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A Water Development Programme  
for Western Province, Zambia

A Preliminary Study

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FOREWORD

The Government of Zambia has requested Norway to provide financial and technical assistance for Water Development in Western Province. Zambian authorities and NORAD agreed that a pre-feasibility study be carried out in order to assess and define better the nature and scope of possible Norwegian assistance.

To carry out the pre-feasibility study, NORAD appointed the following delegation:

Mr. Steinar Sorensen, NORAD, head of delegation

Mr. Tor Selvik, Norwegian Deep Well Drilling

Mr. Svein Stene Johansen, Consultant, Norwegian

Institute for Water Research

(NIVA).

The delegation should appraise the different projects included in the Water development programme, and Mr. Stene Johansen, NIVA, was appointed as a Consulting Engineer to complete a pre-feasibility report based on a five days safari to Western Province and discussions with officials from the Department of Water Affairs, Lusaka.

A report on findings and recommendation was written by Mr. Sorensen and submitted to NORAD within three months upon completion of the field work.

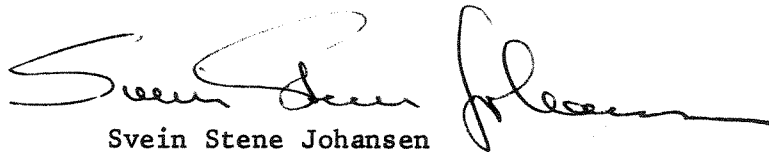
A draft feasibility report was presented to the Zambian Government during a visit to Zambia in November, 1976 by Messrs Sorensen and Stene Johansen.

The report was finalized after discussions with the Deputy Director, Department of Water Affairs, Lusaka.

The funds to be provided by NORAD are limited, and will only be enough for a 1st phase. In addition to the actual funds, consultancy services and Norwegian experts will be provided by NORAD.

Terms of references have been included in Appendix A, Agreement for the Design and Supervision.

NAIROBI, December 1976

  
Svein Stene Johansen

1. PROGRAMME SUMMARY

1.1. Description of the Projects

The Water Development Programme for Western Province to be financed by NORAD consists of five projects, briefly described below.

The implementation period averages 2½ years with a total cost estimate of K 2,285,800

The Programme proposals made below should be considered as a first phase only. The second phase will be to complete the Programme and to extend it to include other water development activities such as Range water supplies and irrigation.

The five projects included in the first phase are as follows:

1. The Township Water Supply Project

This Project includes township water supplies for Kalabo, Kaoma, Lukulu, Mongu, Namushakende, Sesheke and Senanga. Planning and design is to be undertaken by consulting engineers financed directly by NORAD. In addition, technical assistance from NORAD will consist of:

One graduate engineer and two supervising engineers for construction. The period of implementation is assumed to be 2½ years. The provisional cost estimate is K 1,500,000 excluding consultants fees.

2. The Rural Water Supply Project

This Project comprises the development of up to 700 well-points. The well-points will be located as decided by the district and provincial authorities. The period of implementation is assumed to be 3 years with three construction teams in operation. The technical assistance from NORAD will include one supervising engineer for construction. The provisional cost estimate is K 260,000.

3. The Training Project for Operation and Maintenance Staff

The aim of this Project is to establish a training course in Mongu for water supply operators with the object of improving operation and maintenance of water supply installations in the Province. The provision of necessary teaching facilities and equipment is included in the Project. The technical assistance from NORAD will consist of one teaching instructor as Principal. The Provincial Water Engineer (PWE) and the members of the NORAD team will assist in the courses. The provisional cost estimate is K 36,000.

4. The Dam Construction Project

This Project includes planning, design and construction of small earth-filling dams at suitable localities for storage and conservation of surface water for domestic and livestock supplies. The planning and design will be undertaken by the consultant appointed for the township water supplies.

The construction will be carried out by labour intensive methods with a minimum of heavy equipment and motor vehicles. The supervising engineer for the Rural Water Supply Project will supervise the dam construction as well. The provisional cost estimate is K 65,000 excluding consultant fees which will be financed directly by NORAD. The period of implementation will be 2 years, but it is anticipated that the dam construction units will continue to operate after the Programme period.

5. Extension of DWA Workshop at Mongu

The supply of equipment and vehicles is considered essential for the implementation of the whole Programme. The DWA's provincial workshop and stores at Mongu will have to be extended and modernized.



1.2 Summary of Costs.

Table 1.1. Summary of Capital Costs

Township Water Supply Project	K. 1,500,000*
The Rural Water Supply Project	K. 260,000
The Training Project	K. 36,000
The Dam Construction Project	K. 65,000*
Extension of DWA Workshop at Mongu	K. 50,000
	<hr/>
Total	K. 1,911,000
	=====

\* excluding consultant fees.

Table 1.2 Summary of Capital and Operation Costs -  
Annual Expenditure

	1977	1978	1979	1980
	K	K	K	K
Township Water Supply Project	117,567	546,501	629,085	506,847
The Rural Water Supply Project		268,600	17,100	17,100
The Training Project		44,000	16,000	8,000
The Dam Construction Project		50,000	7,500	7,500
Extension of DWA Workshop at Mongu		35,000	10,000	5,000
		<hr/>	<hr/>	<hr/>
Total	117,567	944,101	679,685	544,447
		=====	=====	=====

## 2. TOWNSHIP WATER SUPPLIES

### 2.1 Project Summary

#### 2.1.1 Description of the Project

The Township Water Supply Project consists of:

- (a) Major augmentations and extensions to 7 water supplies.
- (b) The engineering services of design and supervision of the construction works at the water supplies, including construction of stores and buildings.
- (c) A Stores Fund for establishing an "unallocated" store for Western Province.
- (d) Water Department overhead costs on items (a) to (c) above.

#### 2.1.2 Justification

Priority selections to justify the inclusion of water supplies in the project are based primarily on four different types of assessment where they are relevant. They are:

- a) The existing demand exceeding capacity
- b) The need for water to catalyse other existing or complementary inputs to give social and general or specific economic benefits.
- c) Financial viability,
- d) The overall financial limit,

None of these assessments are rated additively for each supply, but are considered on a general basis and all are weighed against the overall financial limit.

#### 2.1.3 Summary of Costs

The following two tables summarize anticipated programme expenditure both in total and by cost categories for each year of the programme and at 1975 and actual prices:

Table 2.1. Cost Categories

Total Project Costs		
Cost category	Description	Expenditure K
A	Water Supply Construction Costs	1,200,000
B	Engineering Services for the Design and Supervision of the Water Supply Stores & Buildings	300,000
C	Construction and Equipping of Stores, Houses, and Offices at the Water Supplies	21,000
D	Stores Fund	10,000
E	Department of Water Affairs, Overheads, Categories A-C (2½%)	38,025
F	Unallocated Items for Physical Contingencies on Items A-E (15%)	230,975
A-F	Grand Total	1,800,000

Note:

1. Prices escalation at 10% per annum would give an additional programme cost of K 180,000. This is assumed to be covered by increases in the grant value or exchange rate variation between the Norwegian Kroner and the Kwacha.
2. All construction costs are estimated at contract rates since in this way all the direct overhead costs are covered whether construction is actually done by contract or direct labour.
3. Cost Category B, Engineering Services will be covered separately by NORAD.
4. The Cost Category A includes the purchase of No.4 4 wheel drive lorries, No.2 2 Land Rovers Pickup, No.1 Land Rover Station wagen, tools and equipment.

Table 2.2. Programme Summary - Annual Expenditure.

Cost category	1977	1978	1979	1980	Sub-total	Escalation	Total
	K	K	K	K	K	K	K
A	-	300,000	500,000	400,000	1,200,000	250,000	1,450,000
B	100,000	150,000	25,000	25,000	300,000	27,500	327,500
C	-	5,000	10,000	6,000	21,000	3,300	24,300
D	-	10,000	-	-	10,000	1,000	11,000
E	2,500	11,375	13,375	10,775	38,025	7,000	45,025
F	15,067	70,126	80,710	65,072	230,975	42,679	273,322
Total	117,567	546,501	629,085	506,847	1,800,000	331,479	2,131,147

#### 2.1.4 Execution of the Project

The bulk of this Project involves the construction of 7 township water supplies and the building and equipping of stores, offices and housing facilities for water operators. Most of these construction and building works will be carried out by direct labour using the resources of the DWA, supervised by Norwegian experts. Design services will be carried out by Consulting Engineers, as the DWA does not have the capacity to carry out the design and supervision of construction. For this reason it follows that in the initial stages of the Project at least, the direct labour construction projects will be limited to those where works are of a standardised nature, and relatively small. In this way it is hoped to utilise the scarce resources of the DWA to the best advantage and use of Consulting Engineer and eventually Civil Engineering Contractors where their services are more competitive and more easily administered.

The unallocated stores "float fund" would also be drawn after the Project starts.

The whole project is expected to last 3½ years from 1976 to 1979. Estimated annual expenditures for each cost category and for the whole project are given in the summary of costs at clause 2.1.3. These show the expected type of growth characteristics with a slight accent towards higher spending than would be expected in 1978 due to the early construction and equipping of the building elements in the project.

2.1.5. The Project List of Goods

The list of Goods comprises various projects and other services as scheduled hereunder.

Item	Description	Name of Project in Service
1	Water Supplies	Lukulu Kalabo Kaoma Mongu Namushakende Senanga Sesheke
2	Stores, Work-shops and Offices	District stores, workshops and offices provisionally selected at the township water supplies.
3	Stores Fund	Initial purchase of stores.

## 2.2. The Project

### 2.2.1 General

#### 2.2.1.1 Demand

With the objectives of the Project it is intended to develop water supplies in Western Province for minor urban areas and their surroundings together with the provision of various necessary ancillary DWA services. The details of demand for the development of water supply are dealt with separately in each section of this chapter. In general they are based upon the projections made by the Zambia Ministry of Finance and Planning. These demands are formulated from past trends and then synthesised to meet expected or desired national physical planning objectives. In this way the supply of water can stimulate or hold back other developments depending upon the availability of these complimentary inputs.

