WASHE
water · sanitation · health education
in Zambia

FIRST EDITION

Technology for Rural Water Supply

Tube Well Standard Construction Details

Supplementary Module 2d

ONE ZAMBIA ONE NATION

DISS 2002

CONTENTS

Preface

In 1993 the Government of the Republic of Zambia (GRZ) initiated the water sector reform process that was aimed at the improvement of water supply and sanitation (WSS) services. Many changes have taken place in the sector since the initiation of the water sector reform process, the major ones being :

- the formulation and adoption of the National Water Policy in 1994
- the enactment of Water Supply and Sanitation Bill in 1997
- the development and adoption of the National Environmental Sanitation Strategy for Rural and Peri-Urban Areas in Zambia in 1997
- development of the Community WSS strategy 1999
- development of the Peri-urban WSS strategy 1999
- formation of National Water and Sanitation Council 1999

- National Water Policy 1994
- Water Supply and Sanitation Act No. 28 of 1997
- National Environmental Sanitation Strategy for rural & peri-urban areas
- draft CWSS Strategy 1999
- draft peri-urban WSS strategy 1999

The formulation and adoption of the National Water Policy in 1994 with the national goal of universal access to safe, adequate and reliable WSS services, has resulted into elaboration of community management strategies for integrated rural water supply, sanitation and hygiene education. Although a lot of progress has been made since the adoption of the National Water Policy, much still remains to be done beyond the year 2000. It is believed more progress could be achieved if the stated policy measures are persued and implemented. The National Water Policy measures are:-

National Goal: Universal access to safe, adequate and reliable WSS services

- to ensure that Rural Water Supply and Sanitation (RWSS) programmes are community based
- to develop a well defined investment programme for sustainable RWSS
- to develop cost recovery approaches as an integral part of RWSS
- to promote appropriate technology and research in RWSS
- to develop and implement a well articulated training programme

It is evident that adoption of the National Water Policy meant profound changes had to be made on how RWSS should be dealt with in future. Starting with the elaboration of community management strategies for integrated rural **W**ater supply, **S**anitation and **H**ygiene **E**ducation which has subsequently developed into the WASHE strategy. WASHE strategy is a people oriented, inter-sectoral and integrated approach to planning, implementation and management of RWSS and hygiene initiatives.

WASHE is:
- people oriented.
- Inter-sectoral and integrated approach for RWSS

The adoption and implementation of WASHE with its emphasis of community management approach implies that agencies do not start with a detailed blue print but formulate guidelines that will facilitate community involvement and participation in planning, implementation, maintenance, management, monitoring and evaluation of programmes. The key concept that has emerged from WASHE is the partnership approach between communities and support agencies. Experience has shown that communities can take more responsibilities in the development of their projects when their capacities are enhanced.

Community Management means:
- Responsibility: the community assumes ownership of "the system" and "the process"
- Control: the community has the power to implement its own decisions
- Accountability: the community accepts the consequences of its decisions and understands that action rests with them
- Authority: the community has the right to make decisions about the action (intervention) taken to change their situation

The experiences gained in RWSS projects has also helped to understand that there is no sustainable development without human development (i.e. increasing the capabilities of people) and it should also be noted that no one can develop an individual or community except themselves. The role of a support agency is therefore to create an enabling environment in which individuals and communities can be creative, take initiative and assume responsibility by maximizing their potential for their development. This could be done through the use of participatory techniques.

Key concept in WASHE is the partnership between the community and support agencies

Working in close collaboration with thousands of communities means that support agencies need to be flexible and be able to adapt to changes that fit local organisations, indigenous knowledge, systems, skills and local needs. Realising that no two communities are alike, joint decision making with communities implies working in environments that can not be standardized and are relatively unpredictable and uncontrollable. It is obvious that no agency would want to be in such a position, hence the role of the agency is to reduce the unknown and the unpredictable to manageable proportion. This can be done by designing a learning environment through the development of the problem solving capacity within the agency and the communities.

In order to support the promulgation of the WASHE strategy to all levels of government and participating partners, GRZ proposed the establishment of National WASHE Co-ordinating and Training Team (N-WASHE). The team was established in April 1996 with the support from the Irish government. The main function of the team was to facilitate the establishment and development of intersectoral district committees (i.e. popularly known as D-WASHEs) in each district. The primary function of these district committees is to co-ordinate all water supply and sanitation programmes in their areas through joint development of integrated programming and planning. This entails district responsibility for co-ordinating planning, resource mobilisation, management and implementation of district specific rural water supply and sanitation initiatives.

