbidity is a measure of suspended and colloidal solids. High turbidity is typical for heavily silted waters, especially during the rainy season, or it might be caused by algal blooms. It is unusual to have to cope with both conditions at once, because it is unusual for heavily silted waters to suffer from algal growth.

All the schemes included in this study were visited during the dry season and most of the water sources must be characterized as good or excellent regarding colour and turbidity.

This means that all of the schemes have a high peak demand when the river is relatively clear and capasity of the works can easily be increased to cope with the demand. On the other hand, during the wet season there is a coincidence of peak turbidity and low demand. In this period of time the coagulation-separation capacity of the treatment plants has to be optimally utilized.

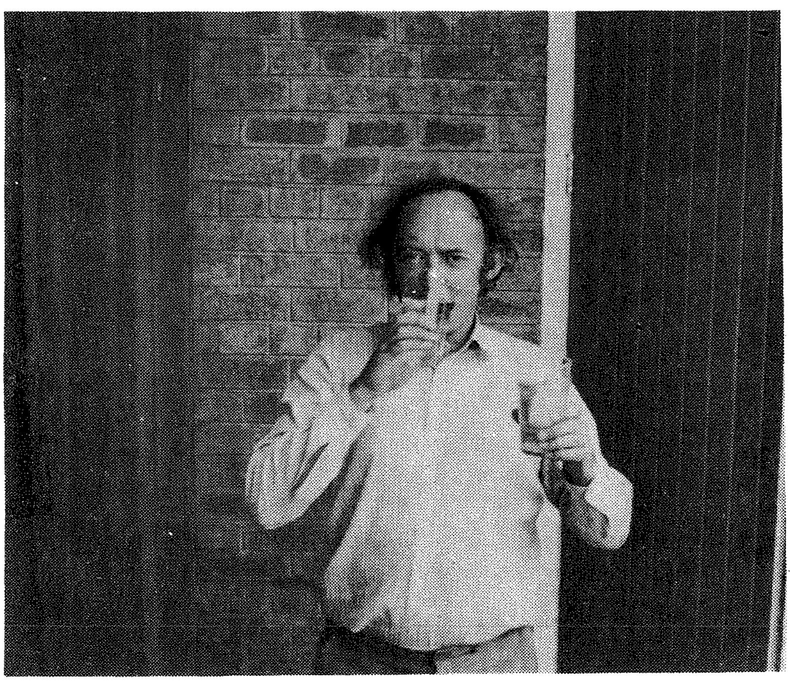


Figure 1. Raw water and treated water samples.

3.3 Intakes and raw water pumping stations

Surface water development for water supply involves the regulation of natural river flows. At nine of the schemes the regulation is arranged by direct abstraction at river intakes and three of them are equipped with provisional rubble weirs across the river (Figure 2).

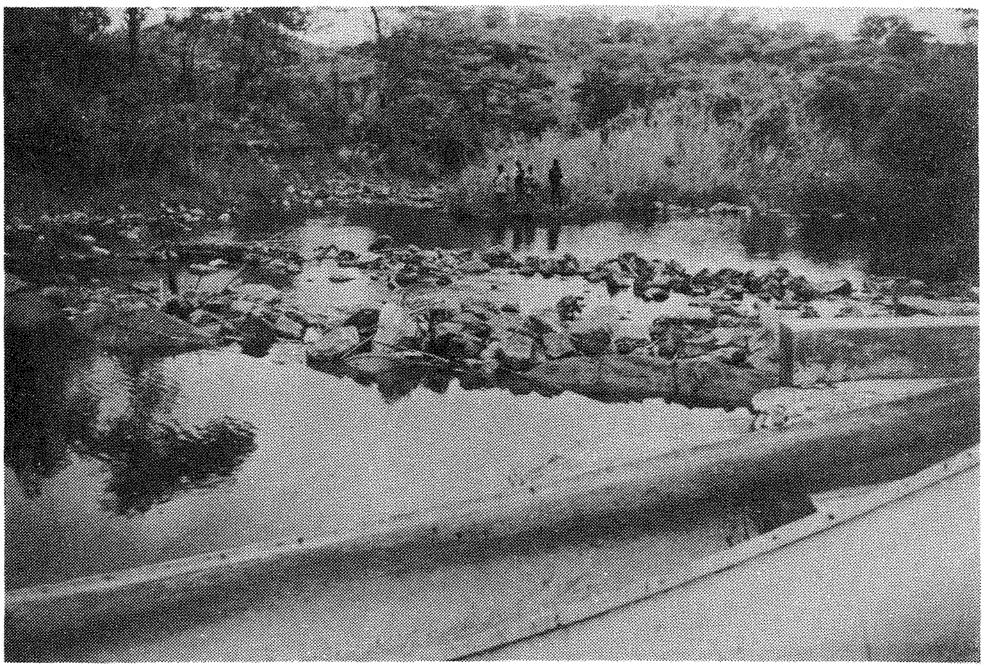


Figure 2. Rough rubble weir downstream the river intake (Kasempa).

At four of the schemes regulation is provided by dams and reservoirs as shown in Figures 3 and 4.

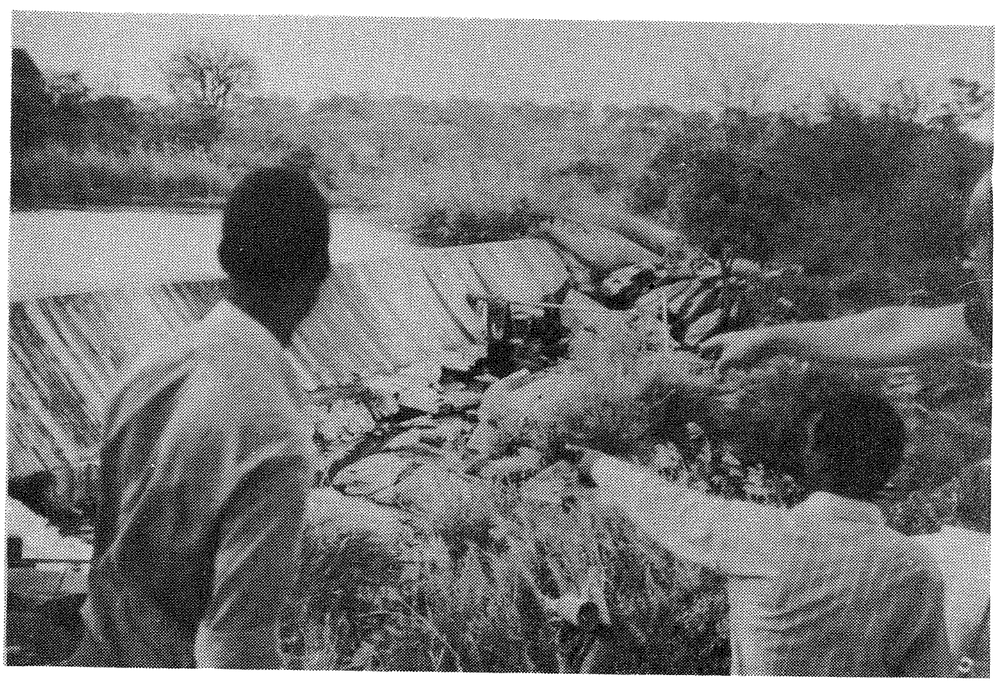


Figure 3. Concrete dam construction (Mumbwa)

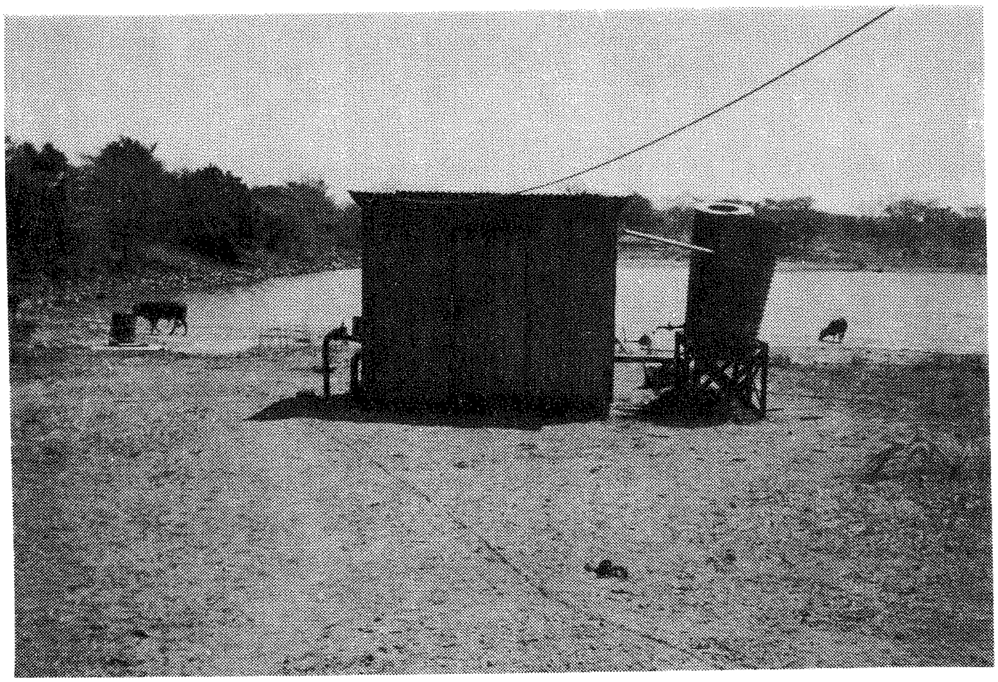


Figure 4. Lowland reservoir with pumped diversion. (Railway Dam at Zimba).

The storage capacity of some of the dams and reservoirs is frequently reduced due to silt deposit and routines to clean out sediments are not established.

River intakes have been designed in many different ways. Despite the fact that a lot of the raw water intake arrangements observed were quite different from the standard recommended designs they were still in operation.

As can be seen from the Figures 5 and 6, the raw water intake arrangements are apparently improvised.

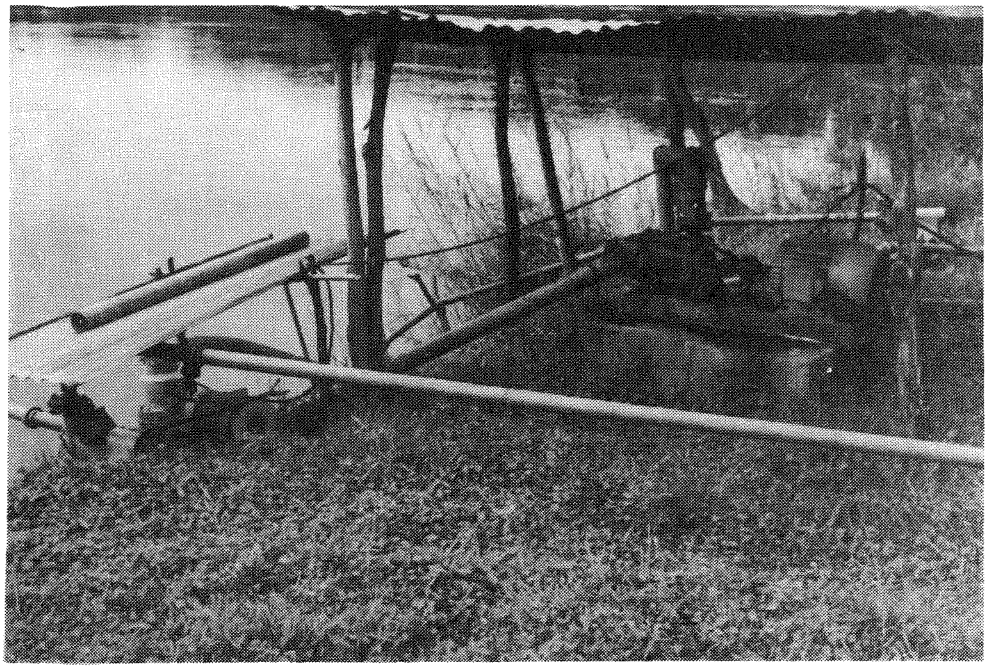


Figure 5. Raw water pumps at Kabompo River.

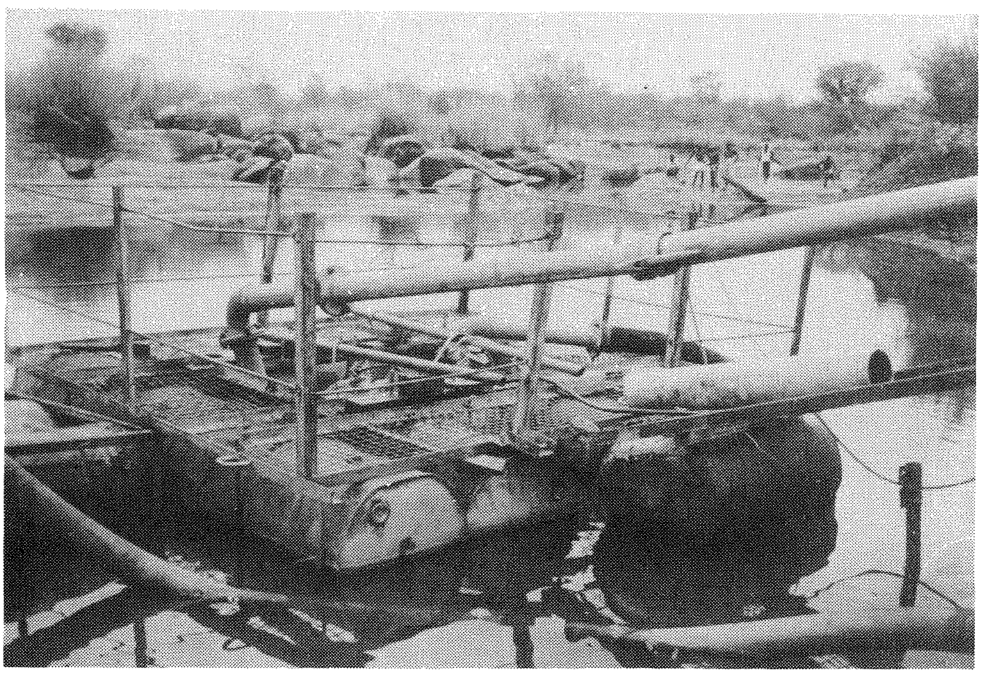


Figure 6. Pontoon mounted raw water pumps (Kalomo).

The pumping stations at the schemes visited were in various states of disrepair. Many of pumps had been dismantled and set aside for spares (Figure 7).

