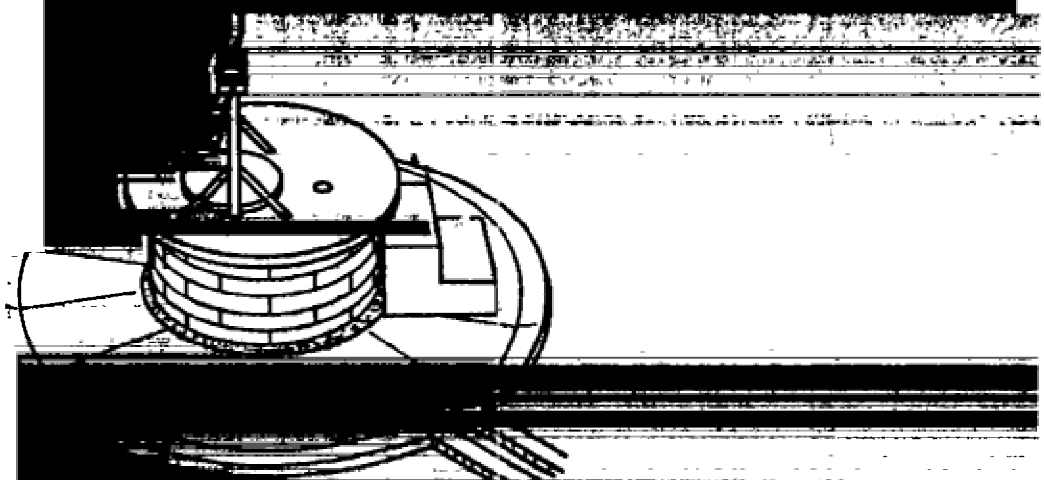
HARVESTING RAINWATER IN SEMI-ARID AFRICA

Manual No. 4

Shallow Wells with Bucketlift.



Erik Nissen-Petersen, Dr. Michael Lee.

Nairobi, 1990

"Harvesting Rainwater in Semi-arid Africa" consists of 6 Manuals:

Manual No. 1. Water Tanks with Guttering and Hand-pump.

Manual No. 2. Small Earth Dam built by Animal Traction.

Manual No. 3. Rock Catchment Dam with self-closing Watertap.

Manual No. 4. Shallow Wells with Bucketlift.

Manual No. 5. Sub-surface and Sand-storage Dams.

Manual No. 6. Spring Protections.

Each Manual deals with siting criteria, standard designs and bills of quantities in a simple text and drawings.

The Manuals are based on practical experience gained by building some 700 water structures for rainwater harvesting in semi-arid Kenya over the last 14 years.

ASAL Rainwater Harvesting
P. O. Box 14333
NAIROBI
Kenya

ACKNOWLEDGMENT

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Much gratitude is also due to the Ministry of Agriculture in Kenya, which together with Danida afforded the opportunity of developing low-technology and labour-intensive methods of harvesting rainwater and thereby enabling people and livestock in a semi-arid region of the country to have access to a steady water supply.

Thanks are also due to the local inhabitants with and for whom these techniques were developed and implemented. Their understandable skepticism in starting up these demanding activities gave the process a sound and realistic foundation on which to build.

Personal thanks are very much due to:

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Erik Nissen-Petersen and Michael Lee

C O N T E N T S

SURVEYORS MANUAL

ON

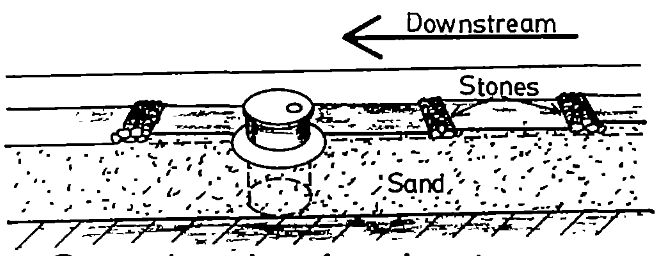
SHALLOW WELLS

1. Siting Considerations

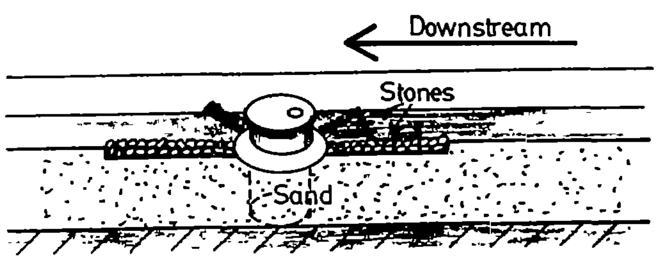
The accurate siting of shallow wells in locations that provide water the whole year round is the most difficult part of shallow well development. The aim is to construct a well that keeps water for as long as possible into the dry season. If the well begins to dry up, and people have to wait a little for recharge by the end of the dry season then the well is still a success, only not 100% perfect.

The type of shallow well described in this manual is called a "sinking well" because during the construction phase the well sinks into the bottom of the excavation by its own weight and by digging soil/sand out from the inside of the well shaft. Besides being a very safe way of building a well, this technique has another advantage: after completion the well can be deepened if the self-help group wishes so.

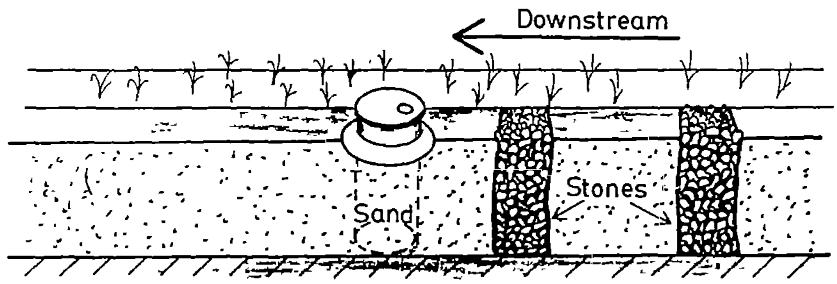
If a well does not get sufficient recharge of its reservoir of surrounding soil or sand, then the infiltration of rainwater run-off can be improved by building some stone structures across or into the reservoir as shown below.