The WASHE concept was formally launched by the two ministers of Energy and Water Development and Local Government and Housing at the first National Water Fair in Livingstone in May 1996. Since then the WASHE strategy has received considerable support from government, donors and NGOs working in the sector. All donors and NGOs active at district and field levels have adopted the WASHE strategy not only conceptually but through the provision of financial and human resources to support the training required for the establishment of D-WASHE and more recently village or V-WASHE committees. The major support agencies include Ireland Aid, UNICEF, JICA, DFID, GTZ, SNV, Africare and Water Aid. Since the launching of the National WASHE Team a total of 63 D-WASHE committees have been established and are functioning. It was the objective of the N-WASHE Team to establish D-WASHE Committees in all districts in the country with their development being a continous process.

ACKNOWLEDGMENTS

We acknowledge the valuable contributions made by many people and organisations involved in WASHE programmes, who have made it possible to develop this manual.

The DISS would like to especially acknowledge the tremendous contributions from the CEP Team Mongu, Western Province where the WASHE concept was 'conceived'. We would also like to thank all our partners who have shared their experiences in implementing WASHE in Zambia.

Management of the National WASHE Team, comprising Mr. Isaac Mbewe, the late Mr. Maurice Samani and all other team members did a lot to execute the WASHE concept throughout the rural provinces of Zambia, making the approach a success todate.

The research, development and production of this publication would not have been possible without considerable financial support from Irish Aid, for which we are most grateful.

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Section

1

Background

1.0 BACKGROUND

Hand augured tube wells have in recent times become an alternative source of water supply to large diameter wells provided soil conditions are suitable. Suitable soil conditions are where the overburden above the rock layer is unconsolidated or semi-consolidated. Auguring can also be achieved in highly weathered rock formation down to the depth ranging 25-35m.

Where water is abundant in the overburden above the rock it is possible to drill a tube well by hand with a standard post auger attached to standard 25mm water piping and turned with wrench spanners. The following sections of this module provide information on the drilling operations and other requirements for completion of the construction of a tube well.

1.1 MODULE OBJECTIVE

This module is to give an insight to institutions, engineers, technicians and institutions who might be involved in the construction of the tube wells on the standard construction of the same.

The module gives the technique of constructing the tube well. It also outlines equipment and tools used and as well as giving advantages and disadvantages of construction equipment.

Section
2

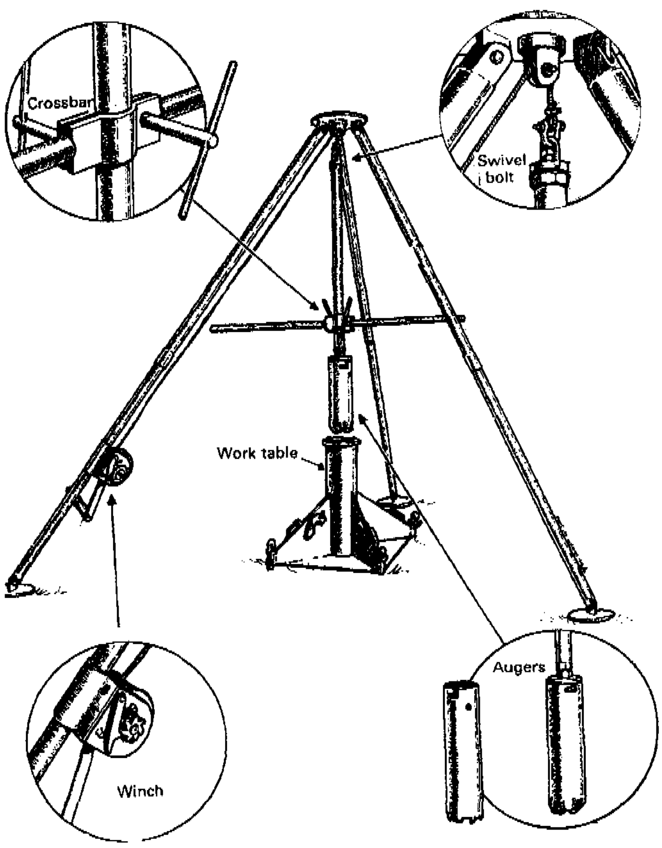
Drilling equipment

2.0 DRILLING EQUIPMENT

Several drilling rigs and accessories have been designed worldwide. In Zambia, tube wells are constructed with the use of a rig designed by V & W engineering of Harare, Zimbabwe, commonly known as the Vander Rig.

