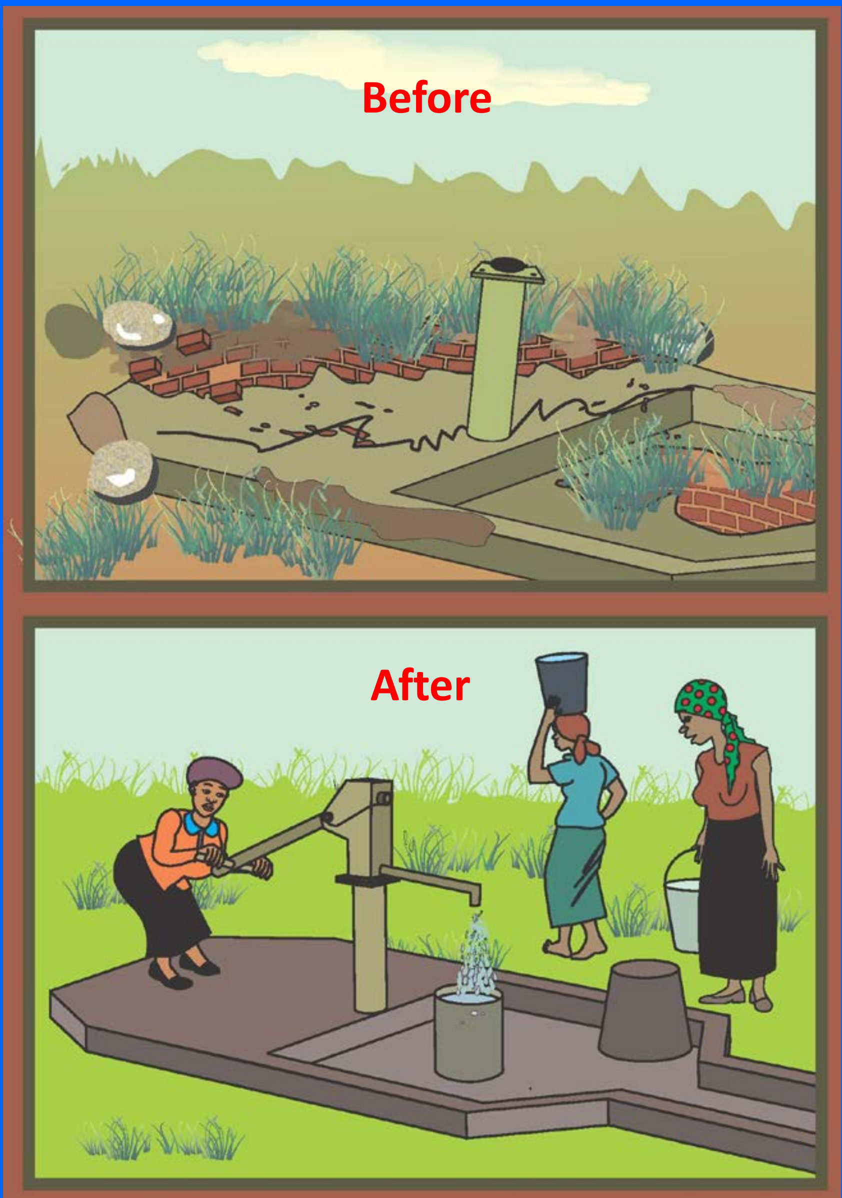
Government of Malawi

Rural Water Supply Operation and Maintenance Series 7

Borehole Rehabilitation Handbook for Extension Workers



Ministry of Agriculture, Irrigation and Water Development

March 2015

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Rural Water Supply Operation and Maintenance Series 7

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Contents

PREFACE

Millions of Malawians, mostly rural, still lack access to clean water and are thus exposed to a number of water and sanitation diseases, such as diarrhea or cholera. Addressing this issue is a key component of the Malawi Growth and Development Strategy (MGDS). To ensure access to clean water in the country, Malawi must build not only the required infrastructure, but also the appropriate institutional systems which can effectively oversee, guide and manage the construction and ongoing operation and maintenance (O&M).

In the past, the Malawi government took full responsibility of the O&M of rural water facilities. However, this system was marred by numerous inefficiencies making it unsustainable. Without a strong presence in communities, these water facilities would often fall into disrepair, but also experience other issues such as catchment encroachment and vandalism.

In response, the national Decentralization Policy, instated in 1998 by the Malawi Government, emphasizes community empowerment through a transfer of power and responsibility to local authorities. Since then, there has been an increasing emphasis on developing community ownership through the adoption of practices like Community Based Management (CBM) trainings.
In the CBM trainings one component is Borehole rehabilitation and defined as restoring a borehole to its most effective condition by various treatment or reconstruction methods. This manual outlines the cause of deteriorations borehole performance and methods of rehabilitations the borehole.