Stone barries forming terraces

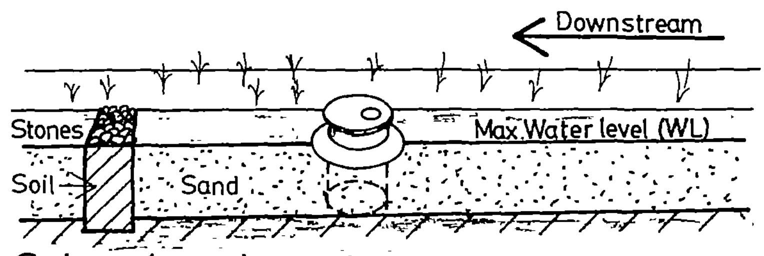


Horizontal infiltration gallery

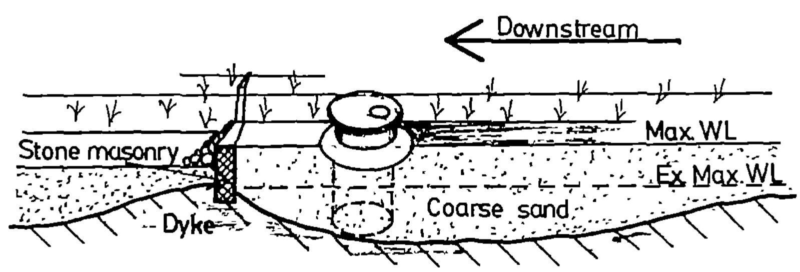


Vertical infiltration gallery

If recharge structures do not improve a well situated in a riverbed sufficiently, then a subsurface dam of clay or stone masonry could be build downstream of such a well.

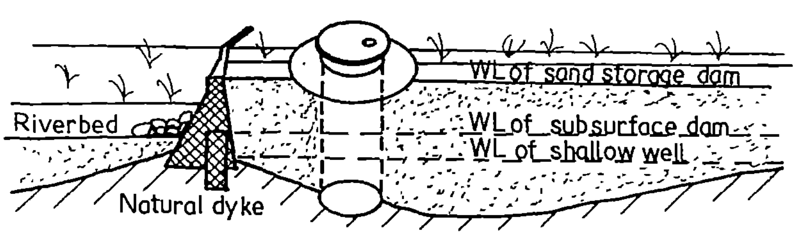


Subsurface dam of soil



Subsurface dam of stone masonry

If that helps, but still not sufficiently, then a sand-storage dam may be build in order to increase the volume of the reservoir for the well.



The Best Sites for Permanently-Yielding Wells

There are three main sites for potential shallow wells;

a. on the soil aprons surrounding rock outcrops or below rock cliffs where the surrounding geology suggests there is a fold in the rock and a trapped pocket of ground water

b. in the bed of a large shallow reservoir, either earth-dammed or a natural depression.

c. in the bed of a large seasonally flowing river channel (sand-river) at one of the following sites

   (i) where a channel suddenly widens
   (ii) where the river bed slope suddenly decreases
   (iii) where the river bed is rocky
   (iv) where the river bends sharply

Regardless of which site it is, the main reason for siting the well is because the soil material is sandy, the coarser the better, and because a reservoir of water is trapped in that location or the sandy soil is recharged continuously with water from upslope or upstream.

If water is not trapped or if recharge does not occur, the amount of water available to the well will reduce rapidly through time after the rains stop and seepage in from above ceases. If the soil material is not coarse and contains a lot of silt and clay, then a lot of water will be retained by the soil and the rate of flow through it will be slow. Only about 30% of the total of the water contained in a clay soil will drain out following saturation, whereas in a sandy soil, 85% of the water will drain out following saturation. In volumetric terms, clay soil will yield 190 litres per cubic metre, and a sandy soil 340 litres per cubic metre following saturation. The water in a coarse soil also moves up to 100 times faster than in a fine soil. Thus in a fine soil water drawn from a well will be replaced very slowly.

Shallow Wells Near Rock Outcrops

Where the shape of the landscape and vegetation indicate that the bedrock has been folded then large depressions between the rocks suggest that there will be a u-shaped pocket of soil in which water will collect.

The best sites are usually where the rock outcrops are lined up at right angles to the slope of the hillside with soil-covered slopes in between. This is best seen from high hilltops, aerial photographs or from the air. The best sites will also have trees and bushes known to need large quantities of water all through the year, (see table on vegetation on page 5).

Shallow Wells and Surface Reservoirs

Wells can either be built in the bed of a small earth-dammed or natural reservoir or downstream of the dam wall, wherever the soil is coarsest and has the best recharge. If the reservoir is over a metre deep and dries up quickly it means the loss has been due to seepage and not evaporation and consumption. In this case the bed is a good place to build the well since it will be sandy. If the reservoir does not seep away quickly then downstream will provide a better site because the soil in the depression will probably be very silty and may even have a clay-pan preventing seepage. If a well is built there it could act like a plug-hole and empty the reservoir by breaking through the impermeable bed. Downstream the soil will be more coarse and the recharge slow but consistent.

Shallow Wells and Sand Rivers

In the wider sand rivers which are seasonally flooded, water moves through the bed at depths from a few centimetres to several metres, depending on the time of year. The suitable locations are those where the bed material is sandy all the way down. They will generally be the following sites;

a. Locations Where the River Widens

Where rivers suddenly widen, sands are deposited because the water spreads out and slows down and the well should be sited just downstream from this point. This is a good site because downstream there are generally silts deposited as the water moves even slower and these act as a natural brake. Also, where the river narrows again, sub-surface dams can be built easily and with the best effect.

b. Locations Where the River Bed Slope Decreases

Where the riverbed changes from a steep slope to a shallow slope coarse sands will once again be deposited because the water moves with less force. Wells can be built on this shallow section which is usually where a smaller valley and channel joins a larger valley and river.

c. Locations Where the Bed is Rocky

If rock outcrops occur across the bed of the sand river from bank to bank it usually means there is a natural rock dyke which will dam the movement of water through the bed. Upstream from this dyke is a good location for a well.

d. Locations Where the Channel Bends

At the bends of larger sand rivers, the channel widens and the material is deepest and coarsest on the outside of the bend. Water drains to the outside of the bend and the deepest point so it receives good recharge. Building the well towards the outside of the bend will tap this water source. Drawbacks to this site include the fact that the well must be well protected with an upstream wedge of concrete and the outside of the bend may continue to be eroded and the well undermined.

Vegetation

First check the vegetation on the hillslope or along the banks and bed of the river. In the table below we include a selection of species that are known to require a lot of water all year round and can thus indicate a permanent water reservoir.

Vegetation indicating a subsurface reservoir

Botanical Name	Kikamba Name	Depth of water level
Cyperus rotundus	Kiindiu (Grass)	4 to 7 metres
Arundinaria alpina	Myaangi (Grass)	4 " 7 "
Vangueria rotundata	Kikomoa (Tree)	5 " 8 "
Delonix elata	Mwangi (Tree)	5 " 10 "
Grewia spp.	Itiliku (Tree)	7 " 10 "
Markhamia platycalyx	Muu (Tree)	8 " 15 "
Markhamia hildebrandtii	Myuu (Tree)	8 " 15 "
Borassus aethiopum	Kyatha (Palm)	10 " 15 "
Hyphaene coriacea	Mlala (Palm)	10 " 15 "
Ficus walkenfieldii	Mombu (Fig tree)	10 " 15 "
Ficus natalensis	Muumo (Fig tree)	10 " 15 "
Ficus capensis	Mukuyu (Fig tree)	10 " 15 "
Kigelia africana	Muatini (Tree)	15 " 20 "
Piptadenia hildebrandtii	Mukami (Tree)	15 " 20 "
Acacia seyal	Munina (Tree)	15 " 20 "

Soil Moisture

Checks should be made in the dry season to see if there is still large amounts of moisture in the soil or river bed material. Cores should be taken with an auger at various places. In the riverbeds they should be taken across the bed and upstream from the site.