The rig is illustrated below. It consists of the following:

I.Worktable with plumb line for levelling. It aligns the drilling auger and makes possible for vertical drilling.
II. Tripod with hand winch and cable. Drilling stems are slung from this tripod.
III.Drilling stem to winch the auger is attached. 8 x 2m heavy duty.
IV.Auger consisting of steel tubes fitted with hard steel blades for cutting and lifting the soil. The auger is fitted at the bottom of the lowest drill stem.
V.Bayonet adapter for augers
VI.Bailer for removal of slurry cuttings and water
VII.Cross bar for turning stems
VIII. Stem stands with oil can
IX Heavy duty spanner for tightening stems



V & W Engineering Vonder rig-Zimbabwe experience

2.1 RIG PERFORMANCE

The Vonder rig drills 170 mm diameter holes down to the depth range of 25 - 35m in soft soils and decomposed rock formations. The following drilling rates have been recorded.

i) intitial drilling rate in average soils is 3.0 m per hour

ii) after 2-3m depth, 1.5 per hour

iii) on harder formation 0.5m per hour to 1.0m per hour

2.2 ADVANTAGE OF THE RIG

The rig is simple in assembling and handling. It is perfectly suited to full village level operation. Villagers can very easily drill their own tube well. In addition, drilling operations can proceed throughout the year. Also the full depth of the groundwater from the water table level can be penetrated to the bed rock on most occasions. This is in contrast to the more traditional techniques of well digging where the water depth is restricted to 2 or 3 metres and where digging is best carried our towards the end of the dry season when water level is at its lowest.

2.3 DISADVANTAGES OF THE RIG

There are notable disadvantages of the rig. The rig cannot penetrate hard rock formations. The augers also find difficulties in penetrating gravel layers especially course gravels, pebbles and stones. In some instance, there is collapse of the tube well due to quick sand and muddy situations. However special equipment has been designed for these conditions. Other notable disadvantages are that drilling becomes less efficient when the auger blades become blunt. This entails sharpening or replacing of the blades. The rig is tried several times in one area to assess whether the area is suitable for its use or not. This means moving the rig from one location to the next if there is much variation in the area. If the area is clearly unsuitable the rig is moved to another area where the soil conditions may be more favourable.

2.4 WELL LOCATION

Locating the best site for the well is one of the most important aspects to achieving good performance wells. The well site should be 30 m away from a latrine, water hole, cattle kraal or any other feature which might pollute the groundwater. It should be located on a raised ground so that run-off water from the apron drains off to the soakaway pit. The general gradient of the ground should be observed so that the well is located on the uphill side of possible sources of pollution such as latrines. The exact well position should be selected by technical personnel from the line ministries or a reputable water diviner. Other stakeholders such as users or community members should be consulted since they are the people who will use the water point. The site should also be conducive to the women and children who are the most involved in collecting water.

Water divining (Peter Morgan)

Section
3

Drilling Process

3.0 DRILLING PROCESS

3.1. SETTING UP THE RIG

Once the exact site has been located, the worktable is levelled by one plumb line provided for this purpose. The plumb line is slung over the top of the worktable barrel and the centre of the plumb should come to rest on the edge of the flange of the barrel. The plumb line is used on at least two sides of the worktable to ensure it is the exact level.

Assemble the tripod and erect it directly over the worktable. Tripod legs are in two sections. In order to get an exact position for the tripod, the steel cable should be lowered with the winch so that the stem linkage on the end of the cable falls centrally within the barrel of the work-table.

The position of the work-table and the Tripod can be adjusted slightly by chiselling away soil with a shovel from underneath the worktable or tripod if need arises. The steel cable and the drill stem threads should be oiled and the worktable secured into position finally with the four steel pegs provided for this purpose.

3.2 THE DRILLING OPERATION

The drilling operation is begun by attaching the crossbar to the first stem, about half way down the stem. The stem is then attached to the stem linkage at the end of the steel cable. The crossbar and the stem are at this stage winched up and the auger attached through the bayonet adapter. Lower the crossbar into a convenient position and tighten the bolts. To drill, the crossbar is turned in a clockwise position.

The auger is then lowered into the barrel of the workable and the two halves of the stem guide fitted over the studs at the top of the workable. The auger is lowered further to meet the ground. The crossbar is adjusted so that it lies about 300 mm above the guide. At this stage the actual drilling starts.