There are numerous causes of poor and deteriorating borehole performance. Causes may include inherent characteristics of the aquifer which supplies water to the borehole, design, its construction, water quality and other environmental factors, and even operation and maintenance of the borehole. Some causes of poor borehole performance are preventable during the design and construction phase if properly addressed.

This handbook is targeting Water Monitoring Assistants (WMAs) and District Water Development officers (DWDOs) in the Districts to provide technical knowledge required when conducting major borehole rehabilitation works to help incorporating the poorly performing existing boreholes back into CBM maintenance system.

It is hoped that with this handbook, direction can be provided on one of the leading approaches to increasing access to clean drinking water through improved O&M of water points. Any substantive comments for improvement on the manual are welcome and should be directed to the secretary responsible for water development.

Sandram C. Y. Maweru

SECRETARY FOR IRRIGATION AND WATER DEVELOPMENT

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This handbook was produced by the “Project for Enhancement of Operation and Maintenance for Rural Water Supply in the Republic of Malawi” under the technical cooperation by Japan International Cooperation Agency (JICA).

A series of workshops were held in the project, and a lot of stakeholders in Malawi, development partners, and NGOs technically contributed in the formulation of the handbook. The Ministry of Agriculture, Irrigation and Water Development therefore, extends special thanks to these stakeholders for allowing their staff to participate in the production of this handbook.

The Ministry is also indebted to JICA for assisting in the development of the handbook, and many who have not been mentioned here but contributed in different ways.

List of Acronyms

VLOM	Village Level Operation and Maintenance
WPC	Water Point Committee
EC	Electric conductivity

Introduction

Borehole rehabilitation is defined as restoring a borehole to its most efficient condition by various treatments or reconstruction methods. Timely maintenance works such as periodic or regular well development can sustain well performance, thereby prolonging well life.

The borehole rehabilitation is described in this handbook.

1. Aims of Rehabilitation Works

Groundwater resources in Malawi have always been developed predominantly for domestic supplies. With Malawi's agricultural background, much of her population lives and works in rural areas and so the provision of potable water for domestic supply across the country is of special importance.

It is clear that groundwater supplies are required to serve the majority of the rural population. From this background of groundwater development in Malawi it is clear that there has been a very considerable investment in boreholes already.

The aim of the rehabilitation works is to ensure that previous investment is not written off but effectively utilised by maximizing the well performance and incorporating the existing boreholes into the community-based maintenance system as non or poorly functioning boreholes are brought back to life.

2. Causes of Reduction in Well Performance

There are many variables that contribute to reduction in well performance.
That is to say,

- Pump damage or wear,
- Well screen and casing corrosion or incrustation,
- Incrustation of the aquifer
- Structural failure of the well

Clayey material on the handpump plunger caused by siltation

Incrustation on the well screen

These problems are often traced to factors such as poor well design or construction or improper selection of pump materials.

Besides, hydrogeological conditions may contribute to reduced well performance.
For examples,

- Reduced aquifer recharge,
- Over pumping of aquifer,
- Interference from nearby wells

Change in groundwater quality is also a significant factor in well performance decline.

3. Solutions to the Reduction in Well Performance

If the existing boreholes fitted with other handpumps than Afridev (VLOM[1]) are to be incorporated into the community maintenance structure, then the pumps must be replaced.

Some of the existing handpumps cannot be maintained at the community level. They should, therefore, be replaced by the Afridev handpumps so that maintenance requirements of new and existing boreholes are unified.

To bring the existing boreholes fully into operation also requires the involvement of the Community. The people living around the existing borehole may have had poor service in the past from a pump which breaks down frequently and is out of action for long periods. The borehole rehabilitation will have to be explained to them clearly emphasizing that rehabilitation will not leave them with an inferior water point.

[1] VLOM is the abbreviation for "Village Level Operation and Maintenance". So, the VLOM Pump is one which can be operated and sustained using village level operation and maintenance.

4. Rehabilitation Procedure

4-1. Planning and Preparation

The number of existing boreholes in an area of intervention is obtained in the planning phase. At this stage all that is required is the number of boreholes so that sufficient provision for rehabilitation is made.

In the preparation phase more detailed information shall be obtained from the construction details and maintenance records of each borehole.

The important information required from the construction and maintenance records (borehole history[2]) is:

- Date drilling completed
- Date civil works completed
- Original depth and depths of borehole measured periodically on maintenance visits[3]
- Original casing details
- Original yield
- Original pumping test data
- Original static water level
- Original first water struck
- Static water level[4] measured on maintenance visits
- Original water quality and water quality measured periodically on maintenance visits
- Frequency and nature of pump repairs.

In case these important information is not available the borehole shall be basically excluded for the rehabilitation work.