#### 2.2.1.2 Qualities and Selection Criteria

The qualities of work involved in carrying out this Township Water Supply Project are calculated from the direct application of the design criteria to meet the demands, with the number of projects limited by the overall financial constraint. Thus selection criteria are applied to each project in accordance with the general guidelines outlined in the summary chapter. Preliminary Feasibility Studies have been carried out at all these centres. They were all considered for priority ranking in a general way in terms of:

- a) Cost per capita of population served.
- b) Capacity/demand ratios.
- c) Future development planning inputs and targets in other fields.
- d) Existing complimentary services.

No positive ranking emerges, nor is it believed correct that it should be attempted at this stage.

The view points for decision making are so broad as to make such an exercise unnecessary when it is intuitively clear that many water supplies have exceedingly large benefits anyway. A coarse selection is amply repaid and the sensitivity to errors in assumption of demand warrants such a procedure.

Per capita costs of water supply projects are indicators of financial viability. Such costs cannot be used as accurate absolute or comparative measures since the figures do not allow for existing assets and liabilities. Neither therefore do they give truly comparative figures as between water supplies.

Demand/capacity relationships indicate the urgency of constructing projects on the assumption that demand is a realistic measure of benefit.

Minor urban growth centres are those where complimentary inputs are envisaged to be an asset to the socio-economic development of the surrounding rural area. All the centers considered are chosen from those justified in the regional physical planning exercise carried out by the Zambia Government.

The need to distribute development equitably throughout the Province is obvious, but the qualification of this need is perhaps best evaluated from various factors such as population densities, previous developments, geographical factors and regional distribution.

#### 2.2.1.3. Costs

Unit costs of the works to be carried out under the Project have been assessed from 1974 contract rates for similar works carried out under standard civil engineering contracts.

Though the construction will be carried out by direct labour rather than by contract, the unit costs used in the Project estimates have all been based on contract rates.



It is felt that this is the correct representation of the Project costs because it enables different water supplies to be compared on a common basis, and because it represents the total amount of construction cost which is not the case using direct labour rates. The labour rates are only a reflection of the current Government accounting system, and leave hidden costs under other budgeting allocations. This is the reason for the Cost Category F where DWA overheads are included. It allows for all the Government costs up to the level of the Director of the DWA that will be expended in carrying out the Project, but excludes civil engineering contract costs and the cost of design and contract supervision.

It includes for the Government costs on planning and administration, and for accounting, banking, and for overseeing of design and construction on all the supplies in the Project.

In the Annual Plan of Operation, costs will be put forward showing the attendant rates related to individual supplies based upon the actual choice of method of construction. The more direct labour construction there is, the more Cost Category E will increase in value and vice versa.

Price escalation is not included in the estimates of cost for individual supplies beyond the base year of 1975. It is recommended that the Annual Plan of Operation, based upon the final design, should review the value and extent of the Project, taking into account escalations actually experienced, and any depreciation both absolute and relative of and between the Norwegian Kroner and the Zambian Kwacha.

Since all estimates have been made at the pre feasibility study stage, it is appropriate to allow for a 25% physical contingency item to the Project costs. To allow for flexibility in allocating between Cost Categories, a part of this contingency, namely 10%, is included in the individual Cost Categories, whilst the balance of 15% is included in Cost Category F, so that it can be distributed to any other Cost Category subsequent to the approval of any draw down from this category as recommended in the Annual Plan of Operation.

#### 2.2.1.4. Engineering

With all construction works costed on the basis of contract performance, the costs of engineering have also been assessed entirely on a commercial basis - namely, through the services of Consulting Engineers. However as stated previously, the design will be carried out by the Norwegian Consulting Engineers, and the supervision by Norwegian technical assistance.

A standard Consultancy Form of Agreement for the construction of water supply works is proposed in Appendix A. The costs of design and supervision allowed for in this Agreement average at approximately 25% for design. The larger the project the smaller the fee structure, and the less the proportional cost of design and supervision to the construction cost.

The conditions of service of Consultants, their duties and responsibilities will conform to generally accepted international practice.

#### 2.2.1.5. Annual Plan of Operation

The annual plan of operation will be drawn up with a view to meet the objectives stated in the Agreement. Among other things, it will give for the subsequent year:

- a) Design reports.
- b) Revised cost estimates and timing.
- c) Control and remedial systems to cover problems that have arisen in the previous year and are likely to recur.
- d) Progress on the activities during the previous year on all projects.

The Annual Plan of Operation will also give for all subsequent years of the Programme the following:

- i) Revised cost estimates and timing.
- ii) Overall Project review including priority selection.
- iii) Recommendations that may assist in the proper and timely completion of the Project.

## 2.2.2. Selection of Water Supplies

### 2.2.2.1. Justification

Optimum Project selection is a complex process, because of the large number and diversity of variables to be considered. It is therefore quite obvious that hard and fast rules are unlikely to be appropriate throughout Western Province. However, one generalization regarding water supply selection is important for policy, and it does not appear to have empirical backing. This generalization is that an improved water supply, though perhaps a necessary input for improved health welfare and economic progress, is not in itself sufficient to ensure any desirable change within the community.

Water investment must be linked to complementary programmes and supplies should be selected on the basis of the existence and advancement of these supporting programmes.

The function of design appraisal is to ensure that the correct supply is selected, that the structure fits the objectives, that the elements and processes are appropriate to the resource endowment, and that the procedure for implementation is workable. Hence the technical competence of the proposal must be determined. The design must not be excessively complicated, but it must be complete. Whilst practices, particularly those established for developed countries must not be slavishly followed, new improved materials and methods should be utilised where appropriate.

Water Supplies in Western Province range from high levels of service in urban areas at the upper end of the scale, down to minimal levels of service in the surrounding rural areas.

The water supplies considered in this report are all at the upper end of the scale, supplying townships throughout the Province. In the supplies selected, both the urban area and the surrounding rural area have been included to obtain economies of scale on both development and operation and maintenance costs.

The township supplies requiring investment fall into two main categories. First, there are those expanding centres which are acquiring urban characteristics and which require a completely new water supply, as well as urban centres which also need a completely new water supply due to the obsolescence for one reason or another of their existing supply.

Secondly and more common, there are those townships which need augmentation and these fall into two distinct categories. There are those townships where the demand from the area which already receives reticulated water, exceeds the water supply, and it is proposed that such urban areas are given high priority. There are also those expanding towns for which the reticulation does not cover the entire urban area. Such townships should be given a lower priority, since by not extending immediately, no industry or person is worse off than previously.

In selecting from alternative urban supplies, it is suggested that the main criterion is the likely failure of a scheme in the near future to meet the water demand of existing consumers.

In new water supply projects, the criterion of lowest cost per capita, the humanitarian need, complementary investment and people's willingness to pay for the services must be considered.

To make a selection based on a point system has been tried elsewhere, but this method is not of practical use for this type of project at this stage of development when great benefits derive from almost any project and where basic planning data is both sadly lacking and often inaccurate.

Various studies have attempted to quantify the benefits of water supplies. A low degree of reliability must be placed on the results which have estimated capital returns varying from almost nothing to several hundred per cent. The data required for such a calculation is obtained using extremely rough estimates subject to large errors.

For example, although statistics on the number of people treated for diseases could be collected, the reduction in the number of cases resulting from a proper water supply would be a matter of conjecture at this stage.

It is also difficult to put a monetary value on the hardship and suffering caused by sickness. Even economic benefits attributable to an improved water supply are difficult to quantify. Time saving has an economic value only if the additional time is used productively, otherwise it's value is social only.

Although it is impossible to present a cost-benefit calculation, the benefits of a water scheme can be identified and are discussed below.

#### Health Benefits

Improvements in public health with the accompanying effects on general well-being and increased productivity are probably the most significant effects of improved water supplies. Data on the number of patients treated for infectious diseases in Zambia has not been possible to obtain. The extent to which improved water supplies can reduce the incidence of the water-related diseases, is not known.

An important aspect of the role of water supplies in Zambia is in controlling diseases, particularly in the prevention of the spread of cholera. It is considered that the installation of protected water supplies in strategic places as in Western Province, would be the most effective measure that can be made to limit the spread of a cholera epidemic. If the cholera vibrio can be kept from food and water, the spread of the disease will be prevented. It is realized that people will continue to use infected water sources in these areas, but protection of the most common watering points will do much to minimize the spread of the disease.

The actual benefits arising from health improvements fall into two categories. First, there are the social benefits arising from a healthier population and the higher level of well-being, a decreased infant mortality rate and increased lifespan.

Secondly, there are the indirect economic benefits. A healthier population is able to work for longer hours, and at agricultural labour peaks, where increased labour availability may have a high economic value. In addition the quality of the labour will improve. An important indirect benefit often overlooked is that improved health among school children will make them more responsive to education.

Another economic benefit that arises, is the saving on health expenditures. The people make fewer visits to clinic, leading to a saving in drugs, and in improved services being given by the limited number of medical personnel, to those suffering from other causes.

#### Time Saving

The provision of a water supply will frequently save the women and children in the surrounding rural areas from walking and carrying water each day. The amount of time saved will vary considerably from area to area as will the value of the time saved. Economic benefits may arise from the productive use of this saved labour. Even if economic benefits do not arise, there is a social benefit in the relief of the daily drudgery of fetching water from a long distance. In addition, the women will be able to devote more time to their children, home and leisure.

#### Other Benefits

The provision of a water supply can be a vital development input to encourage migration to an under-populated area to enable it to be further developed. No real development of certain areas will occur unless a water supply is provided. Such developments apart from utilizing the new areas will help to relieve population pressures in other areas and will consequently have both economic and social benefits. An ample water supply is usually a desirable complement to medical and educational facilities, industries and trade and administrative centres. Water is necessary for industrial development.

Good water supplies together with other improved facilities in the township help to prevent migration to the large urban centres in Zambia where little opportunity for productive work exists.