The rig is operated by at least five persons with one most experienced driller taking overall charge of the operations. Four persons are required to turn the crossbar in a clockwise direction. As the crossbar is turned pressure is exerted downwards. The cable supporting the stem is loosened to allow the movement of the stem and the auger downwards cutting into the soil. In soft soils the auger can penetrate about 300 mm in few turns of the stem. The stem and auger downward movement stops when that auger is filled with soil.

Once the downward movement of the stem and auger occurs, they are winched upwards. Firstly, stem guides are taken off from the worktable and placed on pins provided on the worktable. A steel rod provided with the rig is pushed through the holes in the upper end of the auger. The bayonet fitting is then detached from the auger which remains held in the Barrel of the worktable. The auger is now removed carefully and emptied by knocking the upper end on a log of wood. In some cases the cuttings are removed by rodding them out from the bladed side of the auger.

Once emptied the set of tools are fitted back and the process of chilling restarted. When one stem depth is drilled a further stem is connected and the drilling process repeated. As drilling progresses and more stems are used, more time is taken to go through the drilling cycle. In favourable conditions the cycle of drilling is easily repeated until bed rock is met or sufficient water depth achieved. If the harder conditions are met, the normal auger is replaced by the hole saw and the process repeated.

The process of constructing a tube described above is for favourable and stable soils and weathered rock formations. Drilling through quicksand and muddy formation is referred under Section 2.3 above.

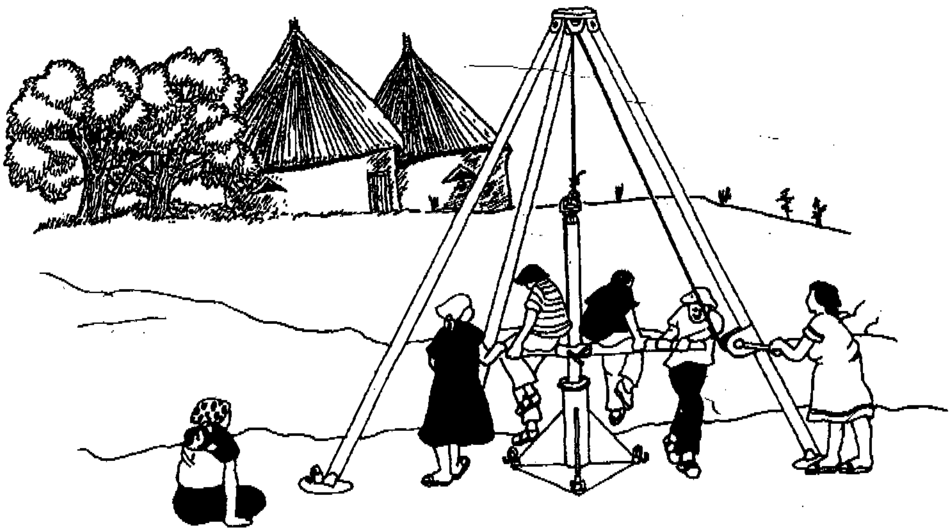


Illustration adapted from Peter Morgan

3.3. DRILLING THROUGH SAND

Drilling through sand or muddy formations can be achieved by use of a steel casing developed for this purpose. The steel penetrates the formation at the same time as the auger. When a manual auger is used, the worktable is fitted with a clamp which is used to secure the working easily. In some instances the steel casing is specially made to drill the holes.

In this case the worktable clamp must be loosened and an adapter fitted at the top which enables it to be turned with a crossbar. The first casing pipe is equipped with a cutting edge similar to a hole saw.

The drilling procedure follows the pattern described above under Section 4.2.

The standard set of tools used in stable formation is replaced by specialised tools the assembly of these tools is designed in such a way that it allows the tools to turn and cut the soil formation. The assembly sequence is as follows:

- Lower the swivel bolt into the bayonet adapter
- Pass the crossbar through the openings in the bayonet adapter
- Attach the first steel casing fitted with teeth to the bayonet
- Use the winch to raise the casing and crossbar
- Lower casing through worktable, and clamp tight
- Fit more lengths of casing until the sand layer is met

Use the crossbar to turn the casing into the loose sand and mud

3.3.1 Removing Out Excavated Material

The sand or mud lying in the working casing can be removed by two methods. In the first, a specialised auger with non return flaps narrow enough to fit in the working casing pipe is lowered down and penetrates the loose material which passes through the flaps. When the flaps close off, the material is raised up to the surface.