[2] Ministry responsible for water affairs requires the drilling contractor to submit the drilling report in the designated format referred to Appendix 1.
[3] WPCs are required to their maintenance records in the designated format referred to Appendix 2.
[4] Rest water level is also used as synonym of static water level. It is natural groundwater level measured in a borehole. No groundwater levels are ever truly static as they continually respond to recharge, discharge and abstraction.

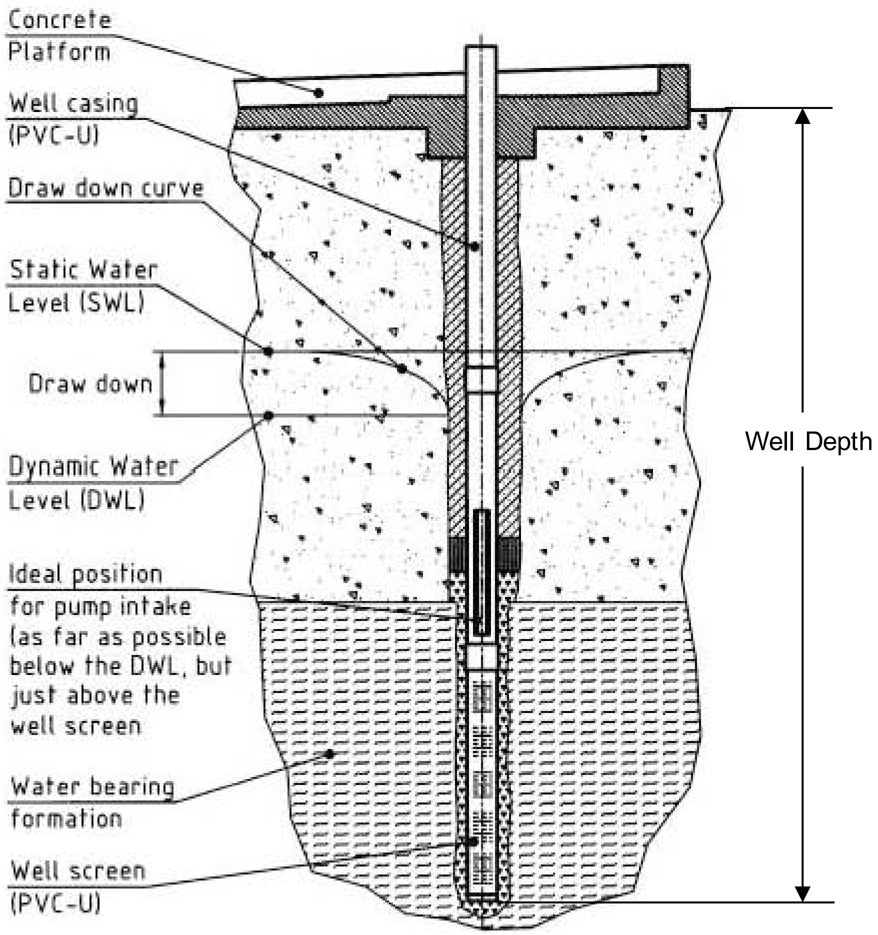


Fig. 4-1 Schematic Drawing of Borehole

The boreholes are visited in the course of the initial fact finding assessments to collect additional information on:

4-2. General Criteria for Rehabilitation of Boreholes

The following information is compiled by the hydrogeologists/engineers/drillers and is related to the general criteria for deciding whether and how to rehabilitate each borehole.

- Date visited
- Current status of the borehole and its surrounding
- Site location in relation to pollution hazards
- Attitude of the community to the borehole
- Chemical and biological quality of water from the borehole
- Population using the borehole
- Pump type (Afridev, Malda, Climax, India Mark II etc.)

4-2-1. Water Quality.