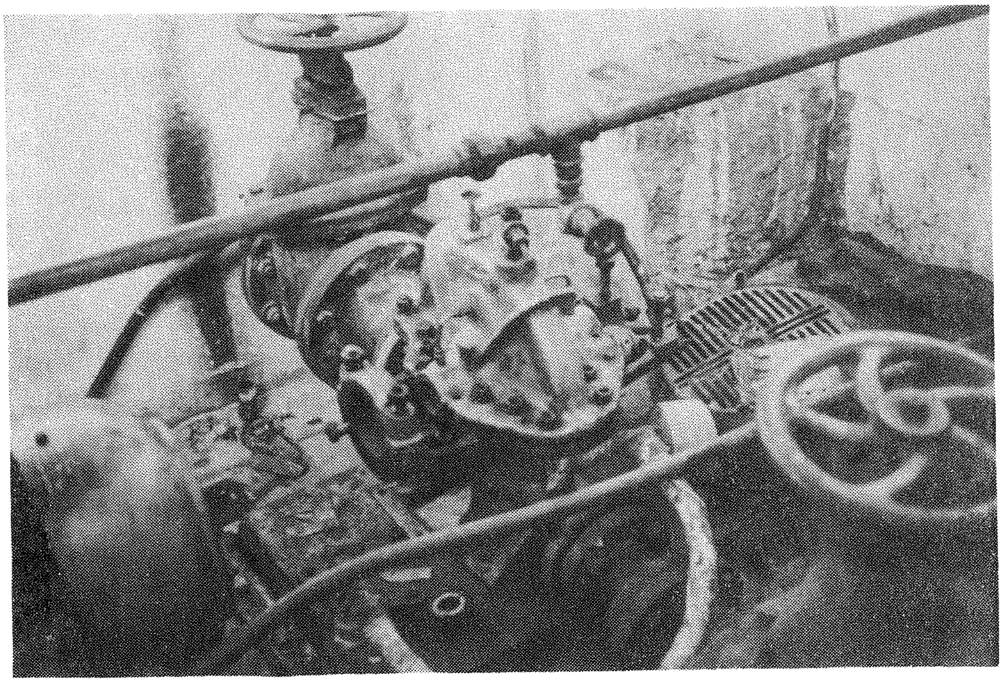


Figure 7. A dismantled centrifugal pump.

At some schemes pumping of raw water is performed by submersible pumps suspended in the intake sump beside the suction pipeline of the existing pumping stations (Figure 8).

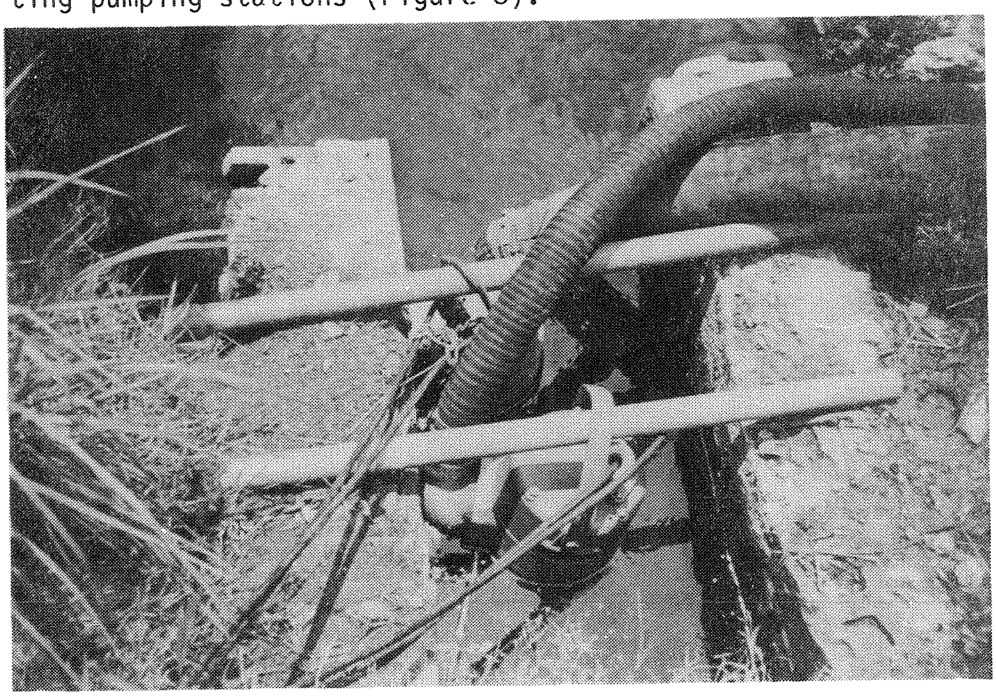


Figure 8. Submerged type of low lift pumps (Solwezi).

The state of the mains and the pipework system were checked very briefly during this survey. However, by the visit at Chomna water works a serious leakage of the raw water main was discovered and the losses were estimated to 10-15 l/s.

Figure 9. Leakage of a raw water main.

3.4 Water treatment works

The general sequence of unit operations is shown in Figure 10.

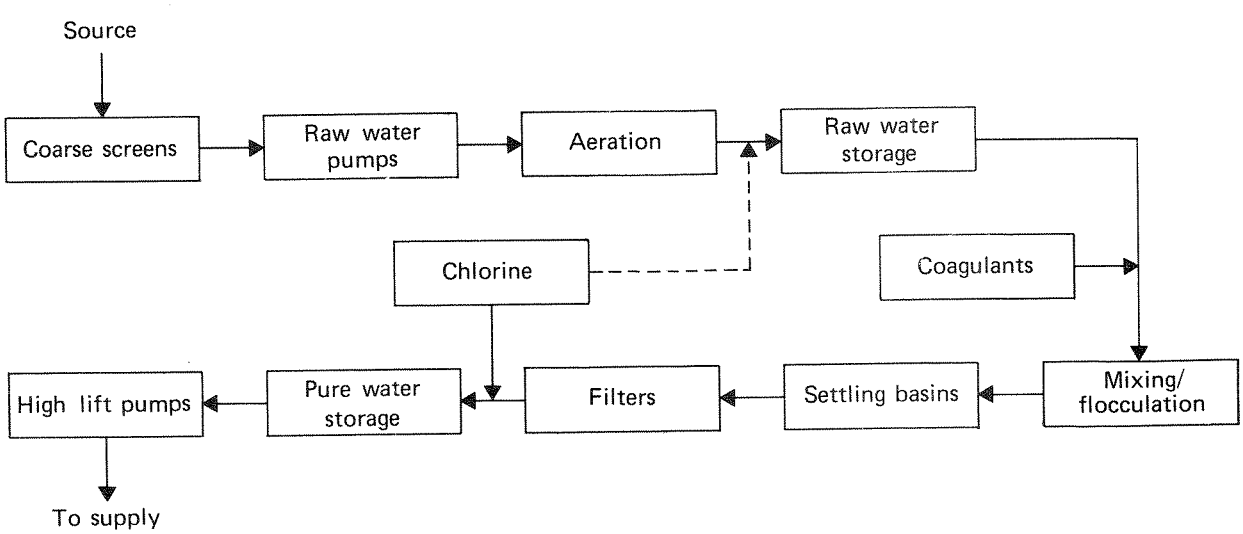


Figure 10. Flow diagram showing typical unit processes at the schemes visited.

Detailed information on the existing water supply systems in any one town is found illustrated in the Appendix B of this report. Some features of the various schemes are outlined in the following pages. This relates to the unit operations put forward in Figure 10.

3.4.1 Aeration

Aeration is commonly practised in the tropics. Aeration can play a part in controlling iron (oxidation) tastes, odours and corrosion (CO_2-stripping). Simplicity of design and operation is desirable and tray-type aerators are often used (Figure 11).

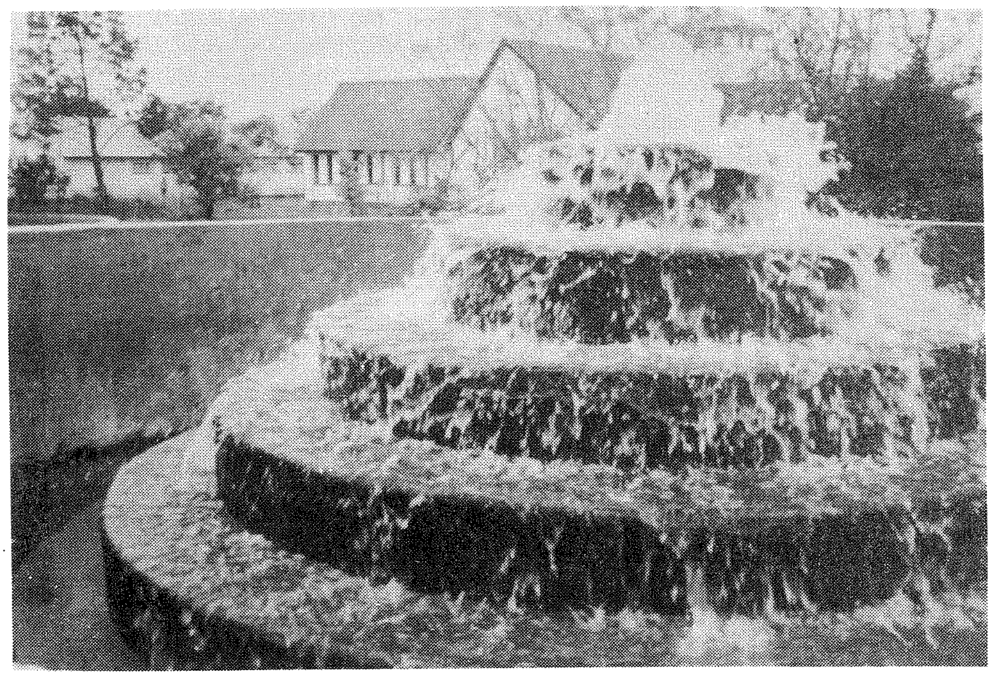


Figure 11. Tray-type aerator (Kalomo).

The need for aeration at Zambian water works is, however, doubtful and the existing units should be regarded as potential volumes for other purposes connected to plant rehabilitation.

3.4.2 Coagulation, mixing, flocculation and sedimentation

The main purpose of these unit operations is removal of colloidal solids and reduction of colour. The smaller water works are often delivered as pre-fabricated plants (Figure 12).

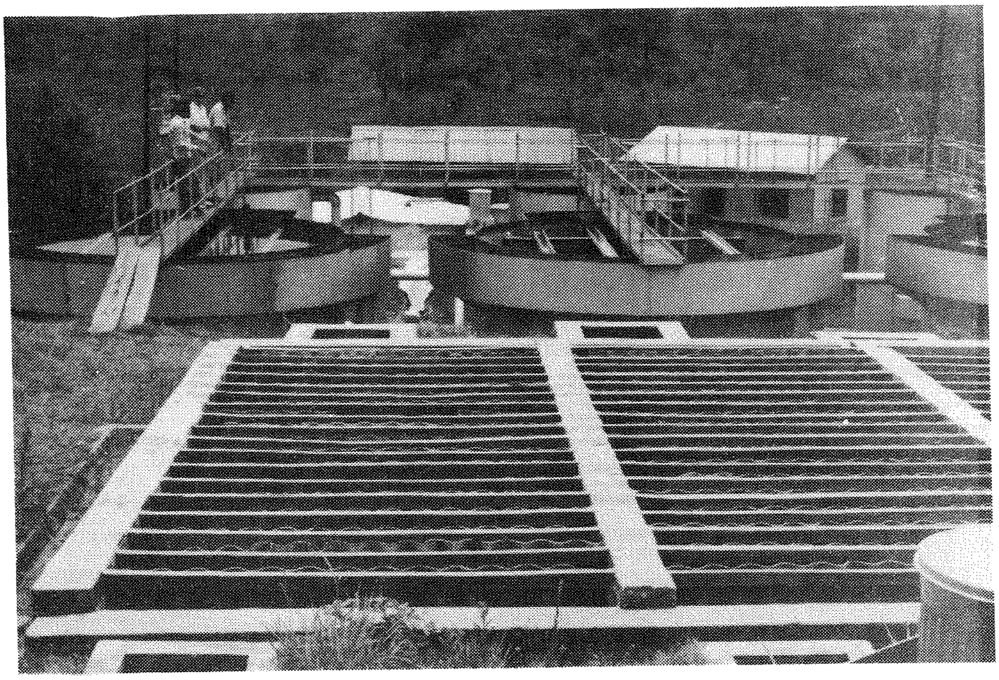


Figure 12. Package treatment plant at Solwezi.

Chemical addition is often carried out by the drip and bowl method using alum solution (figure 13).

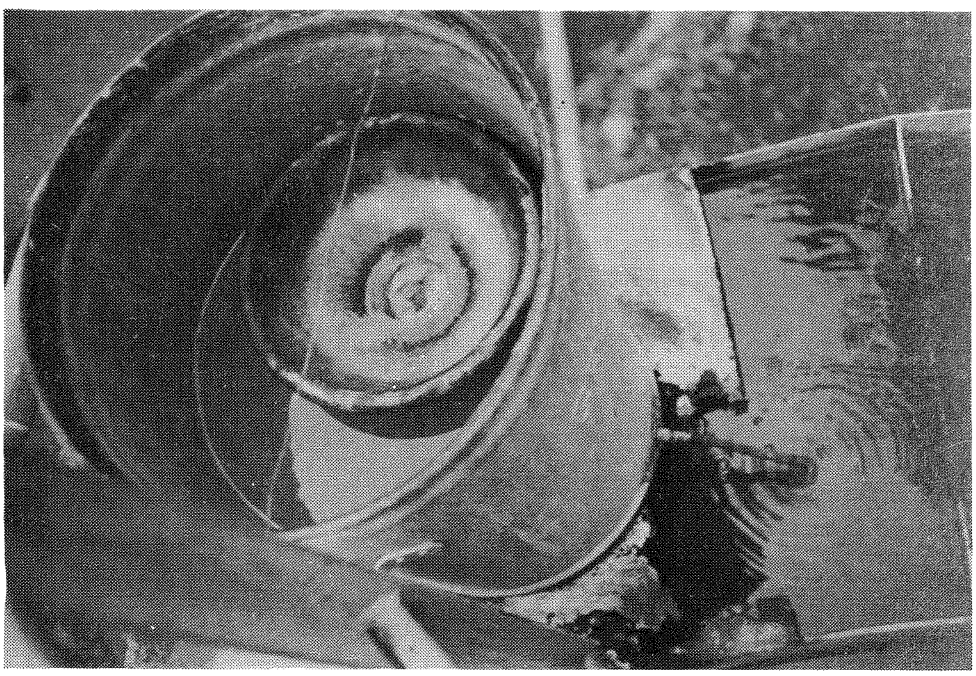


Figure 13. Dosage of chemicals carried out by the drip and bowl method.