The second method of removing the excavated material is by use of a specialised bailer. The bailer is operated on the end of the cable.

The bailing process has the following steps to be taken.

i) the winch cable is slackened

ii) bailer cable is activated and released to fall sharply with the velocity to open the non-return valve as the bailer hits the excavated material.

iii) the process is repeated until the bailer is full

iv) the bailer is hoisted up for emptying

It is important to loosen the sand in the casing pipe before the bailing operation is started. This is achieved by using a mall auger (usually 125 mm diameter) which can pass through the working casing. Once the sand is loosened, it will rise more easily into the bailer.

3.4 CASING THE DRILLED HOLE

3.4.1 Normal Soils

When the hole has been drilled to the greatest depth possible and sufficient water depth achieved, the hole should be cased immediately to prevent collapse. It is important the casing pipe should be available for immediate installation.

Before the casing is installed granite or any available suitable stone chippings measuring at least one auger full should be placed at the bottom of the drilled holes to form the foundation on which the casing will stand.

Normally PVC pipes are used to case drilled holes. These are either class 6 or 10 for bucket pump and hand pump installations respectively. They measure 110 mm diameter, 3 m length and 4 mm thickness. The casing pipes are PVC solvent cemented together and held for at least one minute to allow complete bending before lowering down the hole. The drilled hole should be fully cased with a half metre of casing protruding above ground level.

The lower section of the casing (about 3m) should be slotted with 0.8mm to allow free flow of water into the well.

A graded gravel pack having size between 2.0.mm and 3.0mm ought to be placed in the annular space between the casing and drilling wall of the well to create a filter pack. River sand can be sieved to the required grain size and washed for gravel pack. 6 mm granite chippings can also be used for gravel pack.

Gravel pack is filled in to a depth of about a metre below ground level and the remaining space is filled with concrete mixture which will form a good grout to protect the aquifer from polluted surface water intrusion.

3.4.2 Sand or Muddy Soil

Casing procedures in holes drilled in sand or muddy soil are similar to those described for normal soils under Section 4.4.1 above. The only exception is that the casing pipe is fitted in the working steel casing.

Classification for the casing pipe is described in Section 4.4.1. When the hole is fully cased, gravel pack is placed between the PVC casing and the steel casing. Similar gravel specifications are used.

When the space between the PVC casing and steel working casing is filled, the latter is turned and lifted out of the hole with a crossbar. As each section of the steel pipe removed, the PVC casing will remain with the gravel pack next to the soil formation. Grouting is carried out as for normal soils.

Section 4

The Water Lifting Devices

Pump Headworks

4.0 WATER LIFTING DEVICES

Water from a tube well can be pumped out by either a hand pump or a bucket pump. The latter has become a more prominent arrangement and will be discussed in this module. However, the process of installing hand pumps over the hand drilled tube well is similar to that of mechanical drilled borehole which is discussed under other modules.

The construction operating mechanism of a bucket pump is summarised hereunder for the information of readers who have not come across bucket pumps.

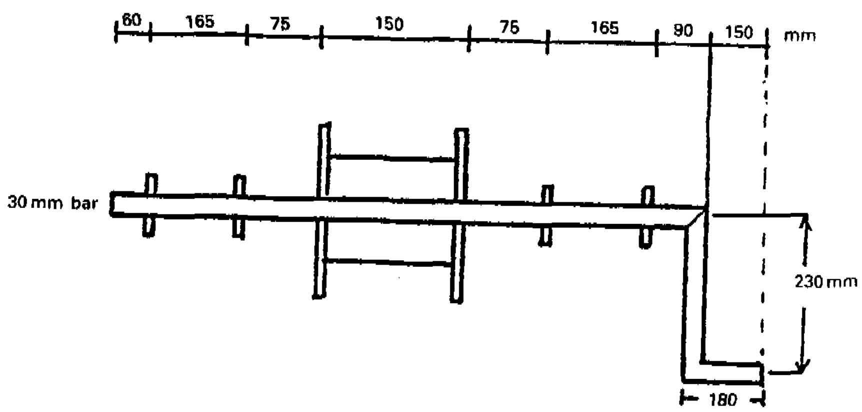
The bucket pump consists of the following components.

i) Pump stand

This is made of two suitable timber or hard wood poles of about 150 mm diameter and about 2 m height embedded in 600 mm - 800 mm deep holes on either side of the tube well. This leaves sufficient height of the windlass above the top of the well for bucket clearance. A 100 mm slot is cut into the poles for the windlass to rest. This slot is filled or greased before the windlass is installed.

ii) The Windlasses vary in size depending on whether the pump is made to fit the large diameter well or tube well. Tube well windlass dimensions are shown in the figure in below.