Soil Texture

The texture of the soil should be examined to see how coarse it is. It should be rubbed and rolled between the fingers looking for the following features.

(a)	When you rub the soil between your fingers can you feel individual rough grains in the mixture?	- YES ------ Suitable - NO ------- Not suitable
(b)	Dry soil falls apart easily when squeezed and pressure is let of?	- YES ------ Suitable - NO ------ Not Suitable
(c)	If the soil is wet when you squeeze it it will stay in that shape, but if you move it or touch it will fall apart?	- YES ------ Suitable - NO ------- Not Suitable
(d)	If the soil is dropped into a glass jar full of water and shaken, the material will settle rapidly at the bottom of the jar when you stop	- YES ------- Suitable - NO ------- Not Suitable

The soil should be sandy all the way down. If it is not, especially if there is only a shallow layer of sand overlying silts and clays it is a poor site for a well. The depth is also important. If the deepest point you find is only 3 metres or less, it generally is not worth lining a well.

Local Knowledge

Wherever possible, local people should be questioned as to what happens to the shallow wells they have dug in the location. It is important to know how deep the water level is during the rainy season and how quickly the level drops and when it dries up. If the water level is originally near the surface and drops quite slowly this is a good sign, especially if you plān to dig the lined well deeper. If the water level is high but then drops quickly and dries up this shows that the area becomes saturated but there is either a rapid seepage loss downstream with little recharge, or else the soil is too fine and holds back a lot of water. The problem of seepage may be corrected in a river bed by building a sub-surface dam downstream.

2. Timing and excavation of a shallow well.

When a self-help group has identified a site where they believe a good well can be built, they must dig an unlined excavation as deep as security allows in order to determine whether the site is capable of supplying water. This excavation should take place shortly after a rainy season when the soil is moist and rather easy to dig. By doing so, everybody will be able to see for themselves how much water the site can yield and for how long.

The diametre of the excavation should be 260 cm.

If the site is found viable for building a shallow well, then the construction should take place a couple of months before the end of a dry season. This timing will give the lowest level of the year, which will make the construction easier and faster.

3. Materials, labour and transport requirements.

The requirements of materials, labour and transport are calculated as follows:

The construction team for a shallow well is usually one contractor working with ten self-help labourers. They can construct one metre of well shaft on average in four days (this includes the well head construction). Knowing the depth of the well gives the requirements of materials, labour and transport.

a. Formula for labour requirements:

1 metre depth of well = 4 contractor days.
1 metre depth of well = 40 labourer days.

Example:

12.00 metre deep well x 4 contractor days = **48 contractor days.**
12.00 metre deep well x 40 labourer days = **480 labourer days.**

b. Formula for materials requirements for 1 metre well shaft:

Formula:

1 metre depth of well requires
200 kg. of cement ....
20 metres of 3 mm galvanized wire ....
6 metres of 12 mm iron rods for steps ....
1 tonne of coarse sand ....
1 tonne of water ....

For well head:

1 socket 4" with spokes welded onto ....
1 bucket lift (or hand-pump) ....
5 metres of polythene sheeting ....

Example: A 12 metre deep shallow well.

1 metre shaft	**x 12 m =**	
200 kg of cement	x 12 m =	2400 kg = 2.40 tons x 20 = 48 bags of cement
20 m of 3 mm wire	x 12 m =	240 m of 3 mm galvanized wire
6 m of 12 mm iron rod	x 12 m =	72 m of 12 mm iron rod
1 tonne of sand	x 12 m =	12 tonnes x 8 = 96 wheelbarrows of sand
1 tonne of water	x 12 m =	12 tonnes x 5 = 60 drums of water
5 metres of polythene sheeting		
1 socket 4" with spokes welded onto it		
1 bucket lift (or hand-pump)		

c. **Transport requirements of materials.**

Transportation of materials is divided into two categories:

(a) Transport of local materials, such as sand, stones and water, will be transported to the site by the self-help groups using oxen, donkey and hand carts. The number of loads to be transported and the distances involved depends on local conditions and cannot be estimated here.

(b) Transport of purchased materials, e.g. cement, reinforcement wire are estimated according to tonnage, distance and cost per km.

Formula: Tonnes x return distance in km x Shs per km = cost of hired transport

Example: 3 tonnes x return distance 75 km x Shs per km. 6/50 = **Shs. 1,462/50**

4. Bills of Quantities and Costing.

Two bills of quantities are needed, because about half the items will be delivered by the donor/Ministry and the other half will be delivered free of charge by the community concerned. Since the community is supposed to contribute about half the cost of the project, a value of their input has to be calculated.

Example for a 12 metre deep shallow well

Bills of Quantity for items to be delivered by the donor/Ministry.

		Cost
Skilled Labour: 1 contractor for 48 days	x Shs	= Shs ....
Cement: 2.4 tonnes = 48 bags x	x Shs	= Shs ....
3 mm galvanized wire, 240 metres	x Shs	= Shs ....
12 mm iron rods: 72 metres	x Shs	= Shs ....
Socket, 4" with spokes welded onto 1 nos	x Shs	= Shs ....
Bucket lift .... 1 nos	x Shs	= Shs ....
Polythene sheeting for curing: ... 5 metres	x Shs	= Shs ....
Transport of contractor and materials: 3 tonnes x .... km	x Shs	= Shs
	Total cost	Shs

Bill of Quantity for items to be delivered free of charge by the self-help group.

Unskilled labour: 480 labour days	x Shs	= Shs ....
Sand: 12 tonnes (= 96 wheelbarrows)	x Shs	= Shs ....
Water: 12 tonnes (= 60 drums)	x Shs	= Shs ....
Transport: 24 tonnes (= 48 cart loads)	x Shs	= Shs ....
	Total value of self-help	**Shs** ....
	Grand total cost and value of project	**Shs** ....

5. Quality Control and Maintenance

It is important that the instructions given are followed closely, particularly the mixes of mortar and cement and the methods of constructing and reinforcing courses.

The most important things to observe is that all the courses are mortared and reinforced every fourth course of blocks except for the first four. If you make a mistake and cement every single course, there will be little recharge into the well because water will not be able to move freely into the shaft. However, the unmortared courses should fit closely together with no apparent gaps because otherwise, sand can flow into the well with the water and gradually fill it up.

The mortar mix for the well blocks should be as directed otherwise the block will be loose and crumbly and will gradually erode inside the well.