Although it is a cheap and extremely simple method it needs a complete understanding of its capability and limitations.

The action of mixing and flocculation can be carried out in two ways, either by mechanical stirrers or by gravity along baffled channels. The latter method has the merit of simplicity and cheapness, thus been the most widely used.

The sedimentation basins are normally rectangular horizontal-flow basins at the larger schemes while the smaller schemes are equipped with upward-flow circular tanks.

When evaluating different systems of sedimentation one should keep in mind that the main task of this process is to remove the bulk of suspended solids before the water is being polished in the following filtration step.

Thus one important operational factor is efficient removal of accumulated sludge during high-silt loading.

3.4.3 Filtration

Filtration is the last separation step in the treatment process. In "conventional" treatment plants coagulation and sedimentation are followed by rapid gravity sand filters or pressure sand filters (Figure 14 and 15).

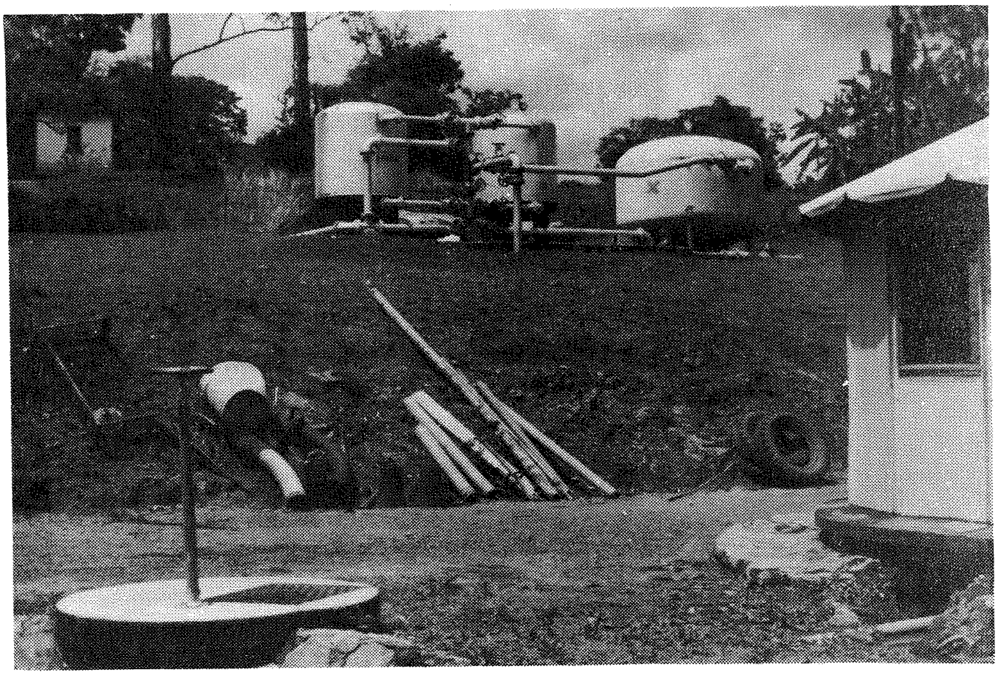
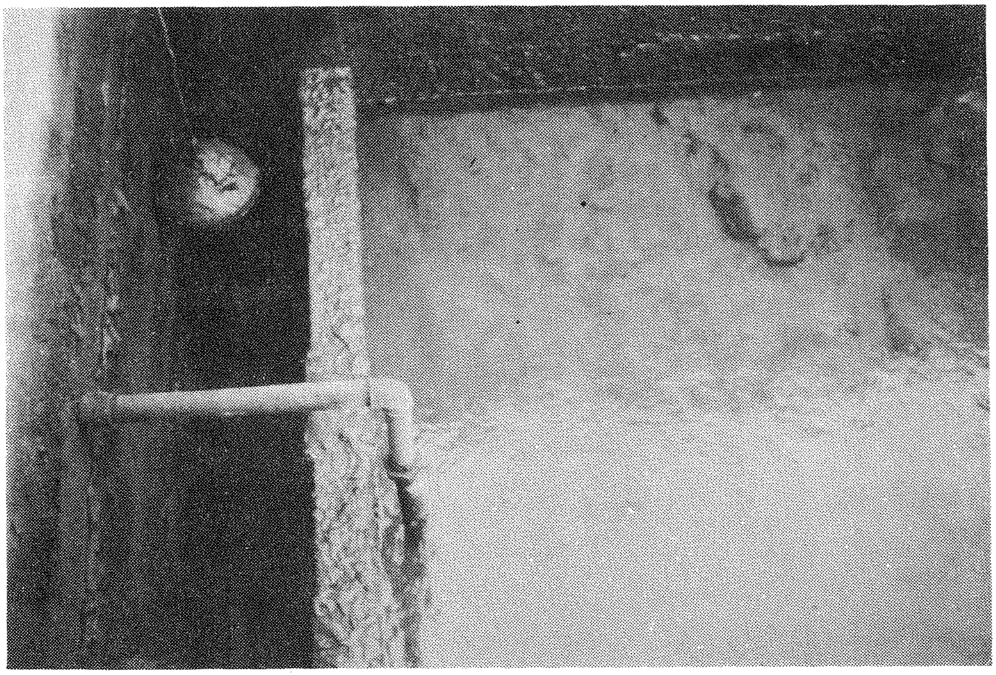


Figure 14. Pressure sand filter at Mwinilunga.

a) Before backwashing.



b) During backwashing.

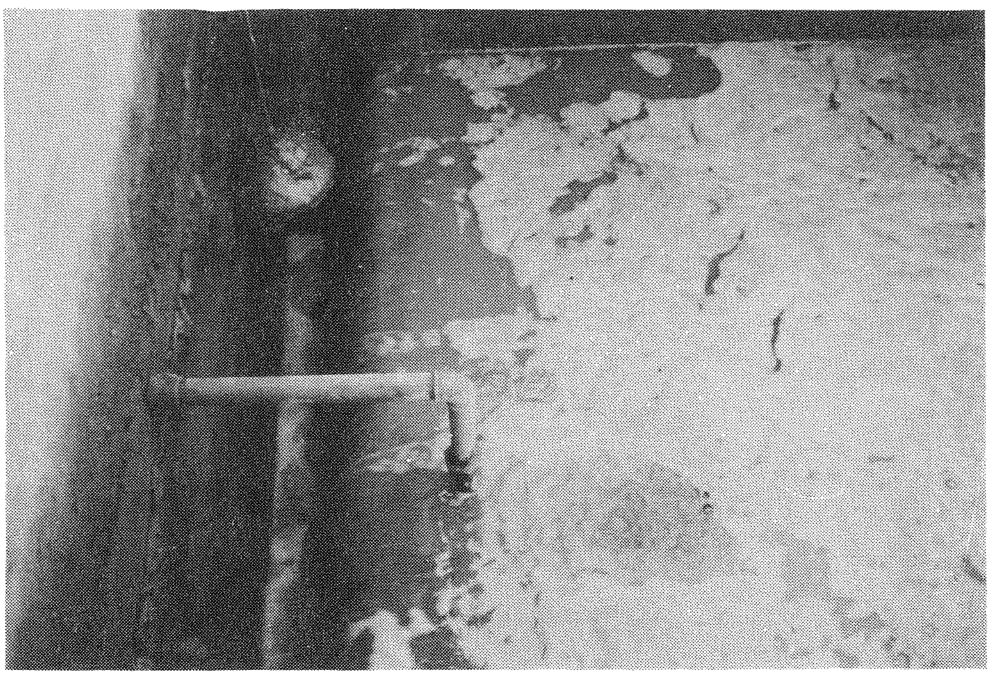


Figure 15. Rapid sand filters at Choma.

A major problem at most of the plants was difficulty in obtaining filter sand of suitable uniformity and grade.

As a result, losses of sand during backwashing etc. were not replaced or were replaced by unsuitable sand. Insufficient backwashing was recognized as a problem at some plants (figure 16).

Slow sand filters are alternatives to conventional treatment. Because of the ready availability of cheap labour it is believed that there are many possibilities for the use of slow sand filters in developing countries. The method would appear to have benefits like no need for chemicals and removal of harmful bacteria, and the filters can be built using local materials.

However, slow sand filters do have disadvantages like large ground area requirements, no colour removal, unsuitability for high turbid water and algal growth, and they are labour intensive and require knowledge of operation.

Three of the schemes in the study sample have slow sand filters. The spare sand sample in figure 16 illustrates the problem of getting sand with proper quality.

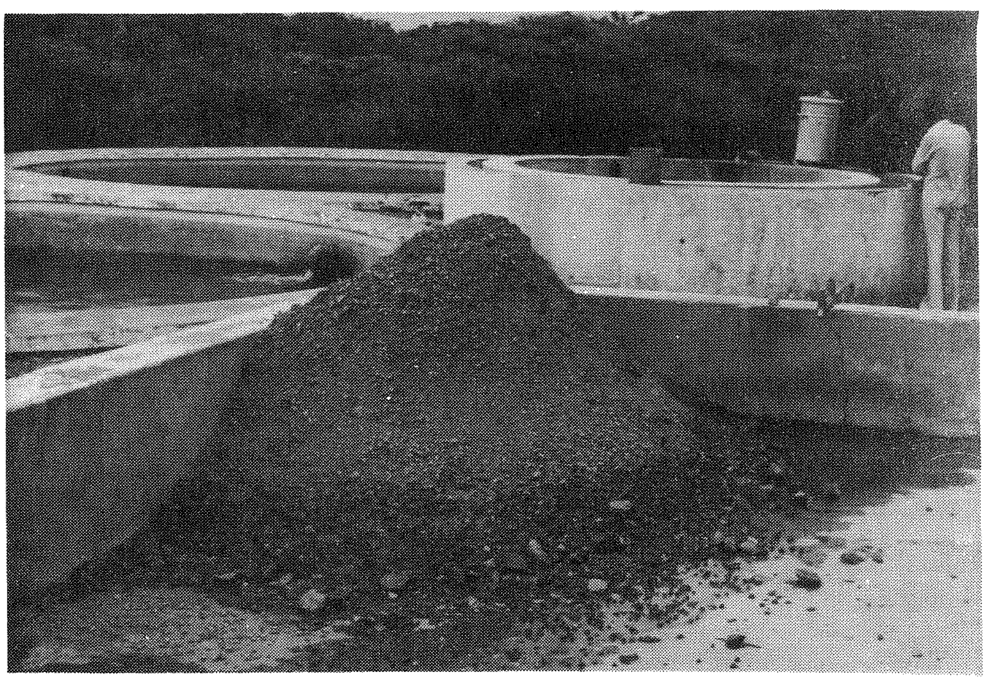


Figure 16. Slow sand filters at Kasempa.

Probably because of silting all the slow sand filters were operating at reduced capacity and pre-treatment is a requirement. Consequently the filters were by-passed during peak load periods in order to reduce the manpower input to a realistic level.

3.4.4 Disinfection

Disinfection of water supply is normally achieved by addition of chlorine to the water.

In small plants it is common to find that the chlorine is added to the water in the form of sodium hypochlorite, powdered chloride of lime or calcium hypochlorite. Solutions are made up at the water works.

The solution may be pumped into the water supply by a dosing pump or may gravitate through a constant head orifice (Figure 13). At some plants disinfection was carried out by adding some spoons of chlorine into the clean water storage several times a day. This intermittent method is not to be recommended due to insufficient mixing conditions and time of reaction.

Chlorine gas is widely used in treatment plants of the large size. Chlorine gas is supplied to the water works in liquid form in steel cylinders or drums. Relieving the pressure on the liquid chlorine allows it to convert to the gaseous form. The chlorine equipment should consist of a pressure reducing valve and a device for measuring the chlorine flow. The chlorine may be made into a solution which can be injected into a pressure main or if circumstances are suitable, the chlorine gas can be added directely without making a solution.

The installation shown in Figure 17 is not suitable for controlled addition of chlorine due to the lack of flow measuring equipment and weight equipment.

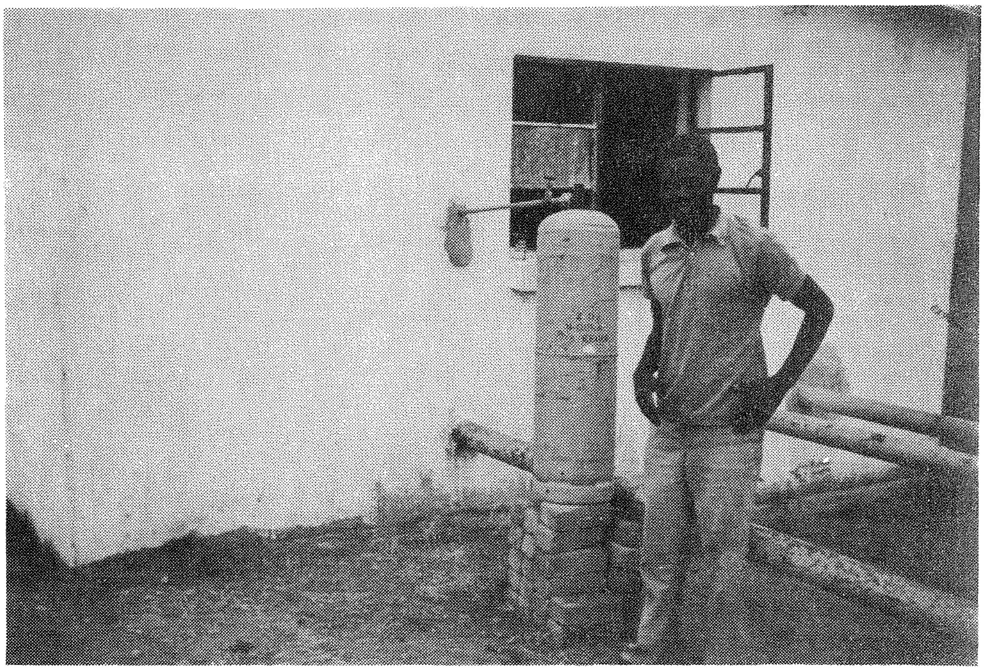


Figure 17. Gas chlorinator installation at Kalomo water works.