If all benefits of water projects could be quantified, project selection could be based on the enumeration of benefit/cost ratios together with a limited number of decision making criteria, such as provincial distribution and other objectives. Unfortunately, benefits cannot be reduced to a common monetary unit. Thus costs and benefits of a water scheme need to be looked of separately. Costs of a project can readily be expressed in monetary terms, since they involve actual cash outlays. Since it is Government policy to provide water to the entire population, and some benefits arise from all water projects, project selection mistakes are probably not as serious for the economy as design mistakes which automatically lead to a waste of resources.

#### 2.2.2.2 Selection Criteria

##### Cost per Head

An important criterion is the cost per head, low cost per capita projects should in general be completed before high cost per capita projects. This means that with limited development funds available for water more people will be provided with water sooner. This results in more people receiving benefits sooner and more people who could be charged rates which could help to finance later projects. The cost per head figure is the present value of the capital and all recurrent and replacement costs, distributed uniformly per head of the present benefitting population. This measure of benefit is a good one for completely new projects; but where the existing supply is being augmented or extended it is not wholly relevant to the financial viability of that water undertaking.

However on the basis that decisions can only be made with respect to future actions, it is a useful tool for decision making on all projects providing this shortcoming is realised at the decision making level.

### Present Demand/Capacity Ratio

Another significant criterion is the demand/capacity ratio which shows how critical the present situation is.

If the ratio is equal to one, the water supply is running at full capacity 24 hours a day. Ratios greater than one are those towns where the demand from the area which already receives reticulated water, exceeds the water supply.

### Other Criteria

All other project selection criteria are devised from the consideration of benefits resulting from water schemes. An important characteristic of a water project is its complementarity with other inputs. Hence, if these other factors are missing, the benefits from the water projects are likely to be low. Conversely, if many of the complementary inputs are already present or are planned for an area in the near future, the provision of water may be the factor which enables development to "take-off". Consequently areas of high economic potential are likely to produce significant benefits if provided with water.

It is recommended that within any rural area whether in areas of high potential or in the desert areas, first priority is given to market and local centres even if they have no more than a school and dispensary. It is obvious to most people that centres should be given priority, but this is just another case of complementarity with the investments that are already there. In addition, water investments in centres will provide foci of development for each area.



## 2.3 Description of Existing Township Water Supplies with Proposals for Implementation

### 2.3.1 General Description

The seven selected township water supplies are all in a very poor condition. Certain areas within each township are without water, due to lack of distribution system or break down.

The raw water qualities are, however, generally good with a few exceptions.

The chlorination equipment usually consists of buckets with just a hole for dosing. Pumps and engines are badly maintained, and replacements are needed all over. Waste of oil has contaminated the grounds around the supplies.

No offices, stores, workshops or proper staffhouses are in existence. Fencing around the premises is missing or very poor. The plots are not all demarcated. The water operators and pump attendants need training courses.

Detailed descriptions and observation of each supply are given in section 2.3.3 through 2.3.9. They are based on reports given by the PWE. Some of the details might not be up to date, but in general, the descriptions give fairly good pictures of the situation.

### 2.3.2 General Proposals for Implementation

Each supply shall deliver adequate water both as for quantities and quality. Due to lack of funds and of skilled staff, complicated treatment shall be avoided if possible providing hygienic standards can be obtained without it.

The chlorination equipment shall be of a proper design to ensure simple operation practice and safe water.

Each township supply shall have an office, store, yard for pipe storage and staffhouses. There should be a standard design for all the buildings.

proper fencing of at least 2 m. height should be constructed to prevent animals and intruders gaining access to the premises.

Outline proposals for implementation are given below. They are meant as a guide for the consulting engineers and will be included in the consultant's terms of reference.

### 2.3.3. Lukulu Township Water Supply

#### 2.3.3.1. Details of present arrangements and equipment.

1. Source: From Well-points
2. Pumping Units: No proper pump-house or pump-installation.
3. Rising Main: 2" Galvanised Iron.
4. Storage Tank: One Braithwaite tank on block tower.
5. Distribution: Only to residential area.

#### 2.3.3.2. General Observation

Except from the storage tank all other elements of the "present supply" have to be replaced.

#### 2.3.3.3. Proposals for Implementing boreholes to be drilled and equipped with adequate pumps to deliver the water to the tank.

Rising main and distribution system to be replaced.

2.3.4 Kalabo Township Water Supply

2.3.4.1 Details of present Arrangements and Equipment

1. Source: Directly from Luanginga canal.
2. Suction pipe: Lenth ca. 30 m, 4" diameter M.S. with foot valve, ca. 3.3. m maximum static lift, which varies with river level.

3. Pumping unit: Engine Lister  
Engine No. 847HR2A22  
H.P. 21.5  
R.P.M. 1500  
GRZ No. 12-2044

Note This sole unit has a broken engine leg, and the engine has fuel leaks.

It is directly coupled to the pump.

Pump K.S.B.  
Type W.K.L. 65-5N  
Ord No. 6-171-287/357-3  
Ser. No. 4121080510202211  
GRZ No. 11-2354.

A dismantled engine of unknown make, possibly Ruston, is at present unmounted in the pump house. This engine is reported to have been broken down for more than 12 months.

4. From the pump, water is pumped via a single pressure filter to the tank. This filter was not in use at the date of visit, due to lack of adequate filter media. It has been suggested that the existing material should be washed, but as the PWE has no rotary tumbler, not even a concrete mixer which has been used with success elsewhere, washing is not possible. Also there is not sufficient sand of mesh 16 size to make restocking a practicable operation.
5. The site is provided with two tanks 9 m<sup>3</sup> corrugated galv. steel on 9 m towers for back washing.

6. Water is pumped on the following rotational hourly basis,  
06.00-10.00 town  
10.00-14.00 school  
14.00-16.00 town  
16.00-22.00 hospital.
7. Two operators are authorized and are working on shift.
8. Tanks are installed at
  - a) School ca. 140 m<sup>3</sup>
  - b) Hospital " 55 "
  - c) Town (old) " 55 "
  - d) Town (new) " 225 "
9. All rising mains are reported to be 4" dia. and direction of flow is controlled by a system of sluice valves.
10. A collection gallery with a vertical shaft 8 m in depth has been dug down at the back of the Luanguga to soft sandstone base by the PWE and yields 40 m<sup>3</sup>/h with a 0.9 m drawdown on 6 h test. The water, despite of the fact that there is no direct connection with the Luanginga canal, is brown, although this may clear on continuous use.

#### 2.3.4.2 General observations

1. As there is no office, the staff has no shelter or place to keep records.
2. The fence is of an inadequate nature.
3. With the extension of the new township boundary, it is doubtful that all sections of the new area will be served by the new tank.

#### 2.3.4.3 Proposal for Implementation

The following alternatives should be considered.

##### Alternative 1.

The collection gallery should be testpumped for a longer period and water samples analyzed.

- 1 a. If the capacity and the water quality are adequate, the water should be chlorinated and pumped to the new existing storage tank for distribution.

1 b. If the capacity is adequate, but the water needs treatment, filters or coagulation should be considered.

1 c. If the water quality is adequate, but the capacity too low. additional infiltration arrangements should be considered.

#### Alternative 2.

To pump the raw water directly from the Luanginga to a treatment plant, likely coagulation. After treatment the water should be pumped to the storage tank for distribution.

#### Alternative 3.

The World Bank Education Project has under construction four gravel packed boreholes at the Secondary School. According to the test-pumping, the boreholes are yielding 7 l/s or 25 m<sup>3</sup>/h on average, giving a total of 1000 m<sup>3</sup>/day, assuming 10 hours pumping.

The depths vary from 30 m to 40 m. The sub-grade consists of a 9-12 m. thick deposit of uniform, probably alluvial, sand of aeolian origin. Further down to a 27 m depth there are stratified formations of clayed sand with a content of clay, varying from 2-20%. Below the 27 m depth, uniform sand as well as a layer of clayed sand, and then layers of pure clay were encountered.

According to Norconsult A/S, the boreholes will be equipped with electrical submersible pumps, supplied from generators. An aeration plant for removal of iron is planned.

One borehole costs K 50,000, including drilling, casing, filter and pump. The water supply is estimated to cost K 200,000 or about K 140 per head (school only).

The water quality from the boreholes will be of vital importance to the final design and the costs. Mineral content in the water will cause operation and maintenance problems.

Assumed water demand for the school:

Boarding students:	100 l/d x 1008	=	100 m <sup>3</sup>
Staff and families:	50 l/d x 400	=	20 m <sup>3</sup>
Day students:	20 l/d x 112	=	<u>2 m<sup>3</sup></u>
Total demand:			<u>122 m<sup>3</sup></u>

The demand for the town is estimated to be in order of 110 m<sup>3</sup>/d, assuming 20% individual connection and 80% communal water points.

Individual connection:	20% of 4000 at 50 l/d	=	40 m <sup>3</sup>
Communal water points:	80% of 4000 at 20 l/d	=	64 m <sup>3</sup>
Dispensary, bars, etc.		=	<u>6 m<sup>3</sup></u>
Total demand for the township:			<u>110 m<sup>3</sup></u>

#### Consideration of Alternatives

The existing distribution system is not adequate and should be improved. Such costs are common for all alternatives and are not included in the comparison below.

#### Costs:

Alternative 1 a:

2 pumps (one standby)	K	4 000
Pipes, fittings, pumphouse	K	<u>1 500</u>
	K	<u>5 500</u>

Alternative 1 b:

Alternative 1 a	K	5 500
+ Coagulation	K	<u>7 000</u>
	K	<u>12 500</u>

Alternative 1 c:

Alternative 1 a	K	5 500
+ Infiltration system	K	<u>2 000</u>
	K	<u>7 500</u>

Alternative 2:

Intake, pumps, pumphouse, pipes, fittings	K	6 000
Coagulation	K	<u>7 000</u>
	K	<u>13 000</u>

Alternative 3: x)

Borehole water supply

K 94 8000

x) The costs are shared with the WBEP, according to assumed daily demand. For alternative 3 the costs of the trunk main, from boreholes to township distribution tank will be additional.