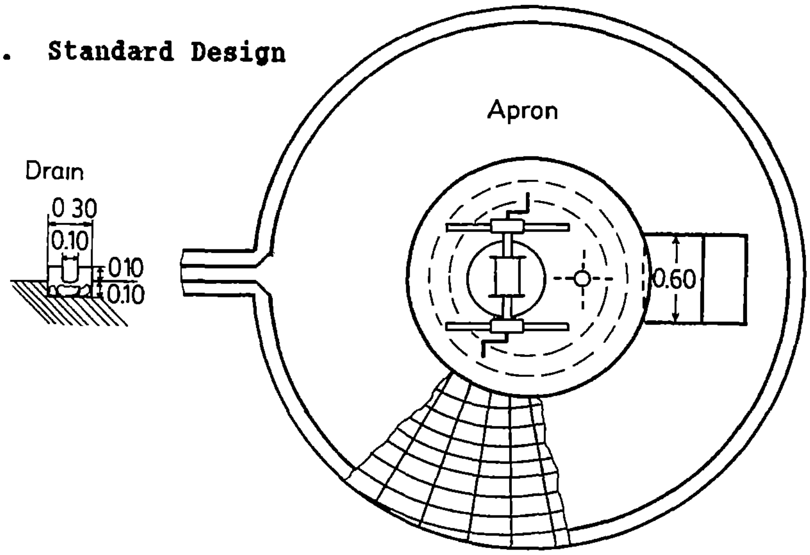
The excavation shaft should be vertical and the foundation ring perfectly horizontal or else you will have trouble sinking the well. The foundation ring should be kept horizontal by digging out equally from underneath it.

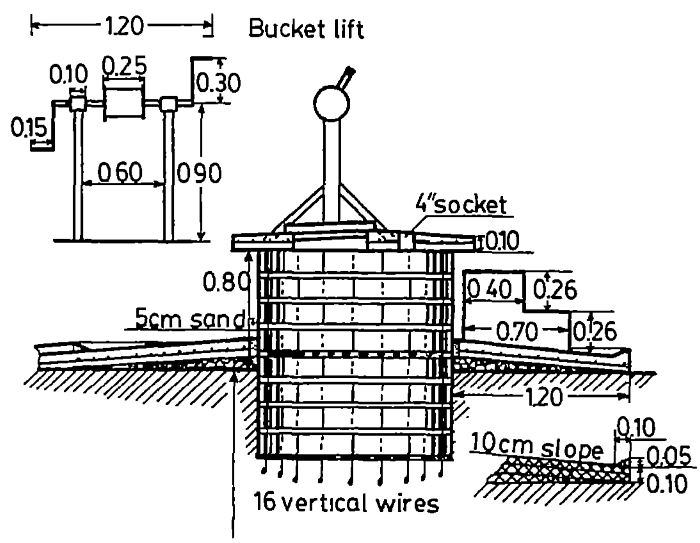
The man-hole cover should be well-fitting to keep out dust, insects or other material that might enter into the well.

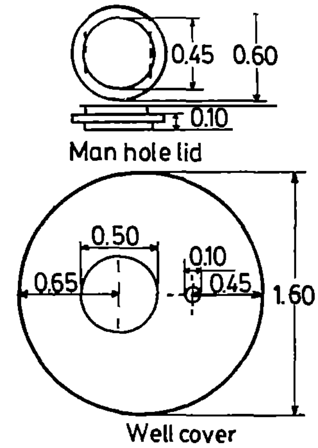
Clear an area downstream of the well for use as a bathing or laundry site and provide a concrete basin to make this cleaner, draining to a pit planted with bananas.

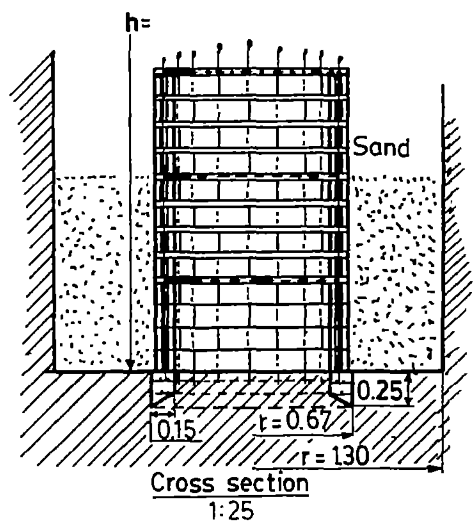
To help maintain the well, the well site and the water quality, fence off around the site with thorny branches or live fencing of spiny plants. Put a gate in the fence to keep out animals. Make a parking place for donkeys or oxen downstream of the well near the drainage pit so that they will not make the well site dirty.

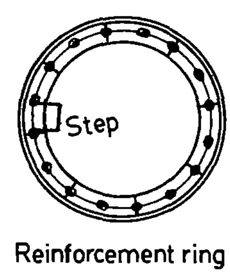
6. Standard Design

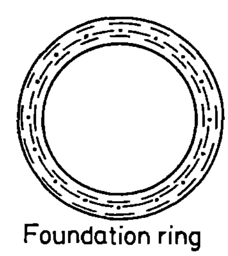












CONTRACTORS MANUAL ON SHALLOW WELLS

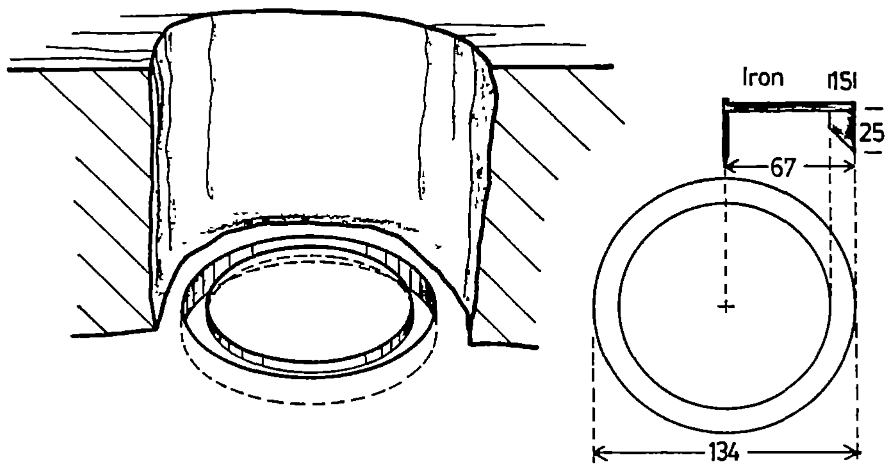
C O N T E N T S

1. Preparation for Lining

1.1 Making the Foundation Ring

a. The foundation ring has to be made before the concrete blocks so that it can be cured properly before the blocks are built upon it. The best place to make the foundation ring is in the bottom of the excavation, but if that is impossible, make it as near the excavation as possible so that later on, it will be easy to lower into the shaft.

b. The mould for the foundation ring is a circular groove cut into the soil by turning the foundation form around whilst standing in the middle acting as a pivot for the circular movements.