One should also keep in mind the hazards of leaks on the joints and chlorine pipes. At one particular plant leakage of chlorine caused serious corrosion problems of the electric equipment.

3.5 Supply of chemicals and filter sand

A reliable supply of chemicals is of major importance for the water treatment processes. The main chemicals are chlorine for desinfection and alum for coagulation. Normally orders have to be placed well in advance, which in turn makes storage and handling of great importance.

Dosage of chlorine is a measure to protect the consumers against water born- diseases and thus is the most important. At the time of visit there was lack of chlorine at four schemes and the actual amounts stored at the other plants were equivalent to 15 to more than 100 days demand. (Table 3).

Table 3. Supply and consumption of desinfection chemicals.

Township	Type of chemical	Normal dosage g/m^3	Method of dosage	Stored at the time of visit kg	Day's consumption	Comments
Mumbwa	Calcium hypochlorite	0.5	Drip feed	Not checked	Not checked	
Chongwe Centre	"	2.9	Manually into low level storage	30	90	
Kitwe	Chlorine gas	1.6	Gas	Plenty	A lot	
Mufulira	"	0.5	Gas	0.5 m^3	105	
Luanshya	Gas or hypochlorite	1.0	Gas or solution	Not checked	Not checked	
Solwezi	Hypochlorite	0.8	Drip and bowl	50	53	
Mwinilunga	"	2.1	Solution added twice a day	0	0*	* Shortage for one week
Kasempa	"	1.3	Not checked	10	15	
Kabompo	"	1.2	Solution added twice a day	0	0*	* No chlorine, this time shortage is expected to last 14 days
Chizela	No disinfection	-	-	-	-	
Choma	Dry chlorine	Not known	Bulk dosage twice a day	Not checked	Not checked	
Kalomo	Calcium hypochlorite	0.2	Manually into clean water tank	20	40	
Zimba	Dry chlorine	5.8	Drip feed*	0	0**	* Not in operation, ** Shortage for one month
Mambova	Not known	-	-	-	-	* No water supply at the moment

At six water treatment plants chlorination was effected by adding dry hypochlorite into the suction chamber or in the clear water tank some times daily. This is a simple but not effective method.

At other small schemes chlorination is carried out continously by using the drip and bowl method using hypochlorite solution.

Coagulant aids are used in most of the works and alum is the most frequently used chemical to assist coagulation.

At the time of visit most of the rivers were relatively clear, hence there was not a crucial need for coagulants. The state regarding supply and dosage of coagulants is summarzed in Table 4.

Supply of filter sand of suitable quality seemed to be a problem at many of the schemes.

As the sand gets dirtier the filter fails to maintain required flow. Filter sand lost during backwashing and cleaning operations has to be replaced by new sand. Table 5 shows the frequency of spare sand addition and problems related to supply of sand.

At most of the plants it was difficult to get spare filter sand while at other plants filter sand was stored in unsuitable locations.

Table 4. Supply and consumption of coagulants.

Township	Type of chemical	Dosage at the time of visit g/m^3	Method of dosage	Stored at the time of visit kg	Stored at the time of visit Day's consumption	Comments
Mumbwa	Alum *	0	Manually twice a week	0	0	* Only during rainy season
Chongwe Centre	No	-	-	-	-	
Kitwe	Alum *	34	Continuous as solution	Plenty	A lot	* In addition: Lime and $KMnO_4$
Mufulira	"	18	"	Not checked	Not checked	
Luanshya	"	18	Day feeder	"	"	
Solwezi	"	20	Drip and bowl	"	"	
Mwinilunga	No	-	-	-	-	
Kasempa	Alum	1.3	Drip feed	25	38	
Kabompo	"	1.2	Drip and bowl	25	30	
Chizela	No	-	-	-	-	
Choma	Alum	43	Drip feed	300	5	
Kalomo	No	-	-	-	-	
Zimba	Alum	4.4	Manually dry feed	100 *	130	* Lack of alum March-Oct.
Mambova	-	-	-	-	-	

Table 5. Supply of filter sand.

Township	Filtration method	Addition of new sand	Comments
Mumbwa	Rapid gravity sand filter	Not known	
Chongwe Centre	Pressure sand filter	Once a year	Spare sand stored at the floor in the pumping station
Kitwe	Rapid gravity sand filter	Not since-80	
Mufulira	"	Not since-75	
Luanshya	"	40 t/year *	* Due to losses through the bottom nozzles
Solwezi	"	Not since-80	
Mwinilunga	Pressure sand filter	Not since-80	
Kasempa	Slow sand filter		Reduced capacity due to silty sand
Kabompo	Rapid gravity sand filter	Once a year	Sand from Luapula, local gravel
Chizela	-		
Choma	Rapid gravity sand filter	Not known	Spare sand spread on the ground. Ineffective backwashing
Kalomo	Slow sand filter	Not known	Periodically scraping of top layer.
Zimba	"	Not known	
Mambova	-		

4. FUTURE INCREASE IN WATER DEMAND AND PRODUCTION CAPACITY

4.1 Estimated population and demand development

The population and water demand development of the study sample as estimated from feasibility studies are shown in Table 6. The average demand does not include losses at treatment plants and leakage/wasteage. These normally add 20 - 22 % to the estimated net demands. Peak consumption factors (Peak month + 20 % and peak day + 10 %) are also to be included when designing the water supply systems.

Table 6. Population and water demand projections.

TOWNSHIP	Study 82/83	Population	Production m3/d	Year	Population	Average net demand m3/d	Year	Population	Average net demand m3/d	Year	Population	Average net demand m3/d	Year	Population	Average net demand m3/d
Mumbwa		6.239	1.800	83 :		1.190	88 :	7.825	1.581	93 :	10.381	2.184			
Chongwe Centre		4.000	114												
Kitwe		130.000	56.000	85 :	154.300	358.800	90 :	200.000	434.700	95 :	254.600	519.400	2000 :	319.000	
Mufulira		65.000	19.500	85 :	92.789	29.300	90 :	118.710	38.900	95 :	148.036	50.100	2000 :	181.260	63.300
Luanshya		90.000	17.000	80 :		11.975	85 :		19.286						
Solwezi		15.000	1.818	80 :	217.500	1.759	90 :	36.068	4.444				2000 :	58.750	8.664
Mwinilunga		3.350	400	80 :	7.500	641	90 :	11.334	1.156				2000 :	17.179	2.045
Kasempa		3.063	500	80 :	4.646	485	90 :	6.617	923				2000 :	13.126	1.487
Kabompo		5.357	700	80 :	11.107	791	90 :	15.358	1.320				2000 :	21.252	2.113
Chizela		2.000	180	80 :	2.000	232	90 :	2.688	316	95 :	3.116	365	2000 :	3.612	423
Choma		3.500	1.380	83 :		9.170	88 :		13.350	90 :		15.500			
Kalomo		11.000	2.070	83 :	12.321	1.481	88 :	15.086	1.807	93 :	18.080	2.159			
Zimba		3.200	171	78 :	3.286		86 :	5.084	466	93 :	6.322	684			
Mambova		2.500	0	89 :	2.845	326	88 :	3.527	545	93 :	4.502	863			

4.2 Potential for upgrading existing schemes

The capacity of existing water works is restricted by one or more of the following components:

- sources and intakes
- pumping stations
- trunk distribution mains
- treatment plants
- storage volumes
- distribution network.

Considerable augmentations or completely new schemes are often required to make the works capable of dealing with predicted future demands.

Only a few of the visited schemes are able to meet 100 % of the present demand. It is, however, felt that short term increase of production may bring the state of supply up to a suitable level.

This section includes a simple analysis of how the water production could be increased, say by 30 - 50 %, at some of the visited schemes. It is assumed that the volume of production is restricted by pumping and/or treatment capacity (i.e. sufficient capacity of water source, storage and distribution system). The limiting link in the treatment process is assumed to be the filtration step. For this study typical rates of 0,2 $m^3/m^2 \cdot h$ (slow sand filter) and 6 $m^3/m^2 \cdot h$ (rapid sand filter) at 23 hours per day operation have been chosen.

The potential of adding more pumping capacity without any extensions of amin pipelines or distribution network is assumed to be 50 % when an extra pump is put into parallell operation.

The results of this analysis is shown in Table 7.

Table 7. Analysis of possible increases in capacity.

TOWNSHIP	SAND FILTRATION		LOW LIFT		HIGH LIFT		SHORT TERM IMPROVEMENTS
	Present output m^3/d	Max Capacity m^3/d	Present output m^3/d	Max Capacity m^3/d	Present output m^3/d	Max Capacity m^3/d	
Mumbura	1.800	3.970	1.800	2.700	1.800	4.320	Put the third filter in operation, increase spare pump capacity.
Chongwe Centre	114	552	114	200	114	1.824	Increase Low Lift capacity.
Kitwe							
Mufulira							Not considered.
Luanshya							
Solwezi	1.818	1.450	1.818	1.818	1.818		Increase treatment capacity and high lift/low lift capacity.
Mwinilunga	(400)	1.063			(400)	1.728	Increase treatment capacity.
Kasempa	500	422	500	500	500	1.000	Increase treatment capacity.
Kabompo	700	676	700	700			Increase treatment capacity and low/high lift.
Chizela					180		New source (Kabompo River) incl. pumping station and pipeline.
Choma	1.380	4.608	2.280	3.500	1.380	1.380	Increase high lift capacity, clean up the sand filters. Repair the raw water pipeline.
Kalomo	2.070	2.150	I:2.070 II:2.070	2.070 2.070	2.070	2.070	Increase treatment capacity and low lift I/high lift capacity.
Zimba	171	240					Slow sand filters must be cleaned up. Coordination with Zambia Railway's scheme.
Mambova	0				0	400	Diesel pumps and chlorination must be installed.

The table shows the present output and the maximum potential capacity of the existing schemes.

As seen from table 8 it is possible to increase the filtration capacity by using spare capacity or by building additional units. Another measure of increasing treatment capacity in the dry season is to bypass the coagulation/filtration step and just chlorinate the water. At some of the plants production is limited by the pumping capacity only.

Despite the simplicity of this analysis it is obvious that upgrading of existing water works is an alternative to construction of new schemes at several townships. At some supplies minor improvements could significantly increase the quantity, and/or improve the quality, of the water available. In some cases the increase in capacity may still fail to supply today's peak requirements. In others the period for which the investment would allow all demands to be met may be quite short. But the crucial factor is that it would represent an improvement and allow a higher proportion of present and future demand to be satisfied. Furthermore the total period required for planning and implementing most of these proposals would be very short.

It is therefore contended that when there is limited money available for water supply development there may be considerable merit in an incremental approach. The application of limited development finance for small augmentations could lead to significant improvements at many supplies even though the solution proposed would be sub-optimal in a situation where more resources were available.

However, a more detailed analysis of each particular scheme is needed before any implimentation of limited augmentations.

4.3 Economical assessment of the limited augmentation concept

4.3.1. Scheme categories

In The Main Report (Chapter 3) the consultants have categorised DWA supplies into three groups, large, medium and small. Inspection of the Phase I design capacities of the consultant's feasibility studies suggests that the suitable grouping would be as follows:

- Large schemes, those having an end of Phase I demand above 1 500 m^3/day.

- Medium schemes, those having an end of Phase I demand between 600 and 1 500 m^3/day.

- Small schemes, those having an end of Phase I demand below 600 m^3/day.

The demand characteristics of three typical schemes, one in every category which will be used in the cost calculations, are shown in Table 8.

Table 8. Typical DWA Supplies.

Supply Category	Demand in 1988 (m^3/day)	Present demand (m^3/day)	Present capacity prior to augmentation (m^3/day)	Probable capacity with limited augmentation (m^3/day)
Large	2 000	1 440	900	1 350
Medium	1 000	920	480	720
Small	350	252	160	240
Overall average	962	693	448	672

It should be noted that these "typical" schemes do not represent any particular township, but they have been constructed to be typical of schemes in their particular category, i.e. the 1988 demands shown in the first column, 2 000 m^3, 1 000 m^3 and 350 m^3 have been selected as typical of large, medium and small supplies, respectively.

The bottom line of Table 8 shows what is termed the typical overall average scheme. Its characteristics were calculated on the assumption that 19 % of schemes are large supplies, 46 % are medium supplies and 35 % are small supplies. These percentages represent the proportions of the 38 schemes, for which the consultants have examined the feasibility studies, which fell into the three categories.

The present demands shown in column two are 72 % of 1988 demands, based on a typical annual increase in demand of 6.7 %. The present capacities shown in column three are based on typical current production capabilities. These are often below the original design capacities due to aging pumps etc. The fourth column shows production capabilities that could result from the limited augmentation strategy proposed in Section 4.2.

4.3.2. Development costs

Table 9 presents the average unit cost figures for the large, medium and small supply categories based on schemes which have been costed or recosted in, or since, 1980.

Table 9. Average Development Costs of Township Water supplies. (K per m^3/d in 1983 prices).

Consultant	Large supplies	Medium supplies	Small supplies
Østlandskonsult	-	1 500	2 300
Lottie	900*	1 800	3 600
Gauff	1 900	4 000*	-
Best guesstimate	1 300	1 800	3 000

* only one scheme involved.

The bottom line of Table 9 shows the consultant's best average unit cost guesstimate i.e. large schemes K1300/m^3, medium sized schemes K1800/m^3, and small schemes K3000/m^3. Although these costs have allowed for all local inflation, they do not include the effects of devaluation which are currently working their way into construction costs. 1983 post devaluation costs will be taken as K1500, K2000 and K3300 for large, medium sized and small schemes respectively. These figures have been applied to the "typical" schemes. Table 10 shows the resulting development costs.

Table 10. Capital Costs of the Major Augmentations of Typical Supplies.

Supply	Proposed capacity (m^3/day)	Unit cost (K/m^3/day)	Total cost (K)
Large	2 000	1 500	3,000,000
Medium	1 000	2 000	2,000,000
Small	350	3 300	1,155,000

4.3.3. Limited augmentation costs

The consultants have proposed a possible strategy for DWA if capital finance is extremely scarce, that of incurring limited expenditures to maximise the value of present resources by upgrading the most severe existing constraints.

Pumping and treatment capacity are assumed to be the limiting factors. This means that storage volumes, rising mains, reticulation and power supply are sufficient for a marginal increase of 50 %.