At this stage it is impossible to decide on alternatives. The consulting engineer has to check in detail on the possibility of implementing the alternatives 1 a, 1 b, 1 c and 2. Alternative 3 will be the most expensive alternative.

Phasing

Phase 1                      To bring adequate water to the distribution tank and to improve parts of the distribution system.

Phase 11                    To improve the distribution system and extend it to the entire township and the surrounding rural areas.

### 2.3.5 Kaoma Township Water Supply

#### 2.3.5.1 Details of present Arrangements and Equipment

1. Source: Direct extraction from a small dam to the west of Kaoma. This dam is spring fed with a minimum flow over the spillway of ca. 30 l/s above the present extraction amount for the town supply from the dam.
2. Treatment: The raw water which is very turbid, is treated at a works situated next to the side of the dam. The treatment comprises alum dosing, flocculation, slow sand filtration, with chlorination into the clear water well. Equipment installed for the above, being
  - a) Flocculation tank, steel
  - b) Slow sand filter tank, steel
  - c) Clear water well, brick, locally constructed, 45 m<sup>3</sup> capacity
  - d) 4 No. x 9 m<sup>3</sup> corrugation galvanized tanks on a 6 m high brick stand for back washing.
3. Inlet to low lift pump: Length ca. 20 m, 3" dia. M.S. galv. steel  
Foot valves reported to be fitted, but not visible at time of visit. Suction lift ca. 2.4 m.
4. Delivery to treatment: 18 m M.S. Galv. 3" & 6", as this was buried, actual length unknown, static head 3 m.
5. Details of pumping units are as follows:
  - No. 1 Low Lift: Engine Lister  
Engine No. 2075SR1 23  
H.P. 6  
R.P.M. 2000  
GRZ No. 12-2049  
Coupled to pump by "V" belt equal dia pulleys  
7" dia.  
  
Pump: HARLAND weir  
Type: SNB 2  
Impeller: 164 M.M.  
Serial No. 53161-405  
Date: 1973 (on pump plate)  
GRZ No. 11-2558



This unit was operative at time of inspection, but leaking fuel was observed in several places.

No. 2 Low Lift: Engine Lister

Engine No. 9464SR2 22  
H.P. 15.5  
R.P.M. 1800  
GRZ No. 12-2031

This engine was broken down at time of inspection and being repaired by the pump operator. It was coupled to the pump by "V" belts with equal dia. 7" pulleys.

Pump: HARLAND WEIR  
Type: SNB 2  
Impeller: 164 M.M.  
Date: 1973 (on pump plate)  
GRZ No. 11-2557

No. 1 High Lift: Engine Lister

Engine No. 1869HR3 319  
H.P. 41.25  
R.P.M. 2000  
GRZ No. 12-1415

This engine was operative at time of inspection, but fuel was leaking. It was coupled to the pump by "V" belts, the engine pulley was 19" and the pump pulley 13" dia.

Pump: K.S.B.  
Serial No. 65-685-70  
Type: WKL 65-3  
GRZ No. 11-1936

No. 2 High Lift: Engine Lister

Engine No. 1904HR3 19  
H.P. 41.25  
R.P.M. 2000  
GRZ No. 12-1858

At time of inspection, this engine was not mounted although reported to be operative. Several parts were disconnected, and no pulley was fitted.

No. 3 High Lift:

A third engine of a similar type to the other two high lift engines was present in a partially dismantled state. M.S.B. staff are reported to have removed parts to repair the other two.

Details as follows:

Engine	Lister
Engine No.	2674HR3 A21
H.P.	41.25
R.P.M.	2000
GRZ No.	12-2079

6. Dam: The embankment of this dam requires major attention and is in a potentially dangerous condition. Large trees have been permitted to grow on the downstream slope which need grubbing out. The freeboard is very small.

Rising Main:

The length of the rising main to the existing town tank is 1500 m. 4" dia., asbestos cement for the most part. The static head to the town tank is 71 m. Regrettably the rising main is also used as a distribution main which, dependant on the demand, varies delivery to the town and school tanks.

Tanks:

- a) The school has 6 No.2000 galv. tanks on 18 m. towers.
- b) The existing town tank is a 55 m<sup>3</sup> Braithwaite type on a 12 m. tower. It is in a poor condition so that only the first tier of panels is usable for storage, reducing its effective capacity to 18 m<sup>3</sup>.
- c) A new 455 m<sup>3</sup> tank was constructed to the south of the school and has been available for use for 18 months. P.W.D. is currently connecting this. The rising main length when complete will be 4000 metres long with a static head of 36 m. above the pumping station.

7. The present pumping arrangements are to divide the pumping between the town and the school on the following hourly basis;

04.00-07.00 School

07.00-09.00 Town

09.00-13.00 School

13.00-16.00 Town

16.00-19.00 School

19.00-22.00 Town

This gives totals to the school of 10 hours

to the town of 8 hours.

8. A collection gallery gravel packed, was completed by the PWE during 1974, which on test gave  $55 \text{ m}^3/\text{hr.}$  delivery on a 7 hour test in early November 1974, at which time the Luena river was at its lowest level. Drawdown was less than 0.3 m., and the level returned to its original point in less than ten minutes. An additional ca. 3.5 m. of depth was available but due to the level of water below the shaft lip, portable pumps available did not permit a more definitive test.

#### 2.3.5.2. General Observations.

1. There is at Kaoma no records kept of any kind. The interior of the washout tank stand is capable of being used as an office if furniture were to be provided. This would also provide a place of shelter for the staff during inclement weather.
2. A number of staff are housed close by to the pumping station in GRZ houses. The houses are regrettably in a very poor state of repair.
3. No watchman is employed, nor is the works adequately fenced.

#### Test data (physical)

A pumping test of the high lift engine and pump to the school and town tanks was conducted on a one hour basis using the draw-down on the clear water well as a basis. Due to the use of the rising main as a distribution main also, this does not necessarily reflect what arrived at the tanks in question. The results were as follows: school ca.  $23 \text{ m}^3$ ; town ca.  $25 \text{ m}^3$ .

### 2.3.5.3. Proposal for Implementation

The following alternatives should be considered:

#### Alternative 1.

Construction of gravel packed infiltration galleries at the existing water supply and improvements of the existing gallery.

A new gravel packed infiltration gallery should be constructed near the existing water supply. If the capacity and the water quality prove adequate, the infiltration gallery should replace the existing treatment plant.

#### Alternative 2.

If the proposed infiltration gallery proves inadequate, a new treatment plant including coagulation based on the dam as source should be considered.

The existing infiltration gallery should be improved and equipped as proposed in alternative 1.

#### Alternative 3.

Four gravel packed boreholes are planned for Kaoma Secondary School (WBEP). If the drilling is successful, and the costs are reasonable, a connection from the School Water Supply to the town should be considered.

### 2.3.6 Mongu Township Water Supply

#### 2.3.6.1. Details of present Arrangement and Equipment

##### 1. Source:

- a) The principle source for the town supply is from the Kambule stream, the stream rising from a spring complex at the head of the valley east of the town. The length of the stream is 2 km, and there is a level difference from the head to the treatment works of approx. 5.5 m. The upper part of the channel is brick lined for a length of 900 m. However, due to lack of maintenance this lining is in a very bad condition. During late October, 1974, the PWE dug out the channel which was at that time blocked completely and buried in sand and silt (average 1 m).
- b) To supplement the above source, a well point ring was sunk by the PWE in 1968 and has been maintained periodically. It has a maximum capacity of 14 m<sup>3</sup>/h, but is for the time being not equipped. The water quality is, according to the PWE, such that it can be delivered directly to the clear water well. This is located on the east side of the Blue Gums recreation area.
- c) An investigation hole was sunk on the west side of the Blue Gums area in the section allocated as a water reserve in 1972. The test yield was in order of 22.5 m<sup>3</sup>/h. Unfortunately the pump on physical test delivered 43 m<sup>3</sup>/h spasmodically, and the resultant ingress velocity drew "fines", blocked the hole and sheared the pump impellers. This hole is now cleaned out, but due to inadequate development, it can only be made to yield 14 m<sup>3</sup>/h.

2. Treatment Works:

- a) The Kambule water enters the works via a concrete lined channel controlled by two 6" dia. gate valves. The entrance channel is provided with an overflow sill to cope with water in excess of the pump house's capacity, and a low level pipe to permit the channel to be drained for cleaning purposes. This last task is not being done. The incoming water is chlorinated and alum dosed within an aeration pipe ring which is fed from a compressor. Details are given below:

Motor	Compressor
Electric ASEA	Make: ATLAS COPCO
Thrice-TITAN	Ser. No. 222357
MOT3-50H2 IEC54.1.1960	Type 1c 302
MT90L24-2	Volume: 150-5.3
2.2KW 3 hp	Work. pres. 15-213
380V4	Test pres. 23-327
Class B	Temp. 100°C 212°F
2870	Made 1970
4.7 Amp	GRZ No. 3-284
COS 2087 CAT NO. MK 110010-B	

A standby compressor is installed, but inoperative, details are given below:

b) Motor	Compressor
Petrol HONDA	Make: ATLAS COPCO
Type G 40 4.5 hp	Ser. No. B177005
Engine No. 1131523	Remainder as above.
No carburettor	GRZ No. 3-284

After passing the valves the raw water enters a swirl chamber. Entrance is by a hole in the side of the channel, although originally there were two pipes, but these have been blocked up for some reason which is unknown, and result in a head loss of 4" - 6" between the entrance water level and the swirl chamber level.

This is of some importance in low flow conditions as the gradient is thereby effectively reduced.