The windlass is made of a barrel measuring 150mm long and 300mm in diameter. Shaft dimensions are also shown in the diagram



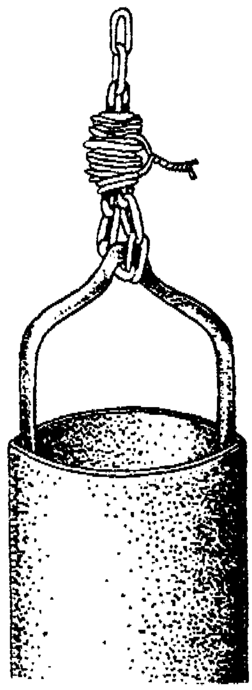
iii) The Tube Well Head

The PVC casing should be protected at the upper end with a steel tube fitted with a steel cap. The steel pipe should be at least 300 mm length and fitting around the 125 mm. The steel pipe is concreted around the casing so that it projects about 200 mm above ground level. The PVC casing is also cut off at the same level. Space between the casing and steel pipe is filled with strong concrete mortar. The steel cap should fit over the casing pipe.

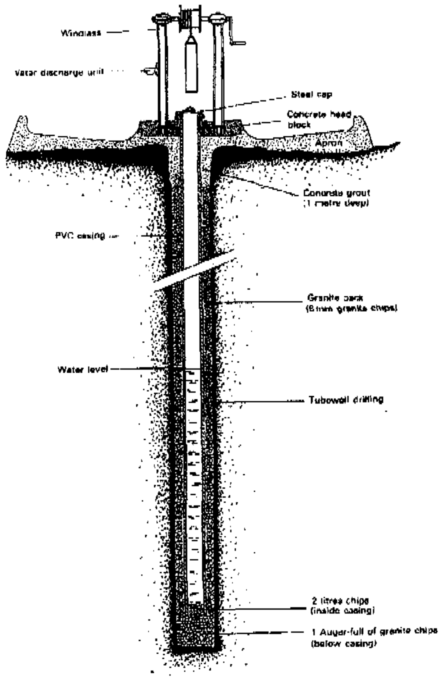
iv) The Bucket

The bucket is made tubular in shape with a handle at the top end and a non return valve at the lower end. The bucket should hold about 5 litres of water and should measure about 700 mm length and 110 mm diameter. The brass non return valve measures about 20 mm and packed in an assembly riveted to the bucket wall. (see figure below). The handle is made of stout steel wire threaded two holes drilled in the upper end of the bucket. The top is reinforced with a thick steel rim.

A 6 mm chain is wired to the bucket handle and fixed to the windlass to provide the pump installation illustrated in figure below.

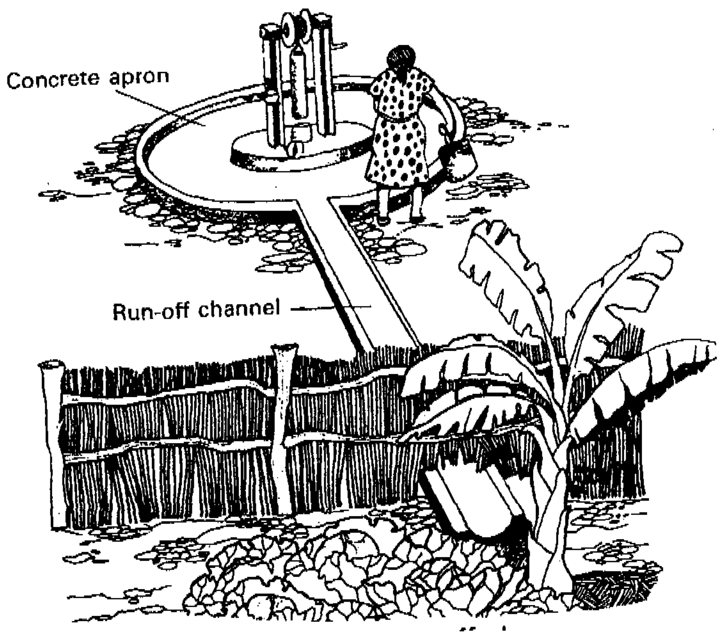


Bucket pump fitted on tube well-Zimbabwe experience



4.1 PUMP HEADWORKS

The pump headworks comprise the wooden poles, steel head, the complete apron and water run-off arrangement. The following sections describe the procedures to be followed in the construction of the headworks.