Formwork for foundation ring

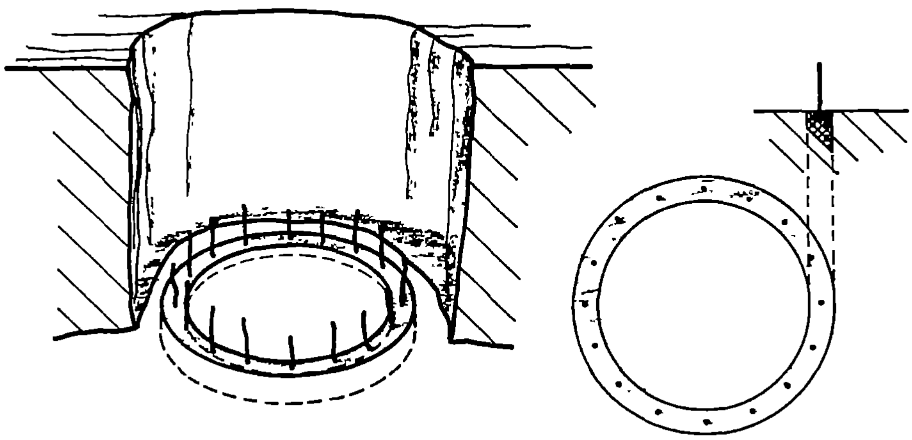
c. Mix 1 portion of cement with 3 portions of coarse sand (1:3). Fill the bottom of the groove with this mortar. Lay a loop of galvanized wire from the roll on to the mortar in the groove and compact it lightly. Do not cut the wire from the roll.

d. Fill the groove with 10 cm of the mortar (1:3) and lay two loops of wire and cover them with 10 cm of mortar, and compact it well. Then lay another two loops of wire onto the mortar.

e. Cut 16 lengths of galvanized wire, each 100 cm long and tie them firmly to the two loops of wire lying on the concrete, spacing the wires equally apart.

f. Fill up the rest of the groove with concrete (1:3:4). Compact it well and level it off smoothly with the 16 wires sticking vertically up from the concrete.

g. Keep the foundation ring moist and under polythene sheeting for two weeks to cure the concrete.



Foundation ring

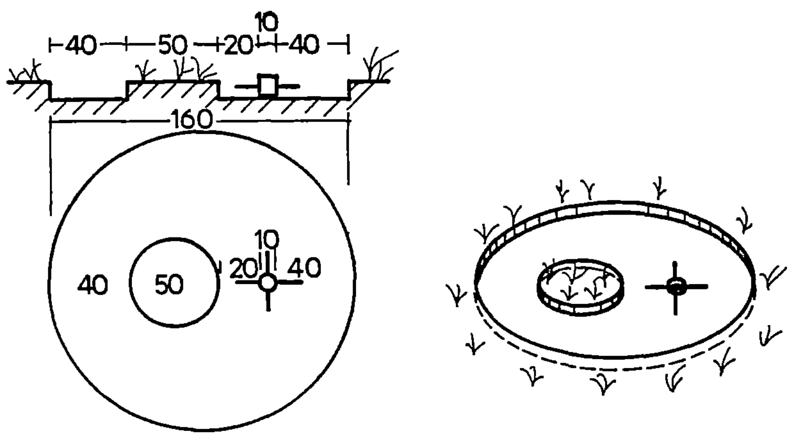
1.2 Making the Well Cover

a. The well cover is made after the foundation ring is completed so that it cures well before being lifted into place on top of the shallow well.

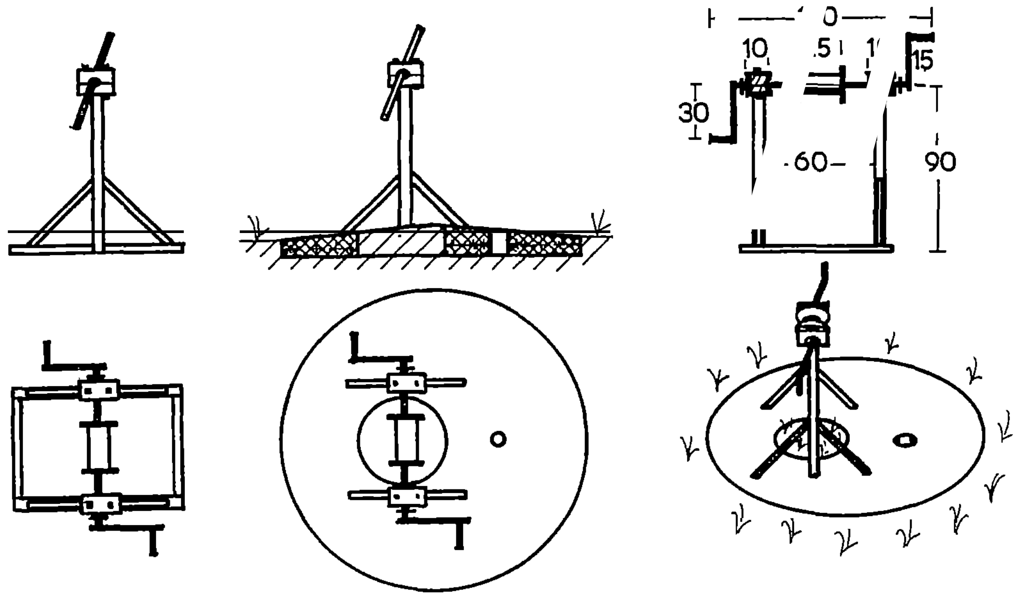
b. The mould for the well cover is a circular excavation made in the surface of the soil near the shallow well excavation. The radius of the excavation is 80 cm and its depth is 10 cm.

c. Leave a circular mould of soil in the excavation for the man-hole of radius 50 cm and height 10 cm, 40 cm in from one edge.

d. Place a 10 cm (4") socket, welded to four iron rods, in the excavation and fasten it in position opposite the man-hole, 40 cm from the opposite edge of the excavation. Fill it with sand to prevent it being filled with cement. This socket may be used for a hand-pump.

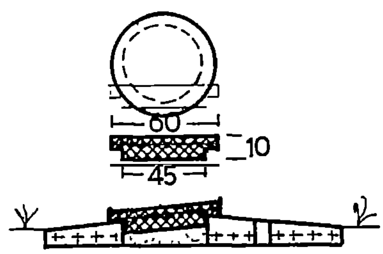


e. Mix mortar (1:4) and use it to fill the excavation half way to the top. Lay 8 rounds of 12 mm diameter on the concrete. Lay another 8 lengths of iron rods at angles across the first 8 and space them equally apart. Place the stand for the bucket lift right over the man-hole and press it into the mortar.



f. Fill up the rest of the circular excavation with mortar (1:4) and compact it onto the iron rods and bucket lift stand. Smooth it off to form a slope running out from the man-hole towards the edge so as to drain water away off the lid. Ensure that the bucket lift is standing vertically upright by using a plumb-line and spirit level. Keep the well cover moist and under polythene sheeting for two weeks to cure the concrete.