- c) The dosed and mixed water then enters a "U" shaped sedimentation tank by pipes installed at  $90^{\circ}$  to the induction channel. The dimensions of this tank are - length along centre line 65 m, top width 6.5 m, bottom width 0.5 m, depth 0.9 m. From the above dimensions it will be seen that the dwell or transition period of the water is such that complete flocculation and sedimentation cannot take place in this tank when a volume of  $2300 \text{ m}^3/\text{d}$ , the minimum being required, is running through it.
- d) The water exits from the sedimentation tank via a rising sill and trash screen, and empties into the channel to the clear water well. This channel is in fact a continuation of the induction channel, and by removal of a board, the supply can be maintained and the sedimentation tanks bypassed for cleaning purposes. The well point and borehole water is delivered to this channel.
- e) The clear water well was extended a year ago, but regrettably it cannot be drained by suction, and hence the sediment previously referred to cannot be removed without interrupting the supply. Chlorine is dosed at the mouth of the clear water well.
- f) The pumping units are housed in two separate structures, one being of "Altent" type and one of brick construction. Permanent structures of three wall open faced configuration, house the compressors and dosing units on the west side of the entrance-clear water well channel.
- g) The pumping units are as follows, all electric all directly coupled (Fenner):

Unit 1	Engine make Compton Parkinson
Brick house	D. 326 Frame K5M2
at entrance to	50 H.P. 380/440 Volts
works. South of	2945 R.P.M. 63 Amps MECH
clear water well	M.C. RATING E. INS. CLASS
	G.R.Z. No. 29-2629
	Pump make K.S.B.
	Maker's plate removed type from
	Impeller body SA 80-25
	G.R.Z. No. 11-2401
	connections, pipe, inlet 3"
	outlet 4" By visual inspection
	single stage?
Unit 2	Engine make Compton Parkinson
	D.180M Frame D6K25E
	30 H.P. 380 Volts
	2920 R.P.M. 42 Amps
	3 Phase
	M.C.Rating
	50 H.Z. E INS CLASS
	No G.R.Z. No. to be obtained from
	M.S.B.
	Pump K.S.B. Single stage
	Type ETA 50-26 AR
	N.R. 732452/257
	Connections pipe inlet 3" outlet 1½"
	No G.R.Z. No. to be obtained from M.S.B.

The relative switch and control gear for the two units detailed above is permanently mounted in the house.



Unit 3  
situated on west  
side of clear water  
well

Engine make Compton Parkinson  
C266 Frame 5K2E  
30 H.P. 380 Volts  
2920 R.P.M. 42 Amps  
3 Phase  
5 C/S  
M.C. Rating E INS CLASS  
G.R.Z. No. 29-2630  
Pump make K.S.B. single stage  
Type ETA 50-26 AR  
Only top half G.R.Z. No. on pump  
G.R.Z. No. ? 11-922 from record  
appears to be 11-3533 connections.  
pipe inlet 3" outlet 2".

Unit 4

Engine make Compton Parkinson  
D180M Frame D6K25E  
30 H.P. 380 Volts  
2920 R.P.M. 42 Amps  
3 Phase  
50 H.Z. E INS CLASS  
M.C. Rating  
G.R.Z. No. 29-2618  
Pump make K.S.B. single stage  
Type ETA 50-26 AR  
No G.R.Z. No. to be obtained from  
M.S.B. connections pipe inlet  
3" outlet 1½"

Note: This unit is in working order.

Unit 5

Engine make Compton Parkinson  
D200L Frame D6M2E  
37 K.W. 380 + 1-6%  
2940 R.P.M. 69 Amps.  
50 H.Z. E INS CLASS  
Rating ?  
G.R.Z. No. 29-2619

Pump make K.S.B. single stage  
Type ETA 80-26  
No G.R.Z. No. to be obtained from  
M.S.B. connections pipe inlet  
4" outlet 3"

Note: Unit is in working order.

Unit 6                      Engine make Compton Parkinson  
D200L Frame D6M2E  
37 K.W. 380 + 1-6%  
2940 R.P.M. 60 Amps  
50 H.Z. E INS CLASS  
Rating ?  
G.R.Z. No. 29-2617  
Pump make K.S.B.  
P. 342464  
From impeller body  
G.R.Z. No. to be obtained from  
M.S.B. connections pipe inlet  
4" outlet 3"

- Note:1. Unit is in working order.
2. The relative switch and control gear for the 4 No. units detailed above is permanently mounted in the house.
  3. Also present in this house is the following equipment in an unmounted stage. By report all these units were working when the new units arrived and were removed at that time. They were all reported to have been giving trouble, unspecified, when removed.

Unit 7                      Engine make Compton Parkinson  
92 Frame 924ET900  
25 H.P. 380/420  
2895 R.P.M. 3 phase  
34 Amps. 50 C/S  
205 R. Volts 35 Amps.  
C.M. Rating E INS CLASS

No G.R.Z. No. to be obtained from  
M.S.B.

Note: This motor as stated is not connected, but is  
reported to be working.

Unit 8                    Engine make First Electric Co.  
                          Type K5626/A221 H.P. 25  
                          C.Y. 50 R.P.M. 2930  
                          Volt 380/400 Amps. 32.3  
                          P.H. 3 Rating cont.  
                          Encco Prot. No. 94109  
                          G.R.Z. No. 29-1113

Note: This motor is reported to be inoperative.

Unit 9                    Pump make K.S.B.  
                          Type WKL. 65-2  
                          No. 659470  
                          G.R.Z. No. 11-2150

Note: This pump may be working if operator's  
memory is correct.

Equipment

stocked

in open:    1.        Engine make Compton Parkinson  
                          Frame No. 92 Ser. No. 9241541  
                          H.P. 25 R.P.M. 2900  
                          Phase 3 380/420 Volts  
                          C.M.R. Rating 35 Amps.  
                          50 C/S 210 R. Volts  
                          50 R. Amps.  
                          No G.R.Z. No. to be obtained from  
                          M.S.B.

Note: May be repairable.

2. Pump make Sulzer Bros.  
No. Ser. HCP-15-16½  
3 stg.  
Order No. 10474 year 1953  
2" inlet 1½ outlet  
No G.R.Z. No. to be obtained from  
M.S.B.

Note: May be repairable.

3. Switch gear consol.  
Slip ring Motor ALLEW WEST & CO.  
Type Sr. 1A No. 5648B  
H.P. 25-50

4. Pump make SULZER BROS.  
HCP 15-6½ 3 stg.  
Order No. 10479 year 1953  
No G.R.Z. No. to be obtained from  
M.S.B.

5. Portable dewatering pump.  
2" ALCON PETERS ENGINE  
No G.R.Z. No. to be obtained from  
M.S.B.

Note: Inoperative.

6. As last 3" ALCON LISTER ENGINE  
GRZ No. 11-2510

Note: a) Inoperative.

- b) Items 5 & 6 used to empty sedimentation  
tank, no unit to use at this date.

- 7 & 8. Two small Compton Parkinson  
3 H.P. electric motors  
No G.R.Z. Nos.

Note: These motors are reported inoperative and used to  
drive compressor. Compressor no longer on  
station.

9. Pump make SULZER BROS.  
H.D.L. 18-8 20<sup>0</sup> 2 st.  
Order P4899 year 1964  
No G.R.Z. No. to be obtained from  
M.S.B.

Note: This pump may be repairable.

The pumping station has a store for treatment chemicals and a garage. No vehicle of any kind has been handed over to date.

There are 2 medium density houses within the security fence.

Rising Main: There are 2 rising mains to the Boma Hill tanks of similar length 1800 m. and static head of 50 m, both asbestos cement. They are of 9" and 6" diameter. No washout is possible without disruption of supply.

Tank: Details of tanks all of which are of Braithwaite type, are as follows:

- 1) 3 tanks on Boma Hill. These are all in fair condition without major leaks, each at 140 m<sup>3</sup> capacity giving a total of 420 m<sup>3</sup> storage. The rising main delivers to the north-west tank, and the tanks cannot be isolated for cleaning out and maintenance. These tanks are the only ones in use at present.
- 2) 1 No. 140 m<sup>3</sup> tank on the Boma Hill. This tank is not connected, and has not been filled, so the situation with regard to leaks is not known.
- 3) 1 No. 55 m<sup>3</sup> tank located at the head of the Kambule valley to the west of the town. This tank is in fact connected to a small bore pipe, and if the delivery to it was not also a distribution, the tank would fill. Due to draw off on the supply side, there is rarely sufficient pressure to raise water to the required head. It has been suggested that a booster pump should be installed at the foot of this tank stand.

### 2.3.6.2 General Observations

1. This station is by far the most complex of all supplies within the Province, and hence the lack of informed planning has led to the present situation whereby the existing system is not only run down, but is extended beyond its capacity even if it were running 100% efficiently.

2. The multiplicity of relatively small, pumping units has been forced on the P.W.D. as the electricity supply is limited, and a need to be able to reduce the current used has necessitated a pumping capacity that could be increased or decreased by increments, as power is available.

The ZESCO local office is not able to give firm data as to when the supply will be adequate to permit improvements, but this is dependent on the Victoria Falls' power line being completed. A diesel standby would be advisable to cope with full demand capacity.

3. The availability of storage totaling 650 m<sup>3</sup> at present not used, especially when related to the 420 m<sup>3</sup> in use, is perhaps the first and most obvious factor to be corrected. If all tanks are connected, approx. 50% of the daily demand could be stored, and as the Kambule has a constant volume, this would then be used effectively. If pumping was not reduced or stopped.

4. There is regrettably a substantial amount of water wastage and misuse in this Boma, partly due to deliberate action by the consumers, pull-type showers being tied with string to window catches, pressure release taps being tied down with vehicle inner tube, or locked open with a rather ingenious wood and wire device, multiple hose pipes being attached to common user taps and left running all night to gardens etc. etc., and partly due to poor maintenance of taps, showers and toilets, particularly on GRZ controlled premises.

As there appears to be no by-laws to correct the former and adequate funds or staff, the latter, it is difficult to see how this problem can be solved, that a 3" pipe connected to the existing rising main controllable by valve within the treatment works would be a more practicable proposition.

5. There is a new 455 m<sup>3</sup> tank situated near to the south of St. John's School site which, although not in use, is well situated to supply the demand of that area. This area comprises the school and the high density area at this date, and the industrial area in the immediate future. This tank is at present not in use.