The major upgrading costs are estimated to be:

Item		Large	Medium	Small
One additional filter unit	K	70 000	60 000	30 000
One additional low lift pump	"	20 000	15 000	10 000
One additional high lift pump	"	26 000	15 000	10 000
Civil works, planning and erection etc.	"	24 000	20 000	10 000
Miscellaneous	"	10 000	10 000	10 000
Total	K	150 000	120 000	70 000

These figures represent 5 %, 6 % and 6.1 % respectively of the cost of implementating the full augmentations proposed by the various feasibility studies. Of course the quantity of water supplied will be considerably less, sometimes even failing to meet current demands. On the average it is estimated that it should be possible to increase the current production capability of a scheme by 50 % by this strategy. This will sometimes mean that a scheme will only be brought up to the original design capacity. However, if capital funds are short this approach represents a "better buy" than major augmentations, even though the latter would meet future demands for several years.

5. A PROPOSED REHABILITATION PROGRAMME FOR EXISTING SCHEMES

5.1 Objective

The concept of maximising the effectiveness of a limited sum of money by identifying low cost improvements which would ease major supply constraints at existing township supplies was endorsed by DWA personnel with whom the consultants discussed the problem. It is, therefore, strongly recommended that the idea be further pursued by a donor funded study which should be part of an aid package which also includes finance for carring out the programme suggested in this chapter.

The major objective of the programme is to increase the quantity and/or improve the quality of the water available at a number of schemes by limited investments. Even if the increase in capacity may still fail to supply today's peak requirements the minimum objective is to produce a disinfected water which meets one or the other of the WHO International Standards for Drinking Water.

5.2 Scope of the programme

The purpose of the programme is to demonstrate the Limited Augmentation Strategy as proposed in the Main Report at several schemes.

The programme is proposed to be conducted by a team which will be responsible for technical improvements, upgrading of operation and maintenance procedures and on-the-job staff training.

The phasing of the project at each particular scheme will be as follows:

Phase 1. Status of the present water supply scheme.
" 2. Augmentation work plan and budgets.
" 3. Implementation of proposed augmentations operation and maintenace programme staff training.
" 4. Project evaluation.

Thus the augmentation team will spend periods at different schemes in sequence during the implementation of the project. The rehabilitation programme should carry on for at least 3 years.

5.3 Content of the programme

Selection of working area and ranking of schemes should be carried out in cooperation with the Department of Water Affairs, Provincional Water Engineers and local water authorities.

Phase 1. Status of present water supply scheme

Identification of the major constraints which affect the supply capacity of the water works and/or the quality of water supplied is an important basis in order to diagnose the situation.

The contraints related to the construction of each scheme will comprise one or more of the elements listed in section 4.2.

Shortages of water available or polluted water in supply may also be a result of inefficient management. This may be due to excessive leakage through the system, poor maintenance of pumps and engines, lack of purchase procedures and inefficient use of water resources.

In general, when entering a District, the District Governor's Office (D.G.O.) will first be visited so that the District Secretary can be met and told of the likely extent of the investigations to be made. He will also be requested for available data relating to population and details or comments or complaints received by his office likely to be of use or interest.

In all cases the schemes will be discussed with the Provincial Water Engineers and the local officers-in-charge (usually Engineering Assistants) and operators will be contacted. The schemes will then be examined in detail at all stages - source, pumping, treatment, storage, reticulation etc. Drawings will be checked, notes made and, where necessary, levels taken to complete the data and permit analyses of the systems to be made. Types, sizes, makes and models of all machinery will be recorded and samples of water will be taken, from the source(s) and after treatment for analysis.

The team will also look into the management aspects of each scheme. Existing Feasibility Study reports will also be important inputs in order to diagnose the existing water supply schemes.

Phase 2. Augmentation work plan and budgets

For each of the schemes covered by the augmentation project an upgrading plan will be worked out. The first step in planning is to list the separate tasks to be carried out in order to improve the level of supply. This will be followed up by a cost-benefit analysis as illustrated in Figure 18.

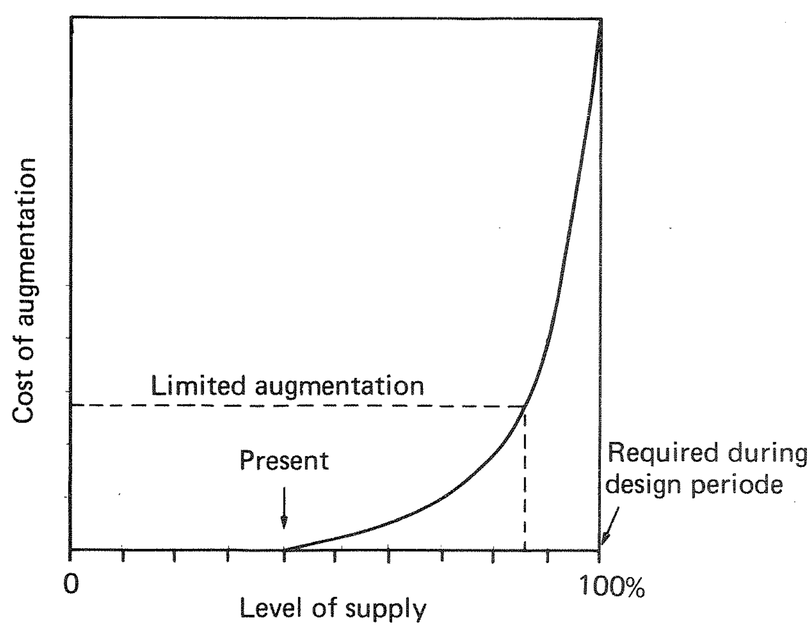


Figure 18. An illustration of expected development costs vs. increased level of supply.

In practical cases the curve presented in figure X will have a stepwise configuration rather than a smooth shape.

Regarding the upgrading of the technical facilities one will distinquish between:

- Improvement which can be carried out immediately with existing staff, tools and spare parts, and
- improvements which require major construction work and/or purchasing of new equipment.

In general the upgrading of a scheme will take place in two or more steps due to the planning work and time of delivery of the equipment.

The plan of augmentation will also include an operation and maintenance programme.

The objective of the operation programme will be to ensure the provisions of a continued and satisfactory service to the consumers at minimum cost. The augmentation team will work out a modified operations manual for each scheme where the essential operational tasks for each part of the water supply system is described. Attention will also be paid to laboratory control and recordkeeping.

The typical type of maintenance at present is known as emergency maintenance which means that equipment is run until it breaks down. Repairs and replacements are then effected if skilled staff and funds are available.

The intention behind a programme of planned maintenance of any item of plant and equipment is to eliminate breakdown.

In proposing the instructions required, direct experience of local operating conditions and plant performance will be of great importance. Thus participitation of the Provincial Water Engineer and the Officer in Charge will be highly appreciated.

The first step in planning preventive maintenance is to list the separate installations. Details of each installation should be recorded separately on a suitable simple form which could eventually provide a complete history of the installation. Certain pieces of equipment may require separate record forms, for example diesel engine, borehole pumps, chlorinators or other chemical dosing equipment.

Details of jobs needing to be done should then be listed in decending order of importance. It will be stressed that the maintenance of very important items must recieve the personal attention of the Engineering Assistant (at larger schemes) or the W.D.O.

The final maintenance programme will be a part of the operating manual referred to earlier.

Plans for purchasing and storekeeping will be updated after augmentation as a part of the strengthening of the management procedures. A good example of this is afforded by the stock of chemicals required for water treatment. Such chemicals are often unobtainable in less than a couple of months, or even longer if they are imported.

One of the most important aspects, if not the most important aspect, of the successful operation of water supply schemes is the proper education and training of the staff.

All levels of operating staff from the labourer through to the manager will require appropriate formal education and training. On-the-job training of different staff categories will be offered as an element of the augmentation package.

The operating staff will be taught how to operate and maintain the works and the reason and significance of the various operations, including the operating of pumps, valves, cleaning screens and knowing how and when to clean slow sand filters, how to ensure the correct chlorine dose and use a disc comparator for measuring the residual. They will also be instructed on how to keep daily records of the quantity of water passed into supply, the quantities of chemicals used, the operating time of the pumps etc., and when to indent for further supplies so that they are received in good time.

Phase 3. Implementation

The augmentation plans will be discussed with DWA and the donors before implementation. It is important to make decisions about the level of service the augmentations should be aimed against considering the financial limitations.

One important aspect of this project should be a short period required for planning and implementing most of the proposed improvements. Thus urgent required low-cost augmentation will be implemented during the field work without further discussions.

Improvements which require purchase of external equipment and services wil be administered by the project group, and carried out when the plans are approved by the donor and the relevant authorities.

The operation, maintenance and on-the-job training program will be implemented simultaneously to the technical part of the program. The training will be followed up annually by refreshment courses.

On a permanent long term basis the rehabilitation activity should be handed over to the Provincional Water Engineers of the local authority who are responsible for operation and maintenance.

Phase 4. Project evaluation

After the schemes have been rehabilitated and have been in operation for one year, an evaluation should be carried out.

5.4. Organization of the programme

It is suggested that the rehabilitation team will be equipped with vehicles, tools, spareparts, pumps and other resources needed for an effective implementation. We initially envisage the composition of the team to be as follows:

- 1 senior Water Engineer (Team leader)
- 1 Water Engineer
- 1 Mechanical Engineer
- 1 Senior Waterwork Superintendent
- 2 Assistants/ Drivers

Due to the specialized nature of the jobs it will be important to use staff with relevant experience from similar studies and who know the local conditions and problems.

The Team Leader should be a qualified engineer of senior rank with considerable experience in operating, training and financial management of urban water supply schemes. The Water Engineer is responsible for the education and on the job training part of the program. The Mechanical Engineer should also be a qualified engineer with practical experience through designant cous.. of water supplies pumping plants, and t.. operations, maintenance and repair. The Senior Waterworks Superintendent should be an person with practical wxperience in day-to-day technical operations of township water supplies. This person will cooperate with the Water Engineer in the training programme.

The assistants should have at least secondary shool education, driver licence and experience with water works, maintenance and repair. In addition to the rehabilitations Team it is of great importance for the results that local staff at different levels take part in the work.

6. REFERENCES

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APPENDIX A

SUMMARY INFORMATION FROM THE QUESTIONNAIRES

Where no records are given in the tables,
no information had been available to the consultants

Township	Page
Mumbwa	51
Chongwe Centre	54
Kitwe	57
Mufulira	60
Luanshya	63
Solwesi	66
Mwinilunga	69
Kasempa	72
Kabompo	75
Chizela	78
Choma	81
Kalomo	84
Zimba	87
Mambova	90

Scheme: MUMBWA, Central Province

Contact persons: Treatment plant operator

General

First built: 1956

Run by: DWA since 1971

Source

Source: Chitilya River, Mumbwa Boma Dam

Quality:

Intake: Concrete channel

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers		6,239		
Average prodn. at visit (m^3/d)		1,800		
" " wet season "		1,800		
" " dry " "		1,800		
For gardeNing " " "				
Estim average demand wet season (m^3/d)		1,500		
" " " dry " "		2,500		
Supply wet season hours per day				Not sufficient capacity
" dry " " " "				

Limiting factor for increased capasity

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe				
Rising main				
Retaiarlation				

Low level storage (m^3): 220 cm^3

Elevated storage ("): 364 cm^3

Pumps

		Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1	2	Flygt			75	24 (12 hours each)
" " " 2		KSB ETA 80 - 20	11	1976		
" " " 3						
High lift pump 1	2	KSB ETA 80 - 26	45	1976	90	20 (10 hours each)
" " " 2						
" " " 3						

Comments

Scheme MUMBWA

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator	5				1 Supervisor
	Mechanician					
	Plumbers	2				
	Pump attendants					
	Handymen					
	Watchmen	2				
	Laborer	3-4		DWA		
	Electrician					
Administrative	Off in charge	1			75 %	W.D.O.
	Licence officer					
	Typist	1			50 %	
	Office ordery					
	Clerical officer					
	Engineering assistant	1			50 %	
	Causal					

Problems associated with the water supply: Insufficient capacity in dry season. The chlorination is not switched off during backwashing of filters, this results in temporary over dosage of chlorine in a small quantity of filtered water.

Scheme:		MUMBWA
	Chemical precipitation	Yes, only in the rainy season
Chemical preacipitation	Supplier	
	Storage	
	Dosage method	Bulk dosage 20 l twice a week in the inlet channel
	Preparation before dosage	No
	Average consumption	40 kg/week x 8 week
	Amount stored at plant by visit	No
	Visible difference og quality?	
Sedim.	Flocculation?	No
	No of sedimentation tanks:	3 (2 in operation)
	Tank configuration	Circular
	Surface area/depth	3 x 13.9 m^2
	Sludge pumping interval, wet	
	" " " , dry	Once a week
Filtration	Type of filtration	Rapid gravity sand filtration
	No of units	3 (2 in operation)
	Tank configuration	Circular
	Filter medium/depth	Sand 0.60 m
	Filter surface area	3 x 9.6 m^2
	Backwashing interval, wet	Two times a week
	" " , dry	Two times a month
	Backwashing time	30 - 45 minutes
	Washwater consumption	One elevated tank 50 m^3
	New sand is added how often	
	Supplier of filtersand	
Desinfection	Type of desinfection chemical	Calcium hypochlorite
	Supplier	
	Storage system	
	Dosage method	Drip feed from a 100 l bucket
	Preparation before dosage	Solution 5 mg/l
	Average consumption	8 - 10 kg/month
	Responsible for buying chemicals	Provincional Water Engineer
	Amount stored at plant by visit	
	Bulk flow meter present	Yes
	Type	
	In correct operation	No
	Meterreadings:	-

Scheme: CHONGWE, Lusaka province

Contact persons: Mr. N. Sibongo D.G. Lusaka Rural District

General

First built: 1973

Run by: DWA Since 1974

Source

Source: River Dam

Quality: Visible: OK

Intake: Pipe from a concrete dam

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers		4,000	114	
Average prodn. at visit (m^3/d)				
" " wet season "				
" " dry " "				100% increase of wet season demand.
For gardeNing " " "				
Estim average demand wet season (m^3/d)				
" " " dry " "				
Supply wet season hours per day				
" dry " " " "		A few		Say 3
Limiting factor for increased capasity				

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe				
Rising main	150 mm			
Retaiarlation				
Low level storage (m^3)	250 m^3			
Elevated storage (")	44 m^3			

Pumps

		Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1	2	KSB ETA 40 - 16	5,5		4.8 is 13 2 m	24
" " " 2						
" " " 3						
High lift pump 1	2	Centrifugal	38		38	3
" " " 2						
" " " 3						

Comments

Estimated high lift pumping capacity by pumping, 80 m^3 from low level storage in 2 hours. The pumps are alternating each second week. High lift pumps are alternating every second month.