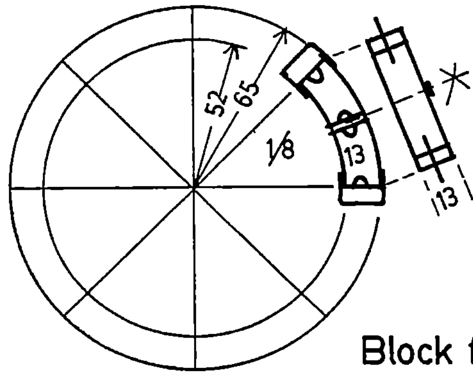
g. The lid for the man-hole is made on top of the well cover whilst it is still lying in its excavation. Dig out the earth from the man-hole to a depth of 5 cm below the surface of the well cover. Press wet newspaper or empty cement bags onto the concrete in and around the man-hole. Place a cylindrical ring of iron-sheet, diameter 60 cm and height 5 cm, around the man-hole on the wet paper.



h. Mix mortar (1 cement:4 sand) and fill the man-hole up with it. Place a few lengths of 12 mm diametre iron rods on the mortar. Fill up the mould with concrete. Compact and smooth it. Cure it for a couple of weeks in that position.

1.3 Making the Concrete Blocks

a. The concrete blocks are made after the ring and the cover. The number of blocks to be made depends on the depth of the shallow well. Each metre in depth requires 7 courses of blocks and each course consists of 8 blocks which gives a total of 56 blocks per one metre of well shaft.



Block form

b. The blocks should be made under a shady tree for good curing and the area used for making the blocks must be clean, smooth and level. Mix mortar (1:4). Dip the block form in water and place it on the ground. Fill it with concrete. Compact it lightly and level the top off. Lift up the form keeping it horizontal by pulling equally on both handles. If the concrete block does not slip out of the form easily, then the concrete is too dry. If the block slips out easily but does not retain its shape, then the concrete is too wet. Correct the mixture and try again.

c. After a few tries, and by keeping the form clean and wet, you should soon learn to make over 100 blocks per day. The following day, stack them together in low piles under a shady tree. Keep the piles moist and covered with polythene sheeting until they are used for building the well shaft.

2. Building the Well Shaft

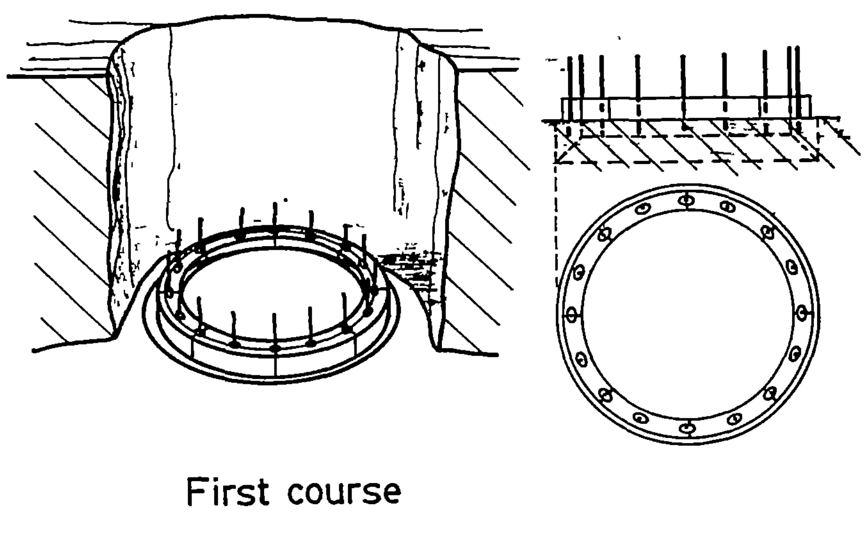
2.1 Constructing the Shaft

a. When all the concrete blocks needed have been made and their bases cut cleanly and evenly, the well-shaft can be constructed inside the excavation dug by the self-help group.

b. Where the foundation ring has been made at ground level, lower it into the bottom of the excavation with strong ropes. Use a spirit level to ensure that the foundation ring is placed horizontally or else sinking the well shaft will prove difficult at a later stage.

c. Place 8 concrete blocks in a circle on the foundation ring without any mortar. Thread each of the 16 ends of wire through the corresponding hole in the circle of blocks. Press the blocks together at their ends so that the inner side are flush with the side of the concrete ring. The space created between the outer side of the blocks and the foundation ring will facilitate the smooth sinking of the well shaft, because the shaft will be thinner than the excavation which will be cut by the slightly larger foundation ring. Place another 3 courses of blocks without mortar on top of the first course. The join between each course will allow water to infiltrate through to the well.

d. Mix mortar (1 cement:4 sand). Place the wires from the foundation ring right in the centre of the holes in the blocks and fill the holes with mortar. Compact the mortar into the holes with a stick. Tie a horizontal ring of galvanized wire around the 16 ends of wire sticking vertically up from the 16 filled holes. Let the wire overlap about 30 cm and tie its ends to two of the vertical wires.

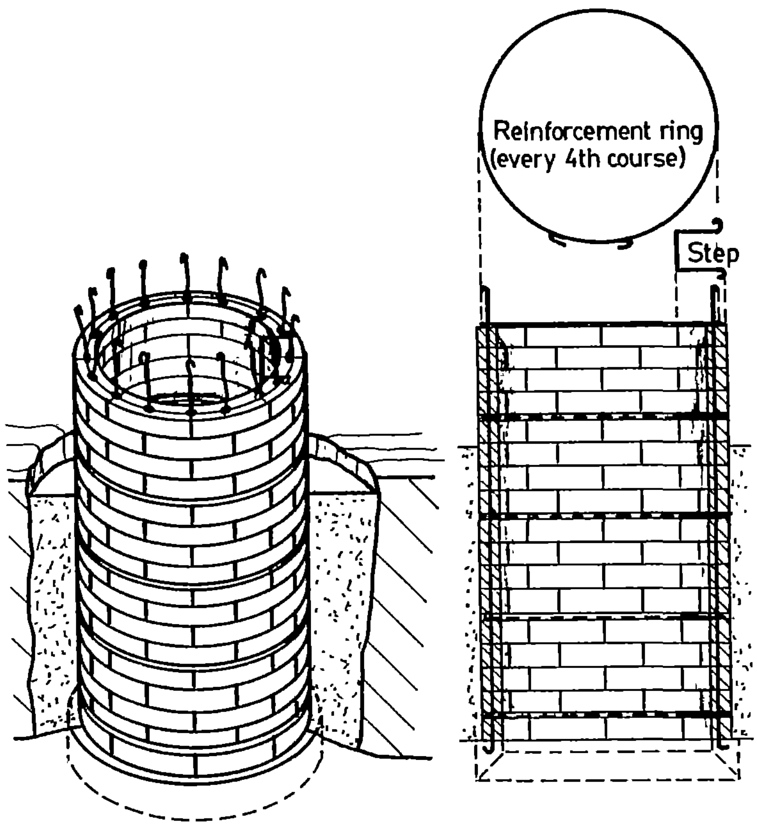


First course

e. Place mortar on the horizontal wire lying on the first ring of concrete blocks and lay another round of 8 blocks onto wet mortar, so that the horizontal ring is embedded properly in mortar and the blocks overlap each other.