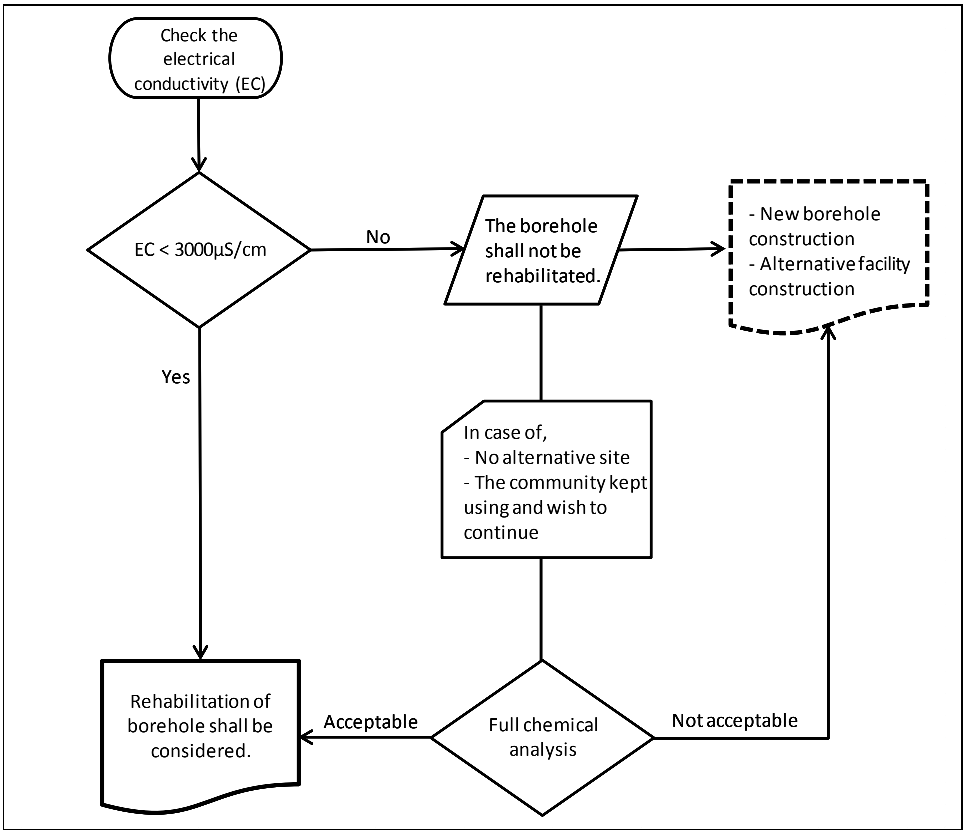
If the electrical conductivity (EC) of the water is above 3,500 µS/cm at initial visit the borehole should basically not be rehabilitated.

If there is no alternative site, and the community has been using the borehole and wish to continue using it, a full chemical analysis should be taken.

If no constituents are unacceptably high then rehabilitation should be considered.

The communities sometimes may prefer to use nearby water source because the water quality of the area is tastily/ Salty hence during rehabilitation these factors should be considered.

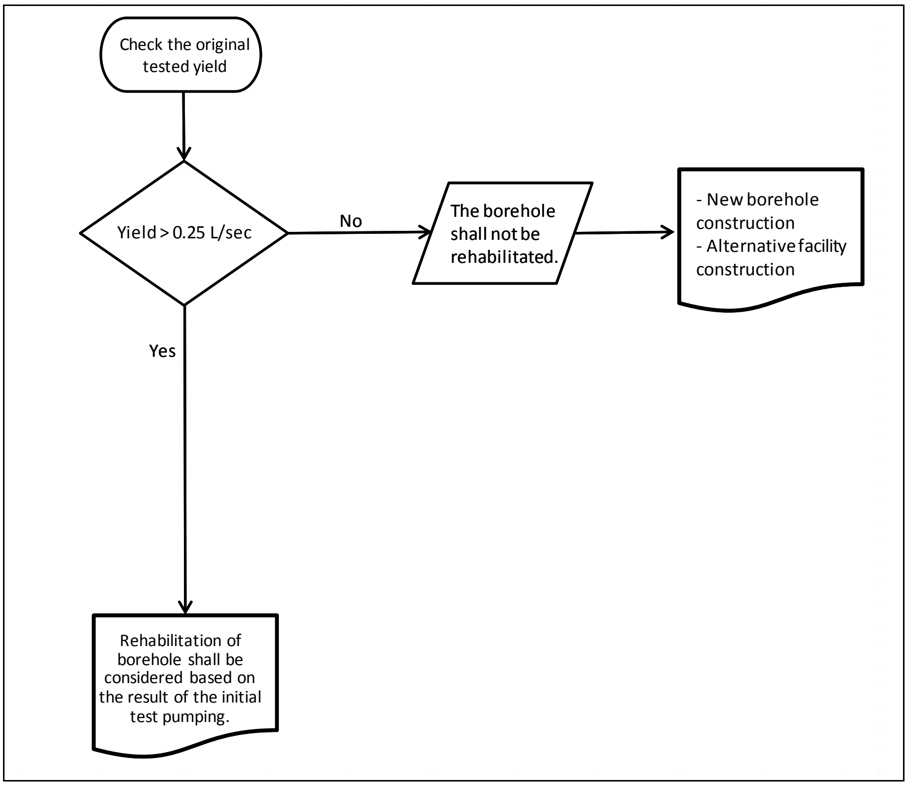
The information gathered from the communities should not be ignored because if the community insists that if you rehabilitate water quality will not change.



4-2-2. Yield.

If the original tested yield of the borehole was very low (less than 0.25 l/sec) then rehabilitation is unlikely to be successful.

An alternative site for a new water point should be selected. If the original tested yield was over 0.25 l/sec but the yield has substantially decreased, the borehole should be included in the rehabilitation program, where a decision to proceed with rehabilitation is made on the basis of the initial test pumping of the borehole.



4-2-3. Siltation.