Scheme CHONGWE CENTRE

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator					
	Mechanician					
	Plumbers					
	Pump attendants	4				
	Handymen					
	Watchmen					
	Laborer					
	Electrician					
Administrative	Off in charge					
	Licence officer					
	Typist					
	Office ordery					
	Clerical officer					
	Causal					

Problems associated with the water supply: There is not sufficient capacity to meet the demand. The low lift station is flooded during the rainy season.

Scheme: CHONGWE CENTRE

	Chemical precipitation	No
Chemical preacipitation	Supplier	
	Storage	
	Dosage method	
	Preparation before dosage	
	Average consumption	
	Amount stored at plant by visit	
	Visible difference og quality?	
Sedim.	Flocculation?	
	No of sedimentation tanks:	
	Tank configuration	
	Surface area/depth	
	Sludge pumping interval, wet	
	" " " , dry	
Filtration	Type of filtration	Pressure sand filtration
	No of units	2
	Tank configuration	Circular
	Filter medium/depth	Sand pressure drop
	Filter surface area	2 x 2 m^2
	Backwashing interval, wet	5 times a week
	" " , dry	2 times a week
	Backwashing time	20 min.
	Washwater consumption	
	New sand is added how often	Once a year
	Supplier of filtersand	Spare sand is stored at the floor in the high lift pumping station.
Desinfection	Type of desinfection chemical	Calcium hypochlorite
	Supplier	
	Storage system	
	Dosage method	Added manually as dry chemicals in the low level storage.
	Preparation before dosage	None.
	Average consumption	20 kg per month
	Responsible for buying chemicals	
	Amount stored at plant by visit	30 kg
	Bulk flow meter present	No
	Type	
	In correct operation	
	Meterreadings:	

Scheme: KITWE, Copperbelt

Contact persons: Mr. Shawa, City Engineer.
Mr. Chitamba, Financial Secretary
Mr. Batelle, Vater Engineer, Mr. ?. Oft in Change at treatment plant

General

First built: 1969 (Extended in 1974)

Run by: Kitwe District Council

Source

Source: Kafue River

Quality:

Intake:

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers				
Average prodn. at visit (m^3/d)		59,000		
" " wet season "		50,000		
" " dry " "		59,000		100% increase of wet season demand.
For gardeNing " " "				
Estim average demand wet season (m^3/d)		50,000		
" " " dry " "		127,000		
Supply wet season hours per day		24		
" dry " " " "		Less than 24		

Limiting factor for increased capasity: Treatment plant and pumping capacity.

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe		400 m		
Rising main		5 km		
Retaiarlation				
Low level storage (m^3)				
Elevated storage (")				

Pumps

	Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1					
" " " 2					
" " " 3					
High lift pump 1					
" " " 2					
" " " 3					

Comments

Scheme KITWE

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator					
	Mechanician	110 for water distr.				
	Plumbers	53 for water works 4 senior staffing				
	Pump attendants	167				
	Handymen					
	Watchmen					
	Laborer					
	Electrician					
Administrative	Off in charge					
	Licence officer					
	Typist					
	Office ordery					
	Clerical officer					
	Causal	Only for construction				

Problems associated with the water supply: Chlorination is more expensive than it should be due to losses. Causes corrosion of electric equipment maintenance problems at the low lift intake because of lack of a screen. Water hammer effect in the pumphouse caused bursts of the pipe. Due to this two days without water have occured two times the last few years. There have been problems with lime supply.

Scheme: KITWE

	Chemical precipitation	Alum, Lime and $KMnO_4$
Chemical preacipitation	Supplier	Alum from Livingstone, Lime from Chilanga
	Storage	
	Dosage method	Continuously as solution
	Preparation before dosage	
	Average consumption	29 g/m^3 1950 kg/day
	Amount stored at plant by visit	Sufficient amounts
	Visible difference og quality?	Yes, flocs are generated
Sedim.	Flocculation?	
	No of sedimentation tanks:	4
	Tank configuration	Rectangular
	Surface area/depth	
	Sludge pumping interval, wet	
	" " " , dry	
Filtration	Type of filtration	Rapid gravity sand filtration
	No of units	4 (one out of operation)
	Tank configuration	Rectangular concrete basins
	Filter medium/depth	Sand
	Filter surface area	4 x 105 m^2
	Backwashing interval, wet	
	" " , dry	
	Backwashing time	
	Washwater consumption	
	New sand is added how often	Not since 1980
	Supplier of filtersand	
Desinfection	Type of desinfection chemical	Chlorine gas
	Supplier	
	Storage system	Pressure tanks
	Dosage method	
	Preparation before dosage	
	Average consumption	15 kg/h, 1.5 p.p.m. should be 0.6 p.p.m. (problems with losses)
	Responsible for buying chemicals	
	Amount stored at plant by visit	Enough
	Bulk flow meter present	Yes
	Type	
	In correct operation	No
	Meterreadings:	

Scheme: MUFULIRA, Copperbelt

Contact persons: Mr. G.G. Lungu, Town Treasurer
Mr. Gosa, Engineering Ass.
Mr. ? Senior Operator Water Works.

General

First built: Second phase in 1974

Run by: Council

Source

Source: River Kafue (Council supply)
(Mine area)

Quality:

Intake: Pontoon-mounted pumps

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers		65,000		
Average prodn. at visit (m^3/d)		19,500		Leakage and wastage 9000 m^3/d is subtracted
" " wet season "		19,500		
" " dry " "		19,500		
For gardeNing " " "				
Estim average demand wet season (m^3/d)		19,500		
" " " dry " "		22,700		
Supply wet season hours per day		24		
" dry " " " "		20		
Limiting factor for increased capasity				

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe	450 mm			
Rising main				
Retaiarlation				
Low level storage (m^3)	6,800 m^3			
Elevated storage (")				

Pumps

	Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1		113	1972	506	24
" " " 2		150	1972	528	24
" " " 3		150	1972	528	Under repair
High lift pump 1		263		484	24
" " " 2		263		484	24
" " " 3		263		484	

Comments: One low lift pump under repair at the time of visit. Two low lift and high lift pumps in continuous operation.

Scheme MUFULIRA

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator					
	Mechanician					
	Plumbers					
	Pump attendants					
	Handymen	total 49				
	Watchmen					
	Laborer					
	Electrician					
Administrative	Off in charge					
	Licence officer					
	Typist					
	Office ordery					
	Clerical officer					
	Causal					

Problems associated with the water supply: Problems with the floating portroom intake. Permanent pumps are required. Too little ground level and elevated level storage capacity.

Scheme:	MUFULIRA
Chemical precipitation	Alum
Chemical preacipitation	
Supplier	
Storage	
Dosage method	
Preparation before dosage	
Average consumption	350 kg/d, 20 g/m^3 at each plant
Amount stored at plant by visit	
Visible difference og quality?	yes
Sedim.	
Flocculation?	
No of sedimentation tanks:	8
Tank configuration	Square
Surface area/depth	4 x 41 m^2
Sludge pumping interval, wet	
" " " , dry	
Filtration	
Type of filtration	Rapid gravity filtration
No of units	4
Tank configuration	Rectangular
Filter medium/depth	Sand
Filter surface area	4 x 28 m^2
Backwashing interval, wet	24 hours
" " , dry	17 hours
Backwashing time	5 min. With air scouring
Washwater consumption	Don't know
New sand is added how often	Not since 1975
Supplier of filtersand	
Desinfection	
Type of desinfection chemical	Chlorine Gas
Supplier	
Storage system	0:5 m^3 drums
Dosage method	
Preparation before dosage	
Average consumption	10 kg/day at each plant
Responsible for buying chemicals	
Amount stored at plant by visit	One drum (3 - 4 months consumption)
Bulk flow meter present	
Type	
In correct operation	
Meterreadings:	
Comments:	There are one old (capacity 13 600 m^3/d) and one new (9,100 m^3/d) treatment plant. The latter was visited.

Scheme: LUANSHYA, Copperbelt

Contact persons: Mr. Chishiba, Town Engineer.
Mr. B.W.P. Sambo, Financial Secretary

General

First built: 1955

Run by: Luanshya District Council

Source

Source: Kafuba River, Luanshya Dam, Mikomfiva Dam, Beerhall stream.

Quality:

Intake:

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers		90,000		
Average prodn. at visit (m^3/d)		17,000		
" " wet season "				
" " dry " "		17,000		10% vast. and leak.
For gardeNing " " "		3,000		
Estim average demand wet season (m^3/d)				
" " " dry " "		17,000		
Supply wet season hours per day				
" dry " " " "				

Limiting factor for increased capasity: Rising main capacity and rehability. Filter capacity.

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe			PVC	
Rising main	400 mm	12 km	Fiberglasscoated steel.	
Retaiarlation				

Low level storage (m^3)

Elevated storage (")

Frequent breakages in the rising main gives big problems.
9.810 m^3 (4 reservoirs)
1.320 m^3 (3 reservoirs)

Pumps

	Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1 Kafubu	2x Weir-Handl.	280		454	24 alternate each week
" " " 2 Luanshya		113		130	
" " " 3 Mikomfiva	2x Sentrifugal	30		95	21
Beerhall	2x Sentrifugal	38		38	24
High lift pump 1					
" " " 2					
" " " 3					

Comments: The pumps are serviced at Water Engineering, KITWE.

Scheme LUANSHYA

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator					
	Mechanician					
	Plumbers					
	Pump attendants					
	Handymen					
	Watchmen	65 workers				
	Laborer					
	Electrician					
Administrative	Off in charge					
	Licence officer					
	Typist					
	Office ordery					
	Clerical officer					
	Causal					

Problems associated with the water supply: Bursts in the rising main cause serious problems in the water supply. There was no water in the plant for twelve days in Oct, due to pipe breakage, Bypass from the pumping stations to the basins. Some shortage in the last part of the peak summer month results in low pressure.

Problems with the bottom nozzles of the filters. Loss of sand through the nozzles. Backwashing of filters 6 times a day seams extremely high.

Scheme: LUANSHYA

	Chemical precipitation	Alum + Lime Ca CO_3 25 kg/d
Chemical preacipitation	Supplier	
	Storage	
	Dosage method	Dry feeder
	Preparation before dosage	
	Average consumption	Normally 300 kg/d = 18g/m^3
	Amount stored at plant by visit	
	Visible difference og quality?	Normally yes, Shut down of the dosage at time of visit
Sedim.	Flocculation?	Yes
	No of sedimentation tanks:	2 Dorrco Clariflocculator
	Tank configuration	Circular
	Surface area/depth	
	Sludge pumping interval, wet	
	" " " , dry	
Filtration	Type of filtration	Rapid gravity sand filtration
	No of units	8(7 in operation)
	Tank configuration	Rectangular
	Filter medium/depth	Sand (1m), top 75 cm 0.4 - 0.55mm, Middle: 10cm 10-5mm, Bottom 15 cm 10-20mm sand
	Filter surface area	8 x 18.5 m^2
	Backwashing interval, wet	6 times a day
	" " , dry	6 times a day
	Backwashing time	
	Washwater consumption	Air scouring
	New sand is added how often	Added 40 tons/year. Losses through the nozzles.
	Supplier of filtersand	
Desinfection	Type of desinfection chemical	Chlorine Gas or Hypochlorite
	Supplier	From Livingstone
	Storage system	
	Dosage method	Chlorinator or solution
	Preparation before dosage	
	Average consumption	1 p.p.m. gives residual of 0.1 - 0.2 p.p.m.
	Responsible for buying chemicals	Assistant Engineer
	Amount stored at plant by visit	
	Bulk flow meter present	No
	Type	
	In correct operation	
	Meterreadings:	

Scheme:	SOLWEZI, North Western Province
Contact persons:	Mr. Midha, PWE. Mr. K. Evans, Water Superintendant, Concil. Mr. J.E. Simbeta, Sr. Superintendant for DWA. Mr. S.A.C. Banda, Treasurer. Mr. L. Chuba and Mr. F. Kipimpi, License off. for Water.

General

First built:	1946
Run by:	Council

Source

Source:	Solwegi River
Quality:	
Intake:	A channel in the river bank atts as sump for two submercible pumps

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers		15,000		
Average prodn. at visit (m^3/d)		1,818		
" " wet season "		1,818		
" " dry " "		1,818		
For gardeNing " " "		600		
Estim average demand wet season (m^3/d)		3,640		
" " " dry " "		4,550		
Supply wet season hours per day				
" dry " " " "		8		
Limiting factor for increased capasity	The whole scheme must be upgraded			

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe	100 and 150	30 m	Rubber hose	
Rising main			1km	
Retaiarlation				
Low level storage (m^3)	450			
Elevated storage (")	4 tanks total volume 850 m^3			

Pumps

		Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1		Flygt	5		55	24
" " " 2		Flygt	5		55	24
" " " 3		Flygt	5			Breakdown
High lift pump 1	4	Centrifugal	30			Three in generation one is broken down
" " " 2						
" " " 3						
Comments	Major repair is undertaken in North by Eddy M. Lean. A new high lift pump is required.					

Scheme SOLWEZI

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator	18				
	Mechanician	1			100	
	Plumbers					
	Pump attendants					
	Handymen	3				
	Watchmen					
	Laborer					
	Electrician					
Administrative	Off in charge					
	Licence officer	2				
	Typist					
	Office ordery					
	Clerical officer					
	Supervisior	2				
	Causal	0				

Problems associated with the water supply: Due to limited treatment capacity only one half of the water supplied is treated by precipitation and filtration. Normally 2/3 of the water is treated. The whole scheme must be upgraded, for instance the diameter of the rising main is too little and there is too low storage tank capacity.