#### Reticulation

This is without doubt the worst feature of the entire system. A precise opinion cannot be given as the existing plan is not to be relied upon. The supply may be, and probably was originally, sufficient and effective, but as connections have been made to reticulation mains without regard to their capacity to transmit the volume required with the available head, the supply is now such that although the connected tanks may be filled to overflowing, the draw off on the mains, in their length, precludes the possibilities to supply water at their end.

#### 2.3.6.3 Plan of Implementation

##### Sources:

An infiltration gallery at the spring complex at Kambule, and eventually gravel packed boreholes, should be considered.

The channel should be replaced by pipes if the silting problems could be avoided by using gravel packed infiltration gallery or boreholes.

The existing well point ring and the investigating hole should be tested and considered as additional sources. If the boreholes which are planned to be drilled for the WBEP, prove successful, gravel packed boreholes should be considered for Mongu Water Supply. However, these boreholes are planned to be drilled at the spring side and would result in a diminution of this flow.

Treatment:

If the proposed infiltration gallery, well points and boreholes are successful, no treatment except chlorination will be required.

If the existing spring source at Kambule has to be in operation, silt traps along the channel should be constructed to avoid silting problems in the channel and treatment works.

Methods of treatment should be considered. From consideration of samples taken at the springsite on the 12th of September 1975, coagulation should not be required.

Reticulation:

Most of the reticulation system has to be improved or replaced. Distribution lines have to be extended to cover the whole area, including the surrounding rural area of Mongu.

2.3.7 Namushakende Township Water Supply

2.3.7.1 Details of present Equipment and Arrangement

1. Source:

- a) By brick lined channel from a lagoon at plain edge to
- b) Brick lined chamber 1.80 dia, into which chlorine is introduced, to
- c) Brick lined clear water well 2.40 m.

The water in the lagoon is reported to be of excellent quality in its natural state. Cumulative diesel oil contamination of the ground around the clear water well, due to spillage, is such that the clear water well has a scum of diesel fuel. At the time of inspection by the PWE at least 15 large dead and decomposed frogs, 4 lizards together with what looks like a large mouse or rat and possibly a snake were found in the well. As there are no valves on the pipes between the clear water well and the chamber, it is impracticable to isolate the well. However, the well must immediately be filled with clean sand, the pipe removed and water pumped from the chamber directly, in the interest of public health.



2. The suction main is from the contaminated clear water well, via multiple 90° bends, to the pump 3" dia M.S. galv.

3. Details of the pumping unit are as follows:

Engine LISTER

Engine No. 66HR322

H.P. 41.25

R.P.M. 2000

G.R.Z. No. 12-2077

This unit, delivered in 1974, appears to be in good condition.

The pump is coupled to the above by "V" belts.

Engine pulley 11", pump pulley

Make K.S.B.

Type ETA 40-3312 AR.

4. Rising main: 3" asbestos cement

640 m long

60 m static head.

5. Tank: 225 m<sup>3</sup> Braithwaite type on 9 m stand, leaks reported, but not observed as during the inspection tank was not filled to the level at which they are reported to occur.

#### Test Data(Physical)

Delivery pump to tank 13.7 m<sup>3</sup>/h.

#### 2.3.7.2 General Observations

1. The station has no records of any kind and no data sheets for equipment.
2. No working schedule is given to staff at time of inspection.
3. There is no office or shelter other than pump house.
4. No watchman is employed, and no one is present during the night. A two shift system is at present employed. The present fencing is inadequate.

### 2.3.7.3 Proposals for Implementation

The brick lined channel, chamber and clear water well to be cleaned. The oil contaminated soil to be replaced.

Additional pumps, engines, rising main and high level storage tank to be installed.

The reticulation system is to be extended and partly replaced.

At the intake site, office, stores and houses for two water operators should be constructed. A proper fencing is required.

### 2.3.8 Senanga Township Water Supply

#### 2.3.8.1 Details of present Arrangements and Equipment

1. Source Zambesi, direct extraction.
2. The river has a flood rise, by local report, of ca. 5.5 m. This may be conservative, and 7.5 m would ensure safety of equipment.
3. There are 2 rail sets for altering the relative height of the pump and engine.
  - a) The narrow gauge set at present not in use, being the original unit installed during the late 50's or early 60's. This is poorly laid out as at the lowest flow level the track terminates 3.5-4.2 m above the river level. This high suction head is aggravated by the trolley being under a semi-permanent shelter about one third of the rail length from its terminal and hence increasing the pump's relative level. This increase is, however, not very great, less than 0.9 m, due to the low angle of the rail bed's gradient.
  - b) The broad gauge railway was installed in 1971, which is at present in use. This rail terminates at low water level.
4. The low end of the suction pipe is supported by 2 oil drums and a flexible pipe to permit the foot valve to clear the river bottom. The pipe has the normal convolutions seen on all installations.

5. Details of the sole pumping unit are as follows:

Engine Lister

Engine No. 1800SR320

H.P. 18

R.P.M. 1800

The engine is reported to have arrived in March 1974 and is in fair condition although attention to the fuel tank is required. This is remotely mounted on an angle iron frame which does not permit the movement of the unit up and down the rail. The subframe of the unit is broken and requires welding.

6. The rising main is 3" dia 330 m length with a static head of 36 m. approx., dependent on river level.
7. A pressure filter, similar to the unconnected one at Sesheke, is installed, but unfilled and not in use. It is reported to have been used for 12 months in the early 60s and appears on superficial inspection to be complete.
8. Chlorine dosing is carried out into the rising main presumably via a venturi, but without stripping this is not definite.
9. Storage tank 455 m<sup>3</sup> Braithwaite type. No leaks were apparent at the inspection date. The outlet and washout are permanently sealed by flanges and require piping away from the foundations.
10. It was found impossible to do a physical test to the school as the main was broken.
11. Test Data (Physical)
- As no information on capacity was available in the unit, a test was run to the town tank and the following delivery rate was observed:

Town tank 18 m<sup>3</sup>/h

School tank, see 10. above.

#### 2.3.8.2 General Observations

1. The station has no records of any kind.
2. No working schedule has been given to the staff.

3. No office other than a 6' x 8" tin shack is available for the station, and no shelter is available for the staff.
4. No watchman is employed and no one is present during the night.  
A two shift system being at present employed. The present fencing is inadequate.
5. The site is not demarkated.

#### 2.3.8.3. Proposals for Implementation

##### Alternative 1

Source: Zambezi River.

Intake: A pumphouse to be constructed on the trolley.

A stand by trolley with pumphouse, pump and engine to be constructed.

Treatment: The water quality is adequate during low level.

Samples have to be taken during flood. If the test results are not adequate, methods of treatment should be considered. The present filter should be filled and commissioned.

If the filtration is successful, more filters should be installed to keep up with the demand.

If filtration alone is not successful, coagulation should be considered.

##### Alternative 11

Source: Groundwater- Infiltration from Zambezi River.

Intake: An infiltration gallery with well to be constructed at the river bank. Alternatively gravel packed boreholes with Johnson screens No. 10.

Assumed that the water quality is adequate, the water can be pumped directly to the high level storage tank.

Common for Alternative 1 and 11:

Storage tanks: Additional storage tanks to be constructed.

Reticulation System: The existing reticulation system should be examined, distribution mains to be replaced, reticulation system to be extended to cover the whole township and the surrounding rural area of Senanga.

### 2.3.9 Sesheke Township Water Supply

#### 2.3.9.1 Details of present Arrangement and Equipment

1. Extraction directly from Zambezi river.
2. The river has a flood rise of approx. 7 m by local report.
3. There is in existence a short narrow gauge rail track with engine trolley and winch which is not at present in use.
4. The low lift engines are mounted on fixed foundation blocks, the lower being 3.5 m above the river's minimum level and the upper 5 m. These engines are mounted with their axis at 90° to the source and have therefore 90° angle bends immediately ahead of the inlet of the pump which is bad practice and prevents the upper pump priming at the present water level. The lower unit has to be removed from its foundation block and then replaced annually. When the flood comes, with the present arrangement, the standby capacity of the two installations is nil!
5. Details of the low lift pump are as follows:

Unit 1                      Engine make Lister  
  
                                 Engine No. 67HR2A21  
                                 H.P. 21.5  
                                 R.P.M. 1500  
                                 GRZ No. 12-1901

Notes: The oil pressure and temp. gauge are broken and were at the time of inspection tied with string to the engine. The remote mounted fuel tank is leaking badly, and the stand requires welding to prevent movement between it and the engine, the pipe is already cracked.

Pump: Directly coupled, fenner, to the above.  
Make K.S.B. Single stage  
Inlet 4" outlet 3"  
Type ETA 80-36  
G.R.Z. No. 12-1930 Not as per P.C.W.  
Inlet pipe 3" dia galv M.S. maximum length 100'.

Unit 2

Engine Make : LISTER

Engine No. 1825SR317

H.P. 15

R.P.M. 1500

GRZ No. 12-1913

Pump: Coupled to the above via "V"  
belts, one belt only fitted at  
time of inspection, although  
pulleys for triple belts.

Make K.S.B. single stage  
Inlet 4", outlet 3"

Type ETA 80-26BR

6. Rising Main from low lift pumps to Clear Water Well

Main pipe, 6" dia. galv. M.S.

Length, unit no. 1 : 200 m.

unit no. 2 : 190 m.

Each has 10' length of 3" dia. connector  
pipe to main

Level, unit no. 1 : 11 m. below clear  
water well

unit no. 2 : 9 m. below clear  
water well

No wash out is fitted on this line.

7. Clear Water Well

Type: circular brick, part buried below  
ground level

Capacity : 225 m<sup>3</sup>

Diameter : 13 m.

Depth : 1.8 m.

Connections.

- 1) 6" dia. inlet from low level pumps  
at F.S.L.
- 2) 2 no. 6" dia feed to high lift pumps,  
fitted with non-return valves.
- 3) 4" dia. washout with gate valve combined  
with overflow connected to 6" dia.  
waste pipe.