Many boreholes encounter siltation to some extent because of the poorly designed screens and/or due to alluvial formations such as soft sand/silt/clay. It is commonly thought that a very large number of the existing boreholes require immediate cleaning because of the amount of siltation.

It is, however, the rate of siltation in relation to the borehole depth and casing configuration that is important.

4-3. Steps in Operational Procedure

Standard operational procedure for a borehole rehabilitation work is shown below;

a) Once the Community has agreed and displayed the need for borehole rehabilitation, the Village Health and Water Committee is requested to organise the contributions towards the rehabilitation exercise. This contribution includes cash/in-kind, labour and supply of local materials.
b) Remove the existing pump.
c) Before measuring the depth of the borehole and the water level, check if there are unexpected falling object in the borehole.

If there is an obstruction in the borehole caused by a dropped cylinder, rising main or rods:-

- If standing above the infill it may be easy to “fish” out.

- If buried by infill material it cannot be economically retrieved.

5. Method of Borehole Rehabilitation

There are typical methods for the borehole rehabilitation as follows;

- Air lifting method
- Mechanical bailing with a bailer
- Mechanical surging with a surge block
- High-velocity water jetting

The air lifting method is the most applicable to the borehole fitted with handpumps in rural area in Malawi.

It is recommended to refer to **Table 5-1** when selecting the rehabilitation methods.

Table 5-1 Applicability of Rehabilitation Method to Type of Well

Type of Well		Applicability of Rehabilitation Method			
Type	Casing/Screen material	Air lifting	Mechanical bailing with a bailer	Mechanical surging with a surge block	High-velocity water jetting
Borehole with Handpump	uPVC Diameter: 4"	applicable	less applicable	inapplicable	inapplicable
Tube well with motoraized pump	Steel/stainless steel Diameter: 6" - 14"	less applicable	applicable	applicable	applicable

Each method is outlined below.

5-1. Air lifting method

Many drillers use compressed air to develop wells in consolidated and unconsolidated formation. The practice of alternatively surging and pumping with air has grown with the great increase in the number of rotary drilling rigs equipped with large air compressors. In air surging, air is injected into the well to lift the water to the surface. As it reaches the top of the casing, the air supply is shut off, allowing the aerated water column to fall.

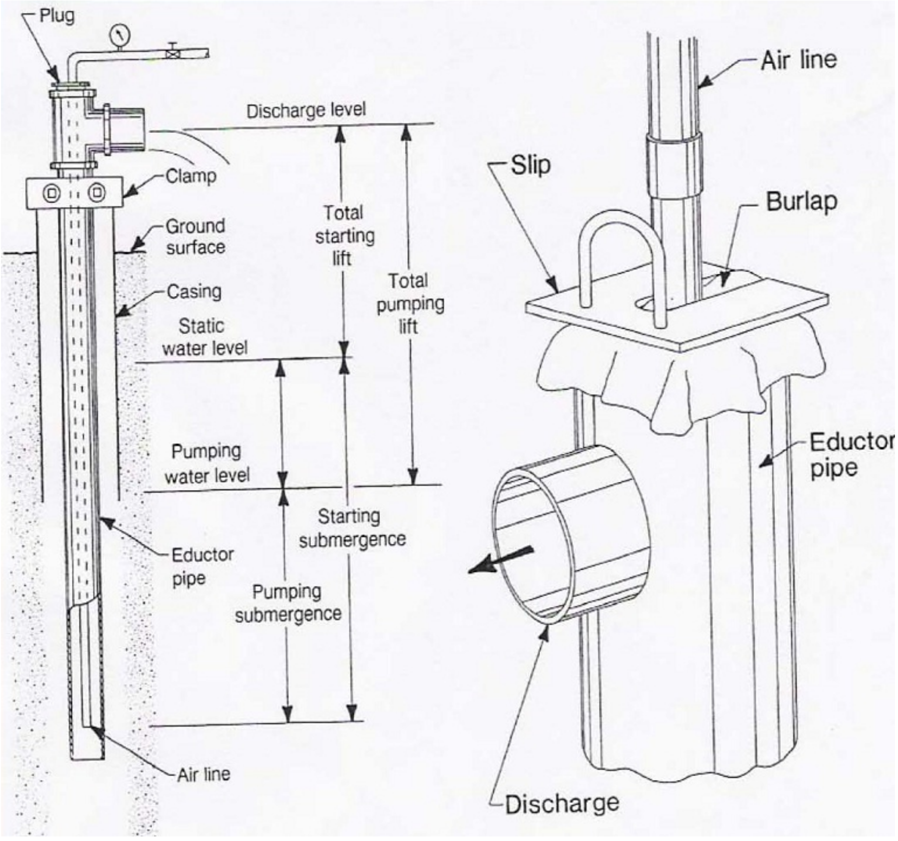


Fig. 5-1-a Basic layout of an air-lift system

Air-lift pumping is used to pump the well periodically to remove sediment from the screen or borehole, and is accomplished by installing an airline inside an eductor pipe in the well.