Head works-Zimbabwe experience

4.2 PUMP FOOTING

The pump footing is mounted in solid concrete foundation. Suitable moulds measuring 900 mm length, 500 mm width and 150 mm depth are used to cat the concrete. This shape of foundation is designed to support a 20 litre household water container once cured.

The concrete mix of 1:2:3 is usually preferred and should be vibrated so that it finds its way in the foundation. The foundation slab should be given a smooth finish and leveled with a trowel when completed.

4.3 THE APRON

Apron construction is carried as soon as the concrete footing for the pump is complete. The apron should be at least 2 m in diameter. The position is marked on the ground after which bricks or stones are laid down in a bed of concrete to form the rim of the apron and side walls of the water run-off.

Construction of the rim and walls of the water run -off can start and the concrete starts to cure. Once the rim has cured, the form can be removed and the space in between the rim and foundation block filled reinforced concrete. This forms the apron itself on which spill water flows to the run-off channel. The apron should be given smooth finish.

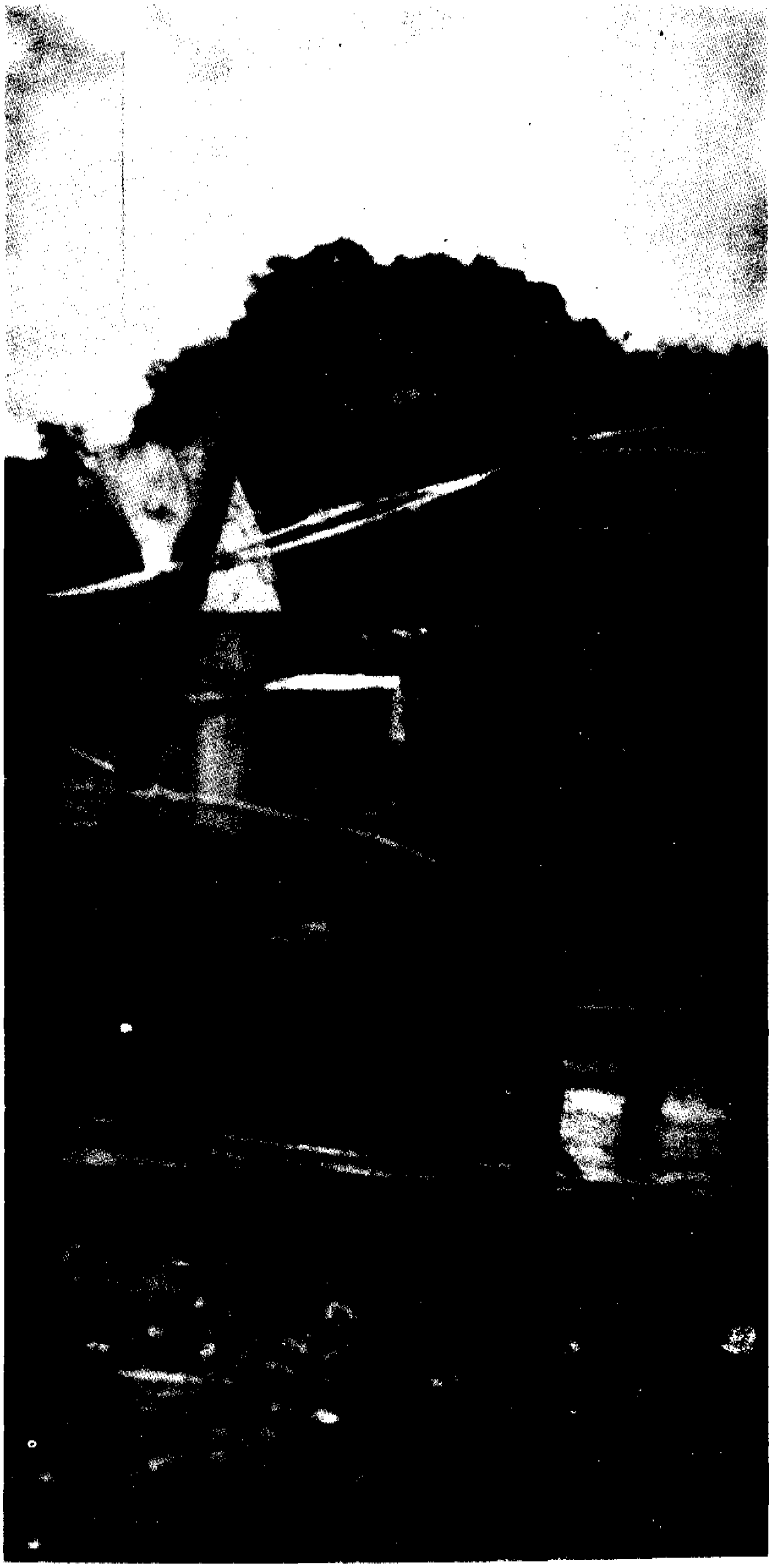
4.4 RUN-OFF CHANNEL

The run-off channel is constructed for the purpose of allowing spill water to flow down hill into an area of drainage. It should be at least 300 mm wide and at least 6m long, preferably 10m long. It should be made with two lines of bricks covered with concrete to form an open channel. The channel can also be made of reinforced concrete in a steel mould.

4.5 THE SOAK AWAY

A soak away pit is constructed in a drainage area to absorb spill water. It is filled with stones especially in soils with good infiltration properties. Where drainage is problematic, water loving plants such as bananas are planted in the drainage area. After the plants develop, they absorb the water that drains therein.

NOTES:



Section
5

Water Quality

Facility protection

5.0 WATER QUALITY

On completion of the well it is advisable that water samples can be taken for physical, chemical and bacteriological analysis. Colour is normally not a critical problem for groundwater.

The chemical quality of groundwater is influenced by the mineral content. It is important to assess the mineral content in order to determine the concentrations and establish whether these concentrations exceed the recommended limit for human consumption. If they do expert technical advise should be sought on the need and methods to remove the excessive amounts of the minerals concerned.