Scheme: SOLWEZI

	Chemical precipitation	Alum
Chemical preacipitation	Supplier	From Ndola
	Storage	25 kg bags
	Dosage method	Drip and bowl method
	Preparation before dosage	15% solution
	Average consumption	40 g/m^3 gives 35 kg/d
	Amount stored at plant by visit	
	Visible difference og quality?	(not asked)
Sedim.	Flocculation?	Yes, static flocculator with corrugated plates
	No of sedimentation tanks:	3 (2 in operation)
	Tank configuration	Circular
	Surface area/depth	Surface approx 3 x 12,5 m^2
	Sludge pumping interval, wet	Once a day
	" " " , dry	3 times a week
Filtration	Type of filtration	Rapid gravity sand filtration
	No of units	3 (2 in operation)
	Tank configuration	Circular
	Filter medium/depth	Sand
	Filter surface area	Approx. 3 x 3,5 m^2
	Backwashing interval, wet	Once a day
	" " , dry	3 times a week
	Backwashing time	(Separate storage for backwashing)
	Washwater consumption	
	New sand is added how often	Not added since 1980
	Supplier of filtersand	
Desinfection	Type of desinfection chemical	
	Supplier	
	Storage system	
	Dosage method	Drip and bowl method
	Preparation before dosage	Solution 7%
	Average consumption	0,8 p.p.m. i.e. 1,5 kg/d
	Responsible for buying chemicals	Superintendant
	Amount stored at plant by visit	50 kg another 300 kg was expected
	Bulk flow meter present	yes
	Type	
	In correct operation	No
	Meterreadings:	

Scheme: MWINILUNGA, North Western Province

Contact persons: Mr. D. Hambula, Off. in charge DWA
Mr. N.C. Mwanza, Deputy Treasurer

General

First built: 1946

Run by: DWA since 1974

Source

Source: Mudyanywama River

Quality: Dry season: Clear. Rainy season: Muddy.

Intake: Provisional dam since 1981. Intake via a channel to a circular pumping chamber.

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers	3,169	3,550		
Average prodn. at visit (m^3/d)	910	400		
" " wet season "	680	400		
" " dry " "	910	400		
For gardeNing " " "	300	200		
Estim average demand wet season (m^3/d)	1,520	800		
" " " dry " "	2,280	1,200		
Supply wet season hours per day				
" dry " " " "		9		
Limiting factor for increased capasity	Treatment plant capasity and pumping capacity			

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe	150 mm	18 m	Steel	
Rising main	200 mm	1.5 km	PVC	One day repair when breakage
Retaiarlation				
Low level storage (m^3)	415 m^3			
Elevated storage (")				

Pumps

	Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1					
" " " 2					
" " " 3					
High lift pump 1	Hardland SDC 50/80	38	1977	36	8
" " " 2	" "	38	1981	36	16
" " " 3	KSB WKL 65/6	27			Stand by

Comments: Major Repair in undertaken i Kitwe. Fairly satisfied with the service.

Scheme MWINILUNGA

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator	0	1			Retired
	Mechanician	0	1 (1			Retired
	Plumbers	2 11 (1	2			
	Pump attendants	3	3	DWA	100	
	Handymen	1	1			
	Watchmen					
	Laborer					
	Electrician					
						(1 WPE-answer
Administrative	Off in charge	1 1 (1	1 (1			
	Licence officer	1 1 (1	1 (1			
	Typist	1 1 (1	1 (1			
	Office ordery	1 (1	1 (1	DWA	100	
	Clerical officer	1 (1	1 (1			
	Causal	0 0				

Problems associated with the water supply: No major breakdowns recently. No qualified diesel engine operator and mechanician at the time of visit (retired). The existing scheme has too low pumping and treatment capacity. The elevated storage tank is leaking, and breakage of the rising main (in the bends) has occured. Time of repair is one day. Shortage of chlorine for one week at the time of inspection.

Scheme: MWINILUNGA

	Chemical precipitation	No
Chemical preacipitation	Supplier	
	Storage	
	Dosage method	
	Preparation before dosage	
	Average consumption	0
	Amount stored at plant by visit	
	Visible difference og quality?	
	Floccula	
	Flocculation?	No
Sedim.	No of sedimentation tanks:	None
	Tank configuration	
	Surface area/depth	
	Sludge pumping interval, wet	
	" " " , dry	
Filtration	Type of filtration	Pressure sand filt
	No of units	3
	Tank configuration	Circular
	Filter medium/depth	Sand 1 m deep
	Filter surface area	2 x 1.4 m^2 and 1 x 4.9 m^2
	Backwashing interval, wet	2-3 times a day
	" " , dry	Once a day
	Backwashing time	15 minutes
	Washwater consumption	
	New sand is added how often	Not been added the last few year
	Supplier of filtersand	From Livingstone.
Desinfection	Type of desinfection chemical	Granular Hypochlorite
	Supplier	From Livingstone
	Storage system	
	Dosage method	Added to suction chamber twice a day
	Preparation before dosage	2.5% soln. in 60 l bucket
	Average consumption	PWE: 25 kg/m Off. in charge
	Responsible for buying chemicals	Pump hand
	Amount stored at plant by visit	No chemicals left. Shortage for one week. Long time since last shortage.
	Bulk flow meter present	Yes
	Type	Kent
	In correct operation	No
	Meterreadings:	

Scheme: KASEMPA, North Western Province.

Contact persons: Mr. B.C. Shisweka, Financial secretary (since 1982)
Mr. ? Superintendant, Water treatment.

General

First built: 1961

Run by: DWA

Source

Source: Lufupa River

Quality:

Intake: A rough ruble weir across the river, Concrete channel to a concrete suction chamber.

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers	3,063			
Average prodn. at visit (m^3/d)	680		500	
" " wet season "	590			
" " dry " "	680			
For gardeNing " " "	220			
Estim average demand wet season (m^3/d)	970			
" " " dry " "	1,130			
Supply wet season hours per day				
" dry " " " "		6		

Limiting factor for increased capasity: Pumping capacity

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe				
Rising main				
Retaiarlation				

Low level storage (m^3):

Elevated storage ("): 350 m^3

Pumps

	Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1	Hardland SNB 2	5		32	24
" " " 2	Loewe HN 4/4AD	5	new		
" " " 3					
High lift pump 1	KSB WKL/65/B	30		36	12 2 pumps
" " " 2	"	30		36	12 2 pumps
" " " 3					

Comments: The low lift pumping capacity was measured to 21 m^3/h.

Scheme KASEMPA

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator Mechanician Plumbers Pump attendants Handymen Watchmen Laborer Electrician	11	11			
				DWA	100	All are PWE-answers
Administrative	Off in charge	1	1			
	Licence officer					
	Typist	1	1			
	Office ordery	1	1			
	Clerical officer	1	1			
	Causal	0				

Problems associated with the water supply: It is a problem with low intake level during the dry season. The operation of the sand filters was not satisfactory due to wrong size-distribution of the filter sand. (Too much fine material (silt.)

Scheme: KASEMPA

	Chemical precipitation	Alum	
Chemical preacipitation	Supplier		
	Storage	50 kg bags	
	Dosage method	Continuously by drip feed	
	Preparation before dosage	Solution	
	Average consumption	PWE: 20 kg/m Superint: 72 kg/m	
	Amount stored at plant by visit	25 kg	Expecting 50 kg soon
	Visible difference og quality?	Hot in dry season	
Sedim.	Flocculation?	No	
	No of sedimentation tanks:	1	
	Tank configuration	Circular	
	Surface area/depth	About 7 m^2	
	Sludge pumping interval, wet		
	" " " , dry		
Filtration	Type of filtration	Slow sand filtration	
	No of units	2	
	Tank configuration		
	Filter medium/depth	Unsuited for water filtration	
	Filter surface area	2 x 44 m^2	
	Backwashing interval, wet		
	" " , dry		
	Backwashing time		
	Washwater consumption		
	New sand is added how often		
	Supplier of filtersand		
Desinfection	Type of desinfection chemical	Hypochlorite	
	Supplier		
	Storage system	50 kg tins	
	Dosage method		
	Preparation before dosage		
	Average consumption	PWE: 20kg/m Superint: 108 kg/m	
	Responsible for buying chemicals	Superintendant	
	Amount stored at plant by visit	About 10 kg.	Expecting 50 kg soon.
	Bulk flow meter present	No	
	Type		
	In correct operation		
	Meterreadings:		

Scheme: KABOMPO, North Western Province

Contact persons: Mr. Nuuluwo, Off. in Charge, DWA, Mr. B.M. Maina, License off.
Mr. D.M. Lumeta, Office ordery
Mr. Y. Mingangja, Plant Supervisor

General

First built: 1961-62

Run by: DWA since 1974

Source

Source: Kabompo River

Quality:

Intake: A concrete sump at the edge of the river.

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers	5,357			
Average prodn. at visit (m^3/d)	1,090	1,640	700	
" " wet season "	910	1,540		
" " dry " "	1,090	1,640		
For gardeNing " " "	270	540		
Estim average demand wet season (m^3/d)	1,800	2,000		
" " " dry " "	2,700	2,700		
Supply wet season hours per day				
" dry " " " "		24		

Limiting factor for increased capasity

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe	3 x 7.5 mm	30 m	Steel	
Rising main				
Retaiarlation				

Low level storage (m^3)

Elevated storage (") 270 m^3

Pumps

	Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1	Hardland SNB 2	5			Stand by
" " " 2	" " "	5			" "
" " " 3	Flygt B2102	52		32	22
High lift pump 1	Weir DC 60/80	30			24
" " " 2	" " "	30			
" " " 3					

Comments

Pump service. Engineering, service, Ndola. The Flygt pump needs repair
1) Capacity estimated at visit: 32 m^3/h
The high lift pumps are alternating once a day.

Scheme KABOMPO

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator					
	Mechanician	1				
	Plumbers	1 (1	(1			
	Pump attendants	6 9	9			
	Handymen					
	Watchmen	2				
	Laborer					
	Electrician					
				DWA	100	(1 PWE-answers
Administrative	Off in charge	1 1 (1	1 (1			
	Licence officer	1				
	Typist	1 1 (1	1 (1			
	Office ordery	1 1 (1	1 (1			
	Clerical officer	1 (1	1 (1			
	Handymen/Watchmen	2				
	Causal					
	Total	17				

Problems associated with the water supply: Sometimes 3-4 days without water supply. One week breakdown in 1980 because of both high lift pumps were out of operation. Just now one raw water pump (Flygt) is broken down. Time of repair is about 1-3 weeks. Rising main burst twice in 1981, time of repair is less than one day. No chlorination at the time of visit.

Scheme: KABOMPO

	Chemical precipitation	With Alum.
Chemical preacipitation	Supplier	
	Storage	
	Dosage method	Drip and bowl. alum is added to a part of the inflow
	Preparation before dosage	4g/c Solution (0,4%)
	Average consumption	PWE-answ.: 25 kg/m Superint:
	Amount stored at plant by visit	25 kg
	Visible difference og quality?	During rainy season: Yes
Sedim.	Flocculation?	No
	No of sedimentation tanks:	1
	Tank configuration	Circular
	Surface area/depth	15.9 m^2
	Sludge pumping interval, wet	2 times a week
	" " " , dry	once a week
Filtration	Type of filtration	Rapid gravity sand filtration
	No of units	1
	Tank configuration	Circular
	Filter medium/depth	Sand, 3 layers each 30 cm deep
	Filter surface area	4.9 m^2
	Backwashing interval, wet	Every day
	" " , dry	3 times a week
	Backwashing time	20 minutes
	Washwater consumption	55 m^3 Backwashing rate 33 m/h
	New sand is added how often	Every year
	Supplier of filtersand	Sand from Luapula, stones and gravel from Kabompo
Desinfection	Type of desinfection chemical	Granular Hypochlorite
	Supplier	
	Storage system	Tins
	Dosage method	Adding 54 l twice a day
	Preparation before dosage	8.3 g/l solution in a 108 l bucket
	Average consumption	PWE-answ: 25 kg/m Superint: 45 kg/m
	Responsible for buying chemicals	
	Amount stored at plant by visit	No chemicals. This time the shortage is expected to last 14 days.
	Bulk flow meter present	Yes
	Type	
	In correct operation	No, broken down 4-5 years ago.
	Meterreadings:	

Scheme: CHIZELA, North Western Province

Contact persons: Mr. H.M. Liyuyu, Off. in charge, DWA (from Feb. 1982)
Mr. ? License off. water revenue
Mr. G.S. Zulu, Water drilling section, DWA.

General

First built: 1975

Run by: DWA since 1979

Source

Source: Ground water

Quality:

Intake: 2 DWA-wells in operation: No. 1 6,1 m deep
No. 2 4,5 m deep

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers	577	2,500		
Average prodn. at visit (m^3/d)	227		180	
" " wet season "	182	(1		
" " dry " "	227			
For gardeNing " " "	45			
Estim average demand wet season (m^3/d)	721			
" " " dry " "	962			
Supply wet season hours per day		24		
" dry " " " "		2		
Limiting factor for increased capasity	Increased numbers of boreholes or another source.			

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe	50 mm	150 m		
Rising main				
Retaiarlation				
Low level storage (m^3)	90 m^3			
Elevated storage (")				

Pumps

		Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1						
" " " 2						
" " " 3						
High lift pump 1	Borehole 1	Mono W/65	4.5		14 (1	17
" " " 2	Borehole 2	Grundfos CPE 860H	8.3		5 (1	14
" " " 3						

Comments

(1 PWE-answer
All the pumps have diesel engines
Borehole 1: Lister diesel-engine STI 291, 1800 rpm
Borehole 2: Hatz diesel-engine F 785, 2900 rpm.

Scheme CHIZELA

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator	1	0			
	Mechanician	1	1			
	Plumbers	2 11(1	2 11 (1			(1 PWE-answer
	Pump attendants	1	1			
	Handymen					
	Watchmen					
	Laborer					
	Electrician					
				DWA	100	
Administrative	Off in charge	1 1 (1	0			
	Licence officer					
	Typist	0 1 (1				
	Office ordery	0 1 (1				
	Clerical officer					
	Causal	3.5 man/year 0 (1				Digging wells during dry season

Problems associated with the water supply: Only 2 hours per day supply during the dry season. No production from 4 boreholes made by Beomin The Deputy District Secretary, Mr. Shiska was complaining about too many dry boreholes. He suggested to use Kabompo River as a new source instead of ground water.