Eductor systems are generally required for large diameter wells, when limited volumes of air are available, or when the static water level is low in relation to the well depth. **Fig. 5-1-a** shows the basic layout of an air-lift system and the appropriate terms.

Compressors, airlines, hoses, fittings, etc., should be of adequate size to pump the well by the airlift method at 1.5 to 2 times the design capacity of the well. Each case is specific in terms of depth, submergence, well diameter, and screen hydraulic conductivity.

For wells less than 90m in depth, with 60% submergence possible, approximately 5.6 m^3/sec of air per 1 m^3/sec water of anticipated pumping rate.

In practice, a 375-cfm compressor developing 100 psi can usually pump 400 to 500 gpm (approximately 44 to 67 cfm or 1.25 to 2.0m3/sec) of water with proper airline submergence.

The first goal in the development process is to establish a piston effect (surging) and not to conduct airlift pumping.

In surging, sufficient air is fed to raise the water level as high as possible, then it will be released to let it drop. Airlift pumping is then used to pump the well periodically to remove sediment from the screen or borehole.

When the well yields clear, debris-free water, the airline is lowered to a point below the bottom of the eductor line and air introduced until the water between the eductor pipe and the casing is raised to the surface. At this time the airline is raised back up into the educator line causing the water to be pumped from the well through the eductor line.

The procedure of alternating the relative positions of the air and eductor line is repeated until the water yielded by the well remains clear when the well is surged and backwashed by this technique.

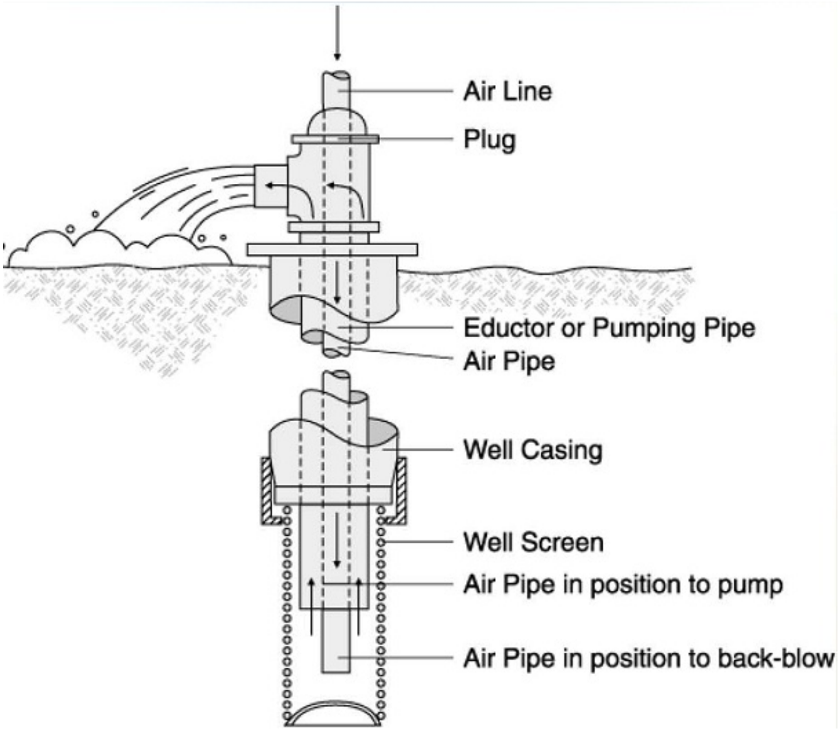


Fig. 5-1-b Well Development using airlift pumping and agitation

Airlift pumping forces compressed air through an airline to the bottom of the well (**Fig. 5-1-b**). As air bubbles rise, they create a surging effect that carries water and dislodged materials out of the well. Airlift pumping is alternated with short periods of no pumping, which forces water and chemicals out into the formation to help break up minerals and bacteria lodged in the aquifer formation surrounding the screen.

This method of well development is effective only if the water is deep enough in the well to get the surging action. Airlifting does not work if the lift to the surface is too great.

5-2. Mechanical bailing with a bailer

The conventional drilling rigs (Cable Tools percussion rig) can be effectively used to rehabilitate boreholes. The procedure is outlined below.

- Begin bailing with bailer (**Fig. 5-2-a, b**), measuring the increased depth.

- Continue bailing to original depth or until bailer is producing water only, in which case infill material is very compacted to be removed by bailer.
- Run in drill bit to disturb infill material.
- Continue alternate drilling and bailing until original depth is reached (**Fig. 5-2-c**).
- Proceed to complete borehole as outlined above.