f. Lay out 3 courses of blocks with mortar. Each block must overlap the blocks beneath it. Press the ends of the blocks tightly together. Whenever the vertical wires become too short connect them to new extensions of wire, each one about 100 cm long. Tie the wire together by bending their ends. Check that this loose wall of blocks is in a straight and vertical position. Fill in coarse sand around the outer side of the well shaft and against the side of the excavation to improve the seepage process, to support the well shaft under excavation and for the builder to stand on.

g. Tie a horizontal ring of the wire around the vertical wires for every four courses. Tie a step, bent from 12 mm diameter iron rod around the outer sides of the vertical wires in such a way that the step cannot be pulled into the well shaft for every four courses. Mix mortar and build another four course of blocks onto the step and wire.



Well shaft

h. The well shaft is built in this manner all the way up to about 60 cm above ground level. To summarise, the well is built as follows:

The first four courses are built without mortar between them to promote infiltration into the well-shaft. However, it is important that these gaps be as small as possible, otherwise sand can enter and gradually fill up the well shaft. Every fourth course is reinforced with a horizontal ring of wire. In that same course, a step is firmly tied to the vertical wires. The horizontal wire and step are mortared to the course of blocks both above and below them. The steps, one every fourth course are placed directly above the last in a vertical line. Coarse sand is filled around the well shaft after every fourth course and the builder will use this as a scaffold to stand on as rings are laid.

2.2 Sinking the Well Shaft

a. To sink the well shaft, a well-digger wearing a helmet enters the shaft using the iron steps built into the shaft. The well-digger uses hand-tools to remove the soil on which the shaft is standing. The soil must be dug from under the whole foundation ring and not from one side at a time.

b. The excavated soil is drawn up in a bucket made from an old tractor tube by means of a sisal rope which can be pulled over a pulley to ease the load. It is dangerous to use a metal bucket because if it accidentally drops it can seriously hurt the well digger.

c. As the soil is removed from beneath the foundation ring, the weight of the whole well shaft will force it to sink slowly. For every 60 cm the well shaft sinks, another 60 cm of blocks are added to the top of the well shaft so that the shaft is always protruding above ground level. This prevents objects like stones from falling into the shaft. However, it should not protrude more than 60 cm because it becomes too difficult to pull up the excavated soil. A pulley placed over the well shaft makes it easier to pull up the soil.

d. When the well shaft is extended above ground level and the space between it and the wall of the excavation filled with sand, the well shaft is ready to be sunk further down. If the well shaft stands on solid rock then it cannot be sunk further and the well head is constructed without further sinking.

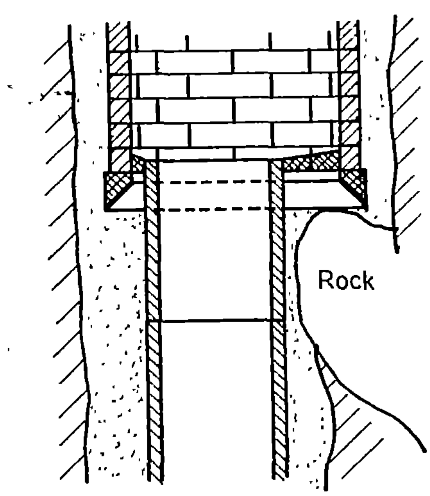
2.3 Building a Telescopic Well Shaft

a. In the process of sinking a shallow well a stone can be encountered that is too big to be removed. If the stone is situated on one side of the excavation, it will block further sinking of the well shaft.

b. Instead of abandoning any further sinking of the well, a "telescopic extension" can be built. The well-digger continues to dig further down while the well shaft hangs above the stone. The well-digger should be aware of the big rock falling and be ready for a quick exit if it shows any movement.

c. When the well has been dug far enough down, the well-digger can leave the shaft. A culvert (cylindrical concrete ring with a diameter of 60 cm) is lowered into the shaft with strong ropes. When it stands safely on the bottom, the well-digger climbs down. The culvert must be placed in an upright position and sand filled into the gaps around the outside and the excavation. The well-digger climbs out of the shaft and another culvert is lowered and positioned in the same way. This continues until the top of the culverts in the excavation is a little higher than the foundation ring of the well shaft. There should be no mortar in the joints between the culverts so that infiltration can take place.

d. A concrete join is built over the sand surrounding the upper culvert and against the foundation ring, so that the two different types of well shaft have a good connection of concrete.



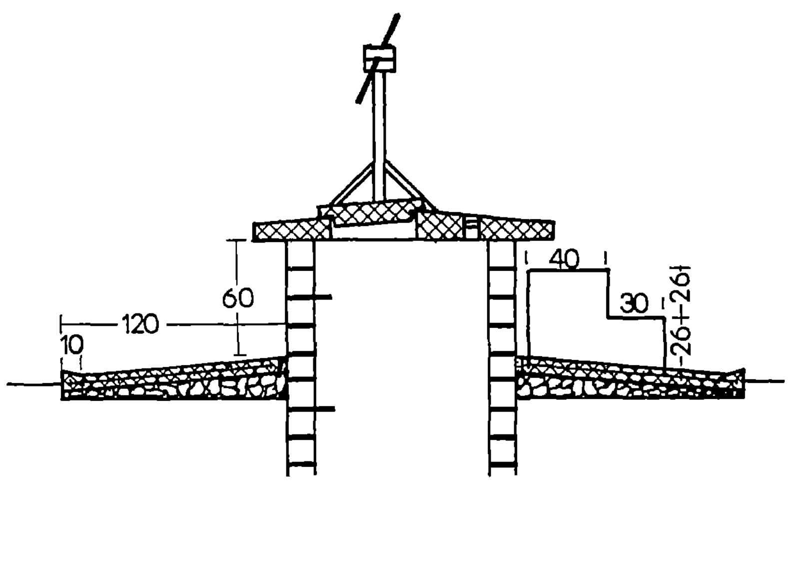
3. Constructing the Well Head

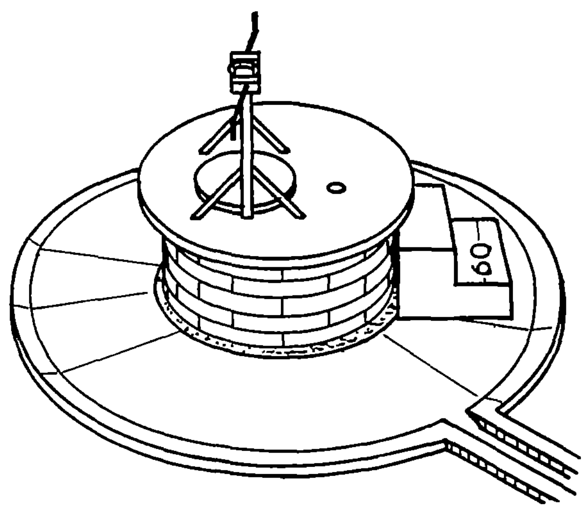
When a well shaft cannot be sunk any further down, the well head can be constructed. The sinking may be stopped by reaching the bedrock or because the shaft fills too rapidly with water. If you have a water pump, this can be used to keep the shaft dry and to allow the sinking to continue. However, because the digging is in the dry season, the point at which the well fills up with water too quickly to be emptied by the digger, is a natural place to stop the excavation. At a later date, if the well dries up, the depth of the well can easily be increased.