Groundwater is generally free from microbes, however it is important that analysis be undertaken to establish whether there is no bacteriological contamination of the water. Whenever possible experts should be consulted on the means of removing the microbiological contamination and establish the source of this pollution. Generally flush chlorination may be undertaken to disinfect the well.

It should be noted that samples taken for analysis should be assessed within the stipulated time before the external environment affects the conditions. Usually bacteriological analysis should be carried out within 24 hours of sampling. Chemical analysis should be done within 72 hours.

5.1 FACILITY PROTECTION

To restrict unwanted movement of animals, it is recommended that a fence be constructed around the facility. The fence should be constructed by the user community using hardwood poles where they are available. Other materials such as bamboos, brick and reeds could be used to put up the fence. In some instances communities prefer to plant trees for the fencing. However, expert advice should be sought on the type of trees to plant as other species consume a lot of water and could deplete the groundwater around the well through high evaporation rates.

THE CORE TRAINING MANUALS AND
SUPPLEMENTARY MODULESPLEMENTARY MODULES

MANUALS AVAILABLE

TITLE AND DESCRIPTION

Manual 1 Understanding the WASHE Concept
Manual 2 WASHE in the Water Sector Reforms
Manual 3 Introducing WASHE at District Level
Manual 4 Establishing WASHE at District Level
Manual 5 Planning for WASHE at District Level

SUPPLEMENTARY MODULES AVAILABLE

TITLE AND DESCRIPTION

1a Coverage Parameters for Rural Water Supply in Zambia.
1b The Status of Rural Water Supply in Zambia
1d Partners in WASHE
2a Making the right choice
2d Tube well standard construction
2e Jetted well standard construction
2f Borehole standard construction
5a Options for Excreta Disposal Facilities
6a Participatory Health and Hygiene Education (Theory)
6b Participatory Health and Hygiene Education (Practical)
7b Making Appointments
7c Community Mobilisation and Sensitisation
7d Conducting Community Assessment
7e Formation of a Village WASHE Committee
7f Site Selection
7g Planning for Construction and Rehabilitation
7h Community Participation During Construction
7i Village WASHE Committee Training
7j Community Problem Solving
7k Fund Raising and Management
7l Promoting Community Ownership
7m Community Participation in Monitoring
7n Well Completion Ceremony (Handover)
7o Community Management in Evaluation
7p Group Dynamics and Energiser Tool Kit
8 WASHE and Gender