Fig. 5-2-a Photograph of Bailer and Flap valve
(Extracted from "Drilling Wells By Hand, Cliff Missen, MA, Wellspring Africa, http://www.wellspringafrica.org/")

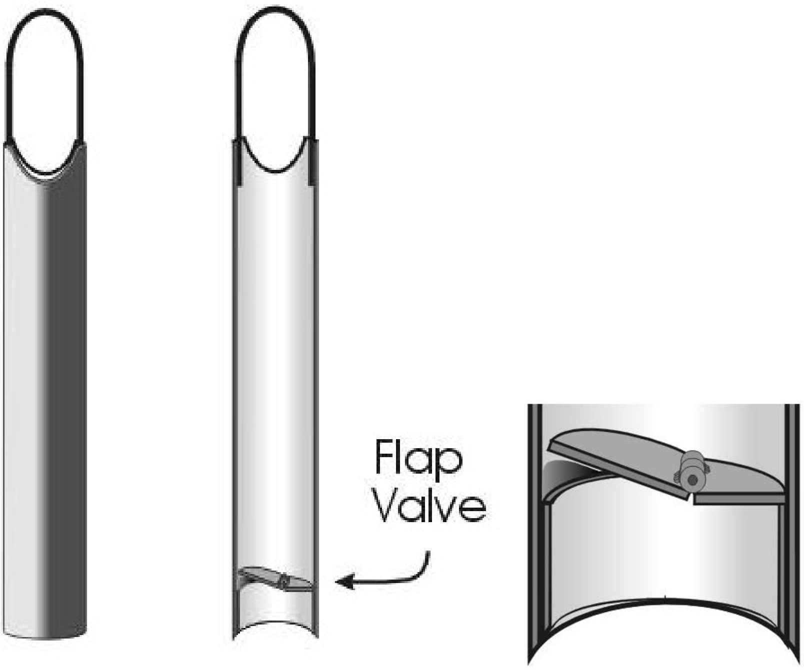
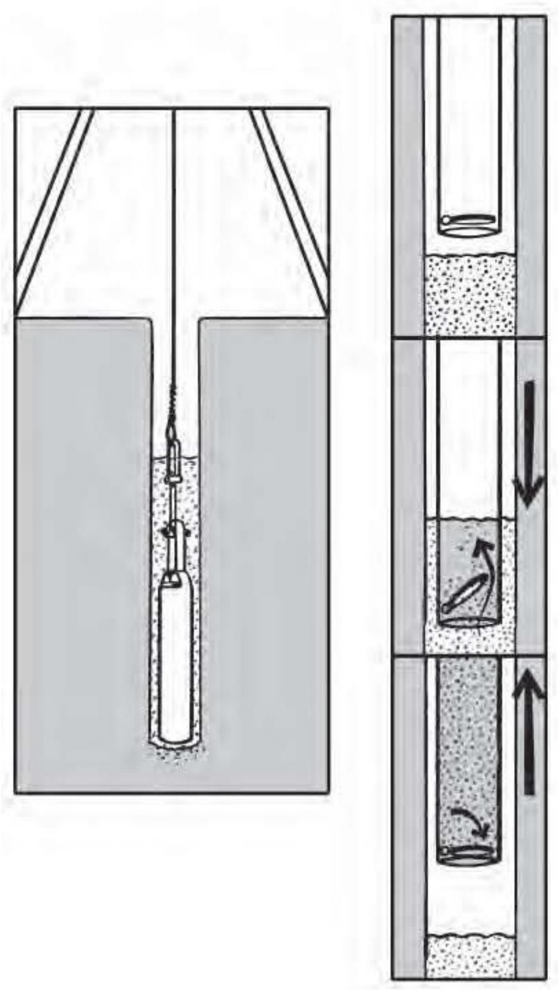


Fig. 5-2-b Structure of Bailer and Flap valve
(Extracted from "Drilling Wells By Hand, Cliff Missen, MA, Wellspring Africa, http://www.wellspringafrica.org/")



One bailing stroke;

The bailer goes down in the hole through the water or sediments.

On the downward movement the flap valve at the bottom of the bailer will open. Then the water or sediments will enter the bailer.

On the upward movement the flap valve will close. The water or sediments is now inside the bailer.

Fig. 5-2-c Conceptual Drawing of Borehole Rehabilitation Work by Bailing Method

(Extracted from “Manual drilling series PERCUSSION, June 2010, PRACTICA Foundation”)

5-3. Mechanical surging with a surge block

One of development methods is to force water to flow into and out of a screen by operating a plunger up and down in the casing, similar to a piston in a cylinder. The tool normally used is called a surge block, surge plunger or swab (**Fig. 5-3-a**).