a. Extend the well shaft 60 cm above ground level. Use mortar (1:4) to cover all the joints and plaster the outside of the well shaft with the mortar.

b. Lift the well cover out of its mould. Place mortar (1:4) on top of the well shaft. Place the well cover on top of the well shaft and adjust it to exact horizontal level so that it is evenly placed on the well shaft and that the man-hole cover is next to the steps inside the shaft. Smooth the joint between the well shaft and the well cover with mortar.

c. Build an apron to drain away waste water. Using stones, level the area around the well shaft to a distance of 120 cm. The area for the apron should have a 10 cm slope outwards to allow waste water to drain off.





d. Place a 5 cm thick ring of sand around the well shaft and pour mortar against it so that the apron and the well shaft are separated by 5 cm. This will enable the well shaft to sink at a later stage without demolishing the apron.

e. Mix mortar (1:4) and pour a 5 cm thick layer of it on the stones leveled for the apron.

f. For reinforcement, lay 20 lengths of wire, each 120 cm long upon the mortar, one end of each wire against the 5 cm ring of sand and the other end facing out like the spokes of a wheel. These wires give the outline of the circular apron. Lay loops of wire over the 20 lengths and space the loops equally in a spiral out from the shaft.

g. Pour another 5 cm layer of mortar (1:4) on the reinforcement and smooth the concrete so that it has a circular appearance and slopes outward way from the well shaft. Built a low gutter around the edge so water can be drained away to the drainage pit.

h. The drainage has two functions, it is used to water cattle or donkeys downstream of the well and outside the protective fence, and it leads spillage away from the shaft. The drainage channel is built of mortar laid over a stone floor 30 cm wide and must slope down to the drainage pit area.

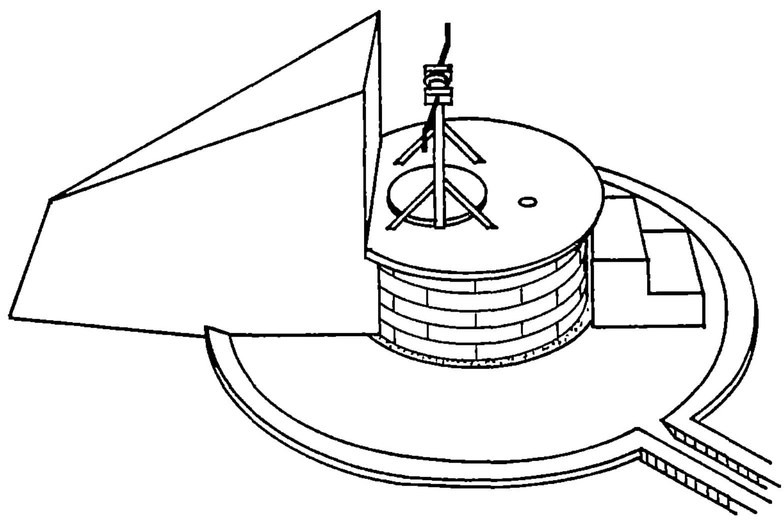
i. If the well dries up in a time of drought, a member of the self-help group can climb down the well shaft and dig below the foundation ring causing the shaft to sink. When the well cover is almost level with the apron, the construction team can be contacted to remove the cover and build the shaft back up to 60 cm. high again. The cover can then be replaced when the excavation has finished.

j. Build two steps, 60 cm wide onto the apron so that people can climb onto the well cover to pump water. The steps are made of stone masonry and mortar (1:4). Plaster the steps with a roughened surface to prevent people slipping when wet. If the well has not been sunk to its deepest point, the steps should not be joined to the well but stand next to it to allow the shaft to be sunk freely.

3.1 Protecting Well Heads in River Beds

a. If the shallow well is built in a river bed which will carry a lot of flood water, a wedge protection structure has to be built from the well shaft towards the direction of flow. This diverts the force of the flood which could dislodge the shallow well.

b. The wedge is built of stone masonry and mortar (1 cement:4 sand). The tip of the wedge starts 250 cm from the well shaft upstream. The back of the wedge is 90 cm higher than the top of the well cover in order to protect the bucket lift (or hand pump) from the force of large floods. Plaster the wedge with mortar.



c. Once again, if the well has not been sunk to its deepest point, the wedge should not be cemented to the well cover or shaft. Instead space should be left to allow the well cover to sink freely without demolishing the structure.

d. All concrete work should be cured for two weeks under polythene and kept moist throughout.

4. Quality Control and Maintenance

It is important that the instructions given are followed closely, particularly the mixes of mortar and cement and the methods of constructing and reinforcing courses. If they are, you should have no problems and can successfully construct your well.

The most important things to observe is that all course are mortared and reinforced every fourth course of blocks except for the first four. If you make a mistake and cement every single course, there will be little recharge into the well because water will not be able to move freely into the shaft. However, the unmortared courses should fit closely together with no apparent gaps because otherwise, sand will flow into the well with the water and gradually fill it up.

The mortar mix for the well blocks should be as directed otherwise the block will be loose and crumbly and will gradually erode inside the well, especially if a rope and bucket is used which will rub up and down the sides.

The excavation shaft should be vertical and the foundation ring perfectly horizontal or else you will have trouble sinking the well. The foundation ring should be kept horizontal by digging out equally from underneath it as you sink it.

The man-hole cover should be well-fitting to keep out dust, insects or other material that might enter into the well. If you do not fit a hand-pump, make sure there is a bucket fixed to the bucket lift and that it cannot easily be removed. This will prevent people using their own rope and bucket which will result in pollutants being added to the water.

Clear an area downstream of the well for use as a bathing or laundry site and provide a concrete basin to make this cleaner, draining to a pit planted with bananas.

To help maintain the well, the well site and the water quality, fence off around the site with thorny branches or live fencing of spiny plants. Put a gate in the fence to keep out animals. Make a parking place for donkeys or oxen downstream of the well near the drainage pit so that they will not make the well site dirty.