Notes: Dosing of chlorine to tank by dustbin drip feed.

There are three pressure filters installed on this station, two of which are connected to the system:

Dimensions diameter 2.6 m.  
depth 1.5 m.

and one of which is not connected:

Dimensions diameter 1.7 m.  
depth 1.5 m.

These were supplied and fitted ca. 1966, but have never been used due to lack of filter media.

#### 8. High Level Units.

These units are used to pump from the clear water well to the town tank and secondary school tanks, details as given;

##### Unit No. 1.

Engine make LISTER  
Engine No. 146HR318  
H.P. 41.25  
R.P.M. 2000  
GRZ No. 12-1188

Notes: This engine appears to be in good condition with only minor work required to put it in good order, i.e. replace tank rubber grommets, replace gauge's mounting plate attachment with bolts instead of wire.

Pump : Connected to the engine via "V" belts, 2 missing at date of inspection.

Make: Kelly and Lewis, single stage

Inlet 3" dia.

Outlet 2" dia.

Manufacturers plate  
marked 2" - 12" G7284SER No.

Model 70

Condition appears new.

Unit No. 2.

Engine make RUSTON  
Engine No. 3YWA-1063-0870-27  
H.P. 35.25  
R.P.M. 1800  
GRZ No. Not given

Notes: The outward appearance of this engine suggests that it is a very old unit indeed, but it may have been reconditioned as it runs quite well. If the amount of lubricant reported to be burnt is correct, it requires examination.

Pump : Directly coupled to the engine. Due to the fact that the engine coupling is an FX9 and the pump a FX8 that do not match, the cushion or rubber bolster disintegrated whilst running tests of 2 hours duration. The faces of the coupling are not aligned either laterally or horizontally, and accurate "setting up" is required using matched couplings.

Make Kelly and Lewis

Inlet 3" dia.

Outlet 2" dia.

Manufacturers plate partially defaced, with legible figures as shown:

Model 50 ???  $\frac{1}{2}$  Series 8

Pump No. J. 68.

9. Rising Mains.

To town tank

6" dia. galv. M.S.

Length 140 m.

Static head 62 m. to inlet

To school tank

6" dia. asbestos cement

Length 9600'

Static head 120' approx.



## 10. Storage Tanks.

### Town Tank:

Type Braithwaite on steel tower 50' high  
Capacity 100,000 gallons  
Dimensions 36' x 36" x 12' in 4' sq. panels

Notes: Minor leaks apparent on north and east side.

Overflow and washout terminate at ground level, with no pipe to lead water away thereby endangering south west leg foundation.

### School Tank:

Details of inlet and construction as for clear water well.

Washout and overflow of smaller size.

### 2.3.9.2. General Observations

1. The station has no records of any kind and no data sheets for equipment.
2. No working schedule had been given to the staff. Engines were running at 17.15 hrs., and the station was closed down at 20.00 hrs.
3. There are no office or stores.
4. Despite the security position at this station, no watchman is employed when the station is not working.
5. The housing of staff is dispersed.
6. The extent of the "stand" is not demarkated.

### 2.3.9.3. Proposals for Implementation

#### Alternative 1.

Source: Zambezi River.

Intake: A new railway trolley to be constructed and winch to be mounted with low lift engines on a gradient excavated to permit pumps to be placed lm. maximum above river level. Inlet pipe to be full bore size of pump and run to be straight to avoid losses due to cavitation. Two low lift units if directly coupled should be mounted on trolley and effective standby use would thereby be obtained.

Treatment: According to the PWE, no complaints have been received on the turbidity of the raw water. However, water samples should be taken during flood. If the water has a turbidity too high, one of the three filters which at present have no media, should be tried. If the results are adequate, the filters should be filled with media and put into operation.

If filtration is not successful, coagulation in addition should be considered.

#### Alternative 2

Source: Groundwater <sup>2</sup> infiltration from the Zambezi River.

Intake: An infiltration gallery and a well should be constructed at some distance from the river. An alternative would be a gravel packed borehole with a Johnson screen No. 10. From the well or borehole, the water would be pumped directly to the existing high level storage tank. With the exception of chlorination, treatment would probably not be needed.

Common for Alternative 1 and 2.

#### Storage Tank:

The foundation of the 455 m<sup>3</sup> storage tank should be repaired.

#### Reticulation System:

The existing reticulation system should be examined, and distribution mains replaced where necessary. The reticulation system should be extended to cover the whole township and the rural population in the surrounding area.

### 3. RURAL WATER SUPPLY PROJECT

#### 3.1. Project Summary

##### 3.1.1. Description of the Project

The main concentration of population in Western Province is along the the Zambesi flood plain. The hinterland east of the flood plain is occupied to a greater degree than that of the west.

Most of the rural population has centered on the rich alluvials of the flood plains where the fertility is renewed annually by the floods carrying down fresh silts. The occupation of land is directly related to the occurrence of water. Along the river edges and on the seepage soils, domestic and livestock water supplies are obtained from uncovered pits, drainage canals, and in some cases from constructed wells. Generally these sources represent a continual health hazard from pollution.

Recognising the need for water supplies, DWA has embarked upon a programme of well-point installation to tap the upper aquifers. To date one well-point construction team is in operation in Western Province, developing about 200 well-points a year. However, the need for well-points far exceeds the team's capacity.

The aim of the Project is to accelerate the development of well-points by establishing three construction teams, developing 60 - 100 well-points each per year. After 2 - 3 years, about 700 well-points will have been installed. After the Project period, the teams should be a part of the DWA organisation and be paid by the Zambian Government.

##### 3.1.2. Justification

Most of the villages have water sources contaminated either by bilharzia or Bacillus coli. In the interests of health, these sources should be replaced by well-points. There are approximately 3000 villages in the Province, for which well-point installations are needed.

### 3.2. The Project

#### 3.2.1. Well Points

##### 3.2.1.1. Well Point Technique

A well-point is generally understood to be a shallow borehole, usually connected to a header pipe or manifold and pumped by suction lift.

Small diameter wells are used, most common is 2" dia. with 1½" dia. or larger riser pipes.

A well-point system consists of a group of closely spaced wells.

Satisfactory operation depends upon three conditions;

a) The water table must be shallow to permit pumping from the wells by suction lift. In such cases the static water level must be within 5 m. of the surface. If 2" dia. or larger pipes are used, certain types of jet-pump or cylinder pump equipment can be installed to lift the water from greater depths.

b) Individual well-points may be driven to the desired depth or they may be sunk by jetting methods. When the well-point has been sunk to the desired depth, the well should be cleaned out and developed. This is the most important step in completing the well. Development of the formation around the screen brings the well up to its maximum yielding ability. The desired effect is obtained by surging water in and out through the screen openings to remove the silt and finest particles of sand from the formation. A loose plunger worked up and down below the water level inside the riser pipe will surge the well. A pump can also be used by connecting it to the riser pipe and alternately stopping and starting it to produce a surging action. Pouring water into the well and backwashing it from time to time, also helps to develop and stabilise the formation around the screen. When the well is fully developed, it should be cleaned.

A well-point with self-closing bottom, is designed to be washed down in sand or other loose formations. A temporary jetting pipe is used to deliver the jetting stream at full force through the self-closing bottom. Half-inch standard pipe should be used for the jetting line, if 1 1/4" well-points are being used; one-inch standard pipe is best for the jetting line if 2" well-points are being used.

The pump needed for jetting well-points into place should have a capacity of about 450 litres per minute at 50 psi pressure. Under favourable conditions, a smaller pump may work all right, but a pump of this capacity is recommended.

For shallow wells 6-12 m deep the well-point and riser pipe are jetted down as a unit. A section of riser pipe 3-6 m long is first coupled to the jet well-point. The auxiliary jetting pipe is then placed inside the riser pipe and well-point, so that the bottom of the jetting pipe rests on the self-closing valve. The discharge side of the pump is connected to the jetting pipe by a suitable length of pressure hose. The hose should be at least 1" diameter. A valve should be placed in the line from the pump discharge. All connections should be tight.

c) As earth is washed out below, the well-point will sink slowly. Up and down movement of the whole assembly will speed up penetration. As the jetting is continued, the flow of water must be increased by opening the pump valve.

If the jetting operation has to be stopped to put on an additional length of riser pipe to permit sinking the screen deeper, the hole around the riser pipe must be kept full of water until jetting is resumed. Keeping the hole full of water will prevent caving, while extra sections of riser pipe and jetting pipe are being connected.

If it is desired to sand pack the well-point in the hole, the volume of water should be cut down to reduce the velocity of the return flow. Coarse sand should then be shoveled into the hole around the riser pipe. This sand will fall to the bottom of the jetted hole around the well-point while the slow return flow keeps the hole open.

The important point in choosing pipe sizes for the riser pipe or well casing and the suction header is to make them generously large. Friction losses in the system are kept to a minimum by using piping as large as practicable. This makes more of the total suction head of the pump available to produce draw-down in the wells. The net effect is to increase the yield of the system almost in direct proportion.

When starting the jetting operation, a hole of about 1' deep has to be dug. The well-point assembly is set vertically in the hole. On the discharge of the pump the valve must be partially opened.

### 3.2.1.2 Selection Criteria and Procedure

#### Selection Criteria

##### Cost per Head

An important criterion is the cost per head. Low cost per capita projects should be completed before high cost per capita projects. This means that with limited development funds available for water, more people will be provided with water sooner. The cost per head figure is the present value of the capital and all recurrent and replacement costs, distributed uniformly per head of the present benefitting population.

All other project selection criteria are devised from the consideration of benefits resulting from water projects. A very important characteristic of a water project is its complementarity with other inputs. Hence if these other factors are missing, the benefits from the water projects are likely to be low. Conversely, if many of the complementary inputs are already present or are planned for an area in the near future, the provision of water may be the factor which enables development to really "take-off". Consequently areas of high economic potential are likely to produce significant benefits if provided with water.