Scheme:		CHIZELA
	Chemical precipitation	No
Chemical preacipitation	Supplier	
	Storage	
	Dosage method	
	Preparation before dosage	
	Average consumption	
	Amount stored at plant by visit	
	Visible difference og quality?	
Sedim.	Flocculation?	
	No of sedimentation tanks:	
	Tank configuration	
	Surface area/depth	
	Sludge pumping interval, wet	
	" " " , dry	
Filtration	Type of filtration	No filtration
	No of units	
	Tank configuration	
	Filter medium/depth	
	Filter surface area	
	Backwashing interval, wet	
	" " , dry	
	Backwashing time	
	Washwater consumption	
	New sand is added how often	
	Supplier of filtersand	
Desinfection	Type of desinfection chemical	No disinfection
	Supplier	
	Storage system	
	Dosage method	
	Preparation before dosage	
	Average consumption	
	Responsible for buying chemicals	
	Amount stored at plant by visit	
	Bulk flow meter present	No
	Type	
	In correct operation	
	Meterreadings:	

Scheme: CHOMA, Southern Province

Contact persons: Mr. N. Konde, Water Superintendant.
Mr. C.M. Siyoto, Sen: Engineering Assistant, DWA, seconded to council.

General

First built:

Run by:

Source

Source: 1. Mozoma dam, 2. Choma dam.

Quality:

Intake:

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers		350 (1		(1 Kamfinsa supply
Average prodn. at visit (m^3/d)			1,380 (2	(2 Measured at the outlet of the sedim. basin
" " wet season "				
" " dry " "				
For gardeNing " " "				
Estim average demand wet season (m^3/d)				
" " " dry " "				
Supply wet season hours per day				
" dry " " " "				

Limiting factor for increased capasity: How sand filters, pumping capacity storage and distribution.

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe	150 mm			
Rising main			Asbestos (1	Breakage 3 km from work
Retaiarlation				loss estimated to 10-15 g/s
Low level storage (m^3)	1,136 m^3			
Elevated storage (")	2 x ? m^3			

Pumps

	Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1	Muthe and Platt	49		95 vs. 12 km/cm^2	24
" " " 2	" " "	49		"	
" " " 3					
High lift pump 1	Worth and Simpson	11.3	54	57.5 vs. 1.3 km/cm^2	24
" " " 2	" " "	11.3	54	"	
" " " 3	" " "	11.3	54	"	

Comments: Problems with one of the low lift pumps. Two of the high lift pumps are out of operation due to motor breakage. Major repairs are undertaken in Lusaka.

Scheme CHOMA

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator					
	Mechanician					
	Plumbers					
	Pump attendants	10-15 men				
	Handymen					
	Watchmen					
	Laborer					
	Electrician					
Administrative	Off in charge					
	Licence officer					
	Typist					
	Office ordery					
	Clerical officer					
	Causal					

Problems associated with the water supply: A serious leakage in the raw water pipeline. Estimated losses: 10-15 l/s. Too low supply capacity. Insufficient backwashing of sand filters, ineffective method of chlorination. The state of repair of the pumps is critical. No spare capacity in case of breakdown.

Scheme: CHOMA

Chemical precipitation	Alum
Chemical preacipitation	
Supplier	
Storage	50 kg sacks
Dosage method	Drip feed gravity inlet channel to sedim.
Preparation before dosage	Solution 130 g/l, in a 0.15 m^3 tank 3 times a day
Average consumption	60 kg/day
Amount stored at plant by visit	300 kg
Visible difference og quality?	Flocs were seen in the sedimentation basins
Sedim.	
Flocculation?	No
No of sedimentation tanks:	1
Tank configuration	Square
Surface area/depth	64 m^2
Sludge pumping interval, wet	
" " " , dry	
Filtration	
Type of filtration	Rapid gravity sand filters
No of units	2
Tank configuration	Square
Filter medium/depth	Sand (mud layer at the top of the filter bed)
Filter surface area	2 x 16 m^2
Backwashing interval, wet	
" " , dry	
Backwashing time	30 min.
Washwater consumption	
New sand is added how often	
Supplier of filtersand	Spare sand was spread at the ground outside the plant
Desinfection	
Type of desinfection chemical	Dry chlorine
Supplier	From Ndola
Storage system	50 kg tins
Dosage method	Bulk dosage 500 g twice a day (0600 and 100)
Preparation before dosage	None
Average consumption	50 kg in 2-3 months.
Responsible for buying chemicals	Plant operator
Amount stored at plant by visit	
Bulk flow meter present	No
Type	
In correct operation	
Meterreadings:	

Scheme: KALOMO, Southern Province

Contact persons: Mr. A.M. Chimuka, Dir. of water works Kalomo
mr. ? Water work operator

General

First built:

Run by: District Rural Council

Source

Source: Kaolom River

Quality:

Intake: Kalomo Dam, 2 submercible pontoon mounted pumps.

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers		11,000		
Average prodn. at visit (m³/d)			2,070 (1	(1 Estimated from low lift-capacity. Some water (about 40% is pumped directly to a 115 m² elevated storage.
" " wet season "				
" " dry " "				
For gardeNing " " "				
Estim average demand wet season (m³/d)		2,070		
" " " dry " "		2,960		
Supply wet season hours per day		24		
" dry " " " "		24		

Limiting factor for increased capasity: Treatment plant capacity

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe	2 x 110 mm	200 m	Galv. steel	
Rising main	150 mm	2.9 km	Arlestos cement	
Retaiarlation				

Low level storage (m³): 250 m³ Clear water
Low level storage: 50 m³
Elevated storage ("): 3 tanks, 115, 315 and 340 m³

Pumps

			Type	Motor kw	Year	Capacity m³/h	In operation hours/day
Low lift pump 1	Stage 1		Flygt	8.3		43 (1	24
" " " 2	Stage 1		"	8.3		43 (1	24
" " " 3	Stage 2		KSB Movi 65/2	30	1980	75 m³/k vs 95 m	14
High lift pump 1	Stage 2		" " "	30	1980	"	
		3x	~~KSB WKL 65/6~~	~~15~~	~~1974~~	~~86~~	One in operation
" " " 2		2x	KSB 8-35 ETH	11	1974		24 hours/day
" " " 3							

Comments

There are two low lift stages, one from the intake to a 50 m tank at the old treatment plant and the other from this tank to the existing treatment plant.

(1 Estimated from 60° overflow weir. Two other pumps out of operation due to lack of spareparts.

Scheme KALOMO

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator					
	Mechanician					
	Plumbers	2				
	Pump attendants	8				1 Senior att.
	Handymen					
	Watchmen					
	Laborer	(some)				
	Electrician	1				
Administrative	Off in charge					
	Licence officer					
	Typist					
	Office ordery					
	Clerical officer					
	Causal					

Problems associated with the water supply: Silting problem in Kalomo Dam. The slow sand filters are claimed to have no or little effect and too low capacity. In emergency situation the filters are bypassed, i.e. pumping directly into the elevated tanks.

Scheme: KALOMO

	Chemical precipitation	
Chemical preacipitation	Supplier	
	Storage	
	Dosage method	
	Preparation before dosage	
	Average consumption	
	Amount stored at plant by visit	
	Visible difference og quality?	
Sedim.	Flocculation?	
	No of sedimentation tanks:	
	Tank configuration	
	Surface area/depth	
	Sludge pumping interval, wet	
	" " " , dry	
Filtration	Type of filtration	Slow sand filtration
	No of units	4 (3 in operation)
	Tank configuration	Circular
	Filter medium/depth	0.75 m
	Filter surface area	117 m^2
	Backwashing interval, wet	Periodically the filters are scraped to remove silt
	" " , dry	
	Backwashing time	
	Washwater consumption	
	New sand is added how often	
	Supplier of filtersand	
Desinfection	Type of desinfection chemical	Calcium Hypochlorite
	Supplier	From Livingstone
	Storage system	45 kg tins
	Dosage method	Manually directly into the clean water tank and in the 115 m^2 elevated storage.
	Preparation before dosage	
	Average consumption	6 cups per day in the clean water tank
	Responsible for buying chemicals	
	Amount stored at plant by visit	No chlorine gas, ½ tin of Hypochlorite
	Bulk flow meter present	No
	Type	
	In correct operation	
	Meterreadings:	

Scheme: ZIMBA, Southern Province

Contact persons: Mr. E.E. Makoni, Water work operator
Mr. A. Musalkoi, Ading Dep. Director of works
Mr. J. M. Lumangomse, Licensing off.

General

First built: 1972 (The rural supply)

Run by: DWA

Source

Source: Zimba Dam: DWA, Ziana Changa Dam: Railway (RW)

Quality: Z.D: Low level in dry season, dirty water, cattle is using it. R.W.: Sufficient capacity, cattle near the intake.

Intake: Z. D. was not in use at the day of visit

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers		3.200 (1		(1 Rural C.: 2100, railway: 1100.
Average prodn. at visit (m^3/d)			170 (2	(2 To the DWA supply. Measured by a meter that may be incorrect.
" " wet season "				
" " dry " "				
For gardeNing " " "				
Estim average demand wet season (m^3/d)				
" " " dry " "				
Supply wet season hours per day				(3 From railway tank to DWA-plant
" dry " " " "		6 (3		

Limiting factor for increased capasity: Too low treatment and pumping capacity.

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe				
Rising main	150 mm	RW: 6.1 km	Steel	
Retaiarlation		70:2km		
Low level storage (m^3)				
Elevated storage (")				

Pumps

		Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1	Z.D.	KSB ETA 80 - 20	7.5	70	36	0
" " " 2	Z.D.	KSB ETA 80 - 20	11.5	70	54	0
" " " 3	RW.2x	Harland SNC 1½	7.5	70		
High lift pump 1	Z.D.2x	KSB WKL 65/3	5.5/3.8	70	14.4	24
" " " 2		KSB WKL 50/3 NA	11	77		8
" " " 3	RW.	KSB WKL 40/5	11	70		16

Comments: Bypass pump at the DWA treatment plant from sedimentation basins to slow sand filters pump SPSRI with a lister diesel engine.

Scheme ZIMBA

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator	1				
	Mechanician					
	Plumbers					
	Pump attendants	6				
	Handymen					
	Watchmen					
	Laborer					
	Electrician					
Administrative	Off in charge					
	Licence officer					
	Typist					
	Office ordery					
	Clerical officer					
	Causal					

Problems associated with the water supply: Lack of chlorination is a serious problem. Too low capacity during dry season, enough water from Dec. - Aug. The sources should be protected against cattle.

Scheme: ZIMBA

	Chemical precipitation	Alum
Chemical preacipitation	Supplier	
	Storage	
	Dosage method	Added manually to the top of the cascade aeration unit
	Preparation before dosage	No
	Average consumption	1 kg/18 hours
	Amount stored at plant by visit	100 kg (lack of alum March-October 1982)
	Visible difference og quality?	
Sedim.	Flocculation?	
	No of sedimentation tanks:	1
	Tank configuration	Circular
	Surface area/depth	50 m^2
	Sludge pumping interval, wet	Once a day
	" " " , dry	Two times a month
Filtration	Type of filtration	Slow sand filters
	No of units	2 (Bypass during wet season)
	Tank configuration	Circular
	Filter medium/depth	
	Filter surface area	2 x 113 m^2 (Actual flowrate by demonstration 1-2 l/s)
	Backwashing interval, wet	
	" " , dry	
	Backwashing time	
	Washwater consumption	
	New sand is added how often	
	Supplier of filtersand	
Desinfection	Type of desinfection chemical	Granular Dry Chlorine
	Supplier	HTH
	Storage system	50 kg
	Dosage method	Drip feed (not in operation)
	Preparation before dosage	20 g/l solution
	Average consumption	30 kg/month
	Responsible for buying chemicals	Operator PWE in Choma is informed but no chemicals have arrived.
	Amount stored at plant by visit	0 (it stopped one month ago)
	Bulk flow meter present	Yes
	Type	
	In correct operation	Relatively constant production over a year may reflect that the meter is not recording correctly.
	Meterreadings:	1981: 147 m^3/d. Last month 154 m^3/d Last week: 374 m^3/d Last day 171 m^3

Scheme: MAMBOVA, Southern Province

Contact persons: The headmaster of the primary school

General

First built: 1968

Run by: Rural council of Zimba. Supposed to be run by DWA.

Source

Source: Zambezi River

Quality: Clear, soft river water during the dry season

Intake: Concrete channel to a circular concrete sump.

Production and demand

	PWE-answ.	Questionnaire	Estim by visit	Comments
Nos. of consumers		2,500		
Average prodn. at visit (m^3/d)			0 (1	(1 For 3-4 weeks
" " wet season "				
" " dry " "				
For gardeNing " " "				
Estim average demand wet season (m^3/d)				
" " " dry " "				
Supply wet season hours per day				
" dry " " " "				

Limiting factor for increased capasity: Pumping capacity and reliability, high level storage and reticulation

Pipes & tanks

	Diameter	length	Material	Comments
Low lift pipe				
Rising main	50 mm	1.3 km	GI	
Retaiarlation				

Low level storage (m^3): None

Elevated storage ("): 8.8 m^3, elevation above ground level: 6 cm.

Pumps

	Type	Motor kw	Year	Capacity m^3/h	In operation hours/day
Low lift pump 1					
" " " 2					
" " " 3					
High lift pump 1	Centrifugal,diesel	7.5			
" " " 2					
" " " 3					

Comments: The pump was broken down and there was lack of diesel.

Scheme MAMBOVA

	Staff category	Number Now	Number 1979	Emp.by	% time on water supply	Comments
Technical	Water work operator					
	Mechanician					
	Plumbers					
	Pump attendants	1				
	Handymen					
	Watchmen					
	Laborer					
	Electrician					
Administrative	Off in charge	1				
	Licence officer					
	Typist					
	Office ordery					
	Clerical officer					
	Causal					

Problems associated with the water supply: Water supply has been out of operation for 3-4 weeks due to breakdown of pumps and lack of diesel. People are collecting water directly from the river. Chlorination should be included in this scheme. According to the health assistant diarrhoea is a great problem at this village.

Scheme: MAMBOVA

	Chemical precipitation	None
Chemical preacipitation	Supplier Storage Dosage method Preparation before dosage Average consumption Amount stored at plant by visit Visible difference og quality?	
Sedim.	Flocculation? No of sedimentation tanks: Tank configuration Surface area/depth Sludge pumping interval, wet " " " , dry	
Filtration	Type of filtration No of units Tank configuration Filter medium/depth Filter surface area Backwashing interval, wet " " , dry	None
	Backwashing time Washwater consumption New sand is added how often Supplier of filtersand	
Desinfection	Type of desinfection chemical Supplier Storage system Dosage method Preparation before dosage Average consumption Responsible for buying chemicals Amount stored at plant by visit	None
	Bulk flow meter present Type In correct operation Meterreadings:	None