It is recommended that within any rural area whether in areas of high potential or in the desert areas, first priority is given to market and local centres even if they only have just a school and dispensary.

It is obvious to most people that centres should be given priority, but this is just another case of complementarity with the investments that are already there. In addition, water investments in centres will provide foci of development for each area.

The proposed procedure is as follows:

1. Requests for well-point project are presented to the District Development Committee (DDC) by representatives from the people.
2. The DDC meets to review project proposals and to prepare a list of proposed schemes and to assign priorities. The priorities can be established on the basis of needs only without weighing against resources required to meet the needs.
3. The priority list prepared by the DDC is reviewed by the Provincial Development Committee (PDC) prior to submission to PWE. The PDC should review the proposals in the light of the Provincial Development Plan.
4. The PWE prepares a preliminary study. The study should include:
  - investigation of possible ground water sources for the proposed project.
  - Analysis of optimum limits of supply for the proposed project. For technical reasons it may be more economical to expand or reduce the limits of supply proposed by the DDC.
  - Review of expected health and social benefits.

When preliminary studies have been carried out for the proposed projects, DWA reviews the priority list prepared by the DDC. Priority should be given to:

Project with low per capita cost, estimated high potential for development and which has been given high priority by the DDC. Project justified on humanitarian grounds which will relieve people from suffering and/or has an obvious potential for improving the health among people.

The latter type of project is primarily found in the low potential areas.

5. The revised priority list with justifications should be submitted to the PDC and DDC for their comments.

### 3.3 Execution of the Project

#### 3.3.1 Well-point Construction Teams

The aim of the Project is to develop 700 well-points during a 2-3 years period. Construction teams like the present well-point team have to be established. The teams will be coordinated and supervised by one construction engineer and one inspector.

With a construction capacity of 60-100 well-points per annum per team, three teams will be required.

#### 3.3.2 Vehicle and Mechanical Equipment

To ensure that equipment is always available, it is proposed to buy equipment for 4 teams and to keep one set in reserve.

One of the lorries will be fully occupied by transporting pipes, etc. out to the teams.

The list of equipment is shown in clause 3.4.1.



3.4. Costs.

3.4.1. Capital Costs

Cost category	Description			Amount K
A	Well-point equipment, including pipes, fittings, handpumps, etc	700	No.	155,000
B	Pumps for jetting, 2 pumps per team	8	No.	2,400
C	Tool-kits etc.	4	No.	4,000
D	Lorries, 4-wheel-drive	4	No.	44,000
	Landrovers	2	No.	<u>11,200</u>
				55,200
E	Water tanks, lorry mounted	4	No.	2,000
F	Tents, & camping equipment	20	No.	2,400
G	Water Affairs, Overhead on Categories A-F (2½%)			5,500
H	Unallocated items for physical contingencies on items A-G (15%)			33,500
A-H	Total			260,000

3.4.2. Operation Costs

The operation costs consist of salaries for Zambians, transport expenses, fuel for pumps, maintenance of vehicles and equipment.

The costs are summarised below.

Operation Costs per annum:

a)	Salaries	10,500K
b)	Transport expenses including fuel, maintenance, etc.	<u>6,600K</u>
	Total	<u>17,100K</u>

For 3 years the operation costs will be of the order of K 51,000

4. THE TRAINING PROJECT FOR OPERATION AND MAINTENANCE STAFF

4.1 PROJECT SUMMARY

4.1.1 Description of the Project

Training facilities are to be established to help alleviate the present shortage of operation and maintenance staff on both water supply and sewerage systems in Western Province. The training courses are expected to last for 8 months, each course having 10 students. The students should have completed Form V.

4.1.2 Justification

The existing township water supply projects in Western Province are all in a very bad condition, due to lack of funds and lack of skilled water operators and pump attendants.

The Water Supply Programme for Western Province requires the establishment of the Training Project. However, numerous other urban and rural water supply projects as well as sewerage projects all over the country will benefit from the school, either delegating their staff to attend courses, or by recruiting operators trained at the school.

4.1.3 Costs.

4.1.3.1 Capital Costs

a) Hostel for 10 students	4,000 K
b) Class rooms and workshops	6,000 K
c) Teaching facilities	10,000 K
d) Transport	11,400 K
e) Contingencies, 20% on item a-d	4,240 K
<hr/>	
Total	35,640 K

#### 4.1.3.2 Operation Costs

a) Students allowances including salaries	8,000 K
b) Hostel	5,000 K
c) Transport	3,000 K
<hr/>	
Total	16,000 K

The operation costs will be in order of 16,000 K per course, excluding salaries for staff

#### 4.1.4 Execution of Project

The principal will be recruited by NORAD. His first duties will be

- a) to study the present situation regarding the demand for O & M staff and to assess future demand,
- b) to outline syllabuses for water operators and pump attendant courses,
- c) to prepare equipment and staffing lists,
- d) to supervise the construction of school buildings.

The members of the Project Team and the Provincial Headquarter Staff will contribute as part-time lecturers.

## 4.2 THE PROJECT

### 4.2.1 General

The first training course is expected to start half a year after the Principal and the Project Team have arrived at Mongu.

When selecting students for the first course, priorities should be given to staff in Western Province. The students should have completed Form V. The course should last for 8 months including both instruction by class lectures and demonstrations of practical operation at existing works and plants in Zambia, especially in Western Province.

Two alternative locations for the training school are suggested. DWA has proposed Kaoma, Western Province, and is planning to establish a national training school there. Why Kaoma is chosen, is not known.

In order to keep the training staff as small as possible, NORAD suggests that the training school should be located at Mongu.

The advantages of locating the training school to Mongu are:

- a) Contribution of the Project Team as part-time lecturers.
- b) The workshop and the transport facilities will be administered by the Project. The students will attend lectures and demonstrations at the workshop.
- c) Mongu and the surroundings have different types of water supplies, like
  - Coagulation
  - Sandfiltration
  - Sedimentation
  - Boreholes
  - Wells
  - Well points
  - Oxidation ponds.
- d) If the school is located at Kaoma, the Project Team will not be able to contribute in the training programme. A training workshop has to be built and equipped, and teachers have to be recruited in addition to the Principal.

#### 4.2.2 Syllabuses

##### 4.2.2.1 General

In the table below the subjects to be offered during the courses are shown, and also the number of hours per week as well as the total number of teaching hours. The proposed syllabuses are meant as a guide for further planning. The principal will have to work out detailed syllabuses.

Subject	Hours/week	Total hours
Drawing	4	40
Water Treatment incl. chemistry	7	105
Pumps and Machines	10	135
Building construction including practical work	8	140
Pipe work	6	90
Hydrology	2	30
Accounting	1	20
Total		560

equal to 16 weeks or 4 months class-room training.

After 4 months of class lectures, the students should participate in the different projects in the field for 3 months. The last month, the students should be given a summarized repetition of the training programme, followed by theoretical and practical tests.

## 5. DAM CONSTRUCTION PROJECT

### 5.1 PROJECT SUMMARY

#### 5.1.1 Description of the Project

Dams for storage of surface water are commonly used for conservation where no other water sources are available, or are too expensive to develop.

The areas to be considered for water conservation are in Kaoma and Mulobezi districts.

The perennial streams are shallow, flat and with limited fall. The height of the earth-filling dams will vary from 3 m to 7 m which is considered the practical range for direct labour construction.

A 7 ton 4-wheel drive lorry and a loader are needed. Heavy equipment and machinery will be kept at a minimum because of the need for intensive labour projects.

#### 5.1.2 Justification

The dam project will be an input to the livestock development programme. The dams will primarily serve nearby watering points along stock-routes and for the livestock in the area surrounding the dams.

The reservoirs will also serve as water supply for human consumption through communal water points near the dams.

#### 5.1.3. Summary of Costs

##### Capital Costs

The costs of constructing embankments and spillways will be in order of 0.5 K per m<sup>3</sup> by direct labour construction.

Assuming 5 earth-filling dams constructed per annum, and each dam of an average of 1500 m<sup>3</sup>, the costs will be as follows,

7 tons lorry	13,500K
1 Landrover pick-up	5,200K
150 Wheelbarrows	3,000K
150 spades, etc.	1,500K
1000 m fencing to prevent livestock from climbing into the dam	3,000K
Camp	1,500K
Wages	7,500K
Oil, fuel, etc	8,000K
<u>Unallocated items</u>	<u>8,300K</u>
<u>Total</u>	<u>65,000K</u>

#### Operation and Maintenance Costs (O & M costs)

There will be no O & M costs during the construction period.

Later, a mobile O & M team has to check periodically.

Maintaining the fences, cleaning the embankments and spillway for grass and bushes as well as bilharzia control, will be the main O & M duties. The O & M team will have to look after all the DWA's water supplies in the Province.

#### 5.1.4 Execution of the Project

Some damsites are already selected for implementation, but further investigation on ground conditions, hydrology and design has to be carried out by consulting engineers.

The dams will be constructed by direct labour supervised by a foreman and one of the water engineers in the Project Team.

6. EXTENSION OF DWA WORKSHOP AT MONGU

6.1. Project Summary

6.1.1. Description of the Project

The present workshops with stores and yard at Mongu have to be modernized.

The workshop for vehicles has to be extended and equipped with tools and instruments to be able to maintain and repair the DWA-provincial vehicles and the Project vehicles.

The workshop for maintaining and repairing of pumps and engines has to be modernized as well.

The store buildings have to be extended along the fences with windows and gates facing the yard.

The yard has to be tarmaced.

6.1.2. Justification

Without transport, no water development, without DWA-workshop no maintenance and repair of DWA-vehicles and project vehicles in reasonable time.

The roads in the Province are very rough, and breakdown is common. The main problem to-day is lack of spare-parts and skilled manpower.

Since all water supplies have pump-installations, a workshop to maintain and repair pump is necessary.

6.1.3. Plan of Implementation

The buildings have to be erected with local material by direct labour. The tools, equipment and instruments have to be bought overseas and imported together with the vehicles and water supply materials.