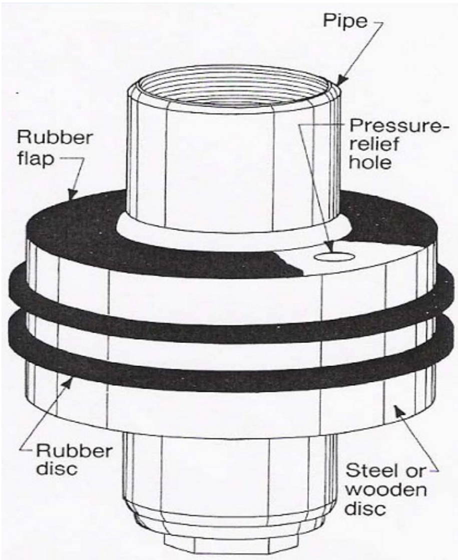


Fig. 5-3-a Surge Block

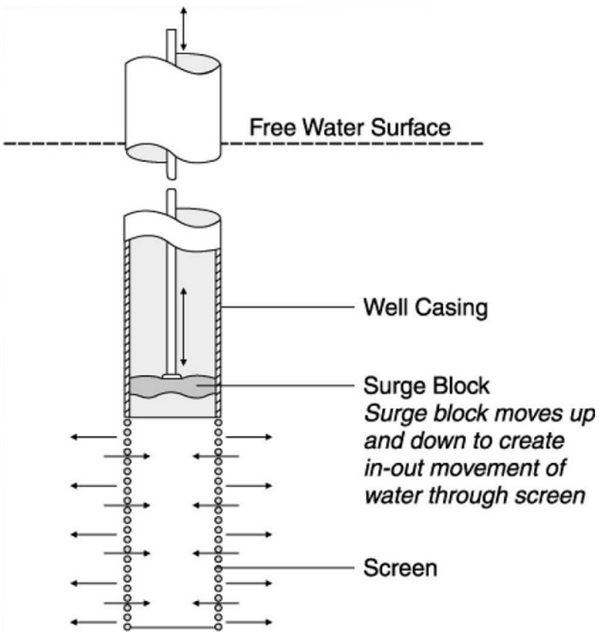


Fig. 5-3-b Movement of water through screen

Surging alternately forces water into and out of the formation through the well screen openings (**Fig. 5-3-b**). A piston like tool moves up and down in the well to create the surging action.

The water surging through the well screen loosens the minerals and fines in the borehole and draws them into the well to be removed by pumping or bailing.

Surging is somewhat effective in reaching into the surrounding aquifer, but doesn't provide consistent cleaning throughout the length of the screen. Surging is most effective near the bottom of the screen and progressively less so the closer the surge block gets to the top of the screen. Surging can cause channeling through the screen into the porous formation, leaving layers of silty, finer-grained particle formations undeveloped.

Although some drillers depend on surge blocks for developing screened well others feel that this device is not effective and that it may, in some cases, even be detrimental because it forces fine material back into the formation before the fines can be removed from the well. To minimize this problem, fine material should be removed from the borehole as often as possible.

Surging especially is suited to cable-tool drilling. Surging is not very effective with very deep wells (more than 200 feet) or those with multiple screens.

5-4. High-velocity water jetting

The best well development method is high-pressure water jetting with simultaneous pumping (**Fig. 5-4-a**).

High-velocity water jets through the screen and gravel packing to the formation to loosen and breakdown the fine materials. The jetting tool rotates slowly as it moves up and down inside the well screen.

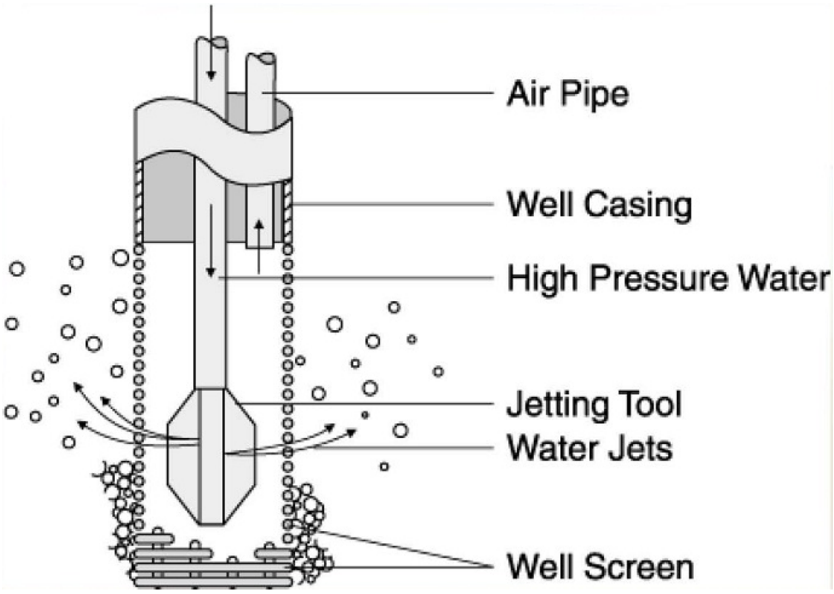


Fig. 5-4-a Well Development using high-velocity water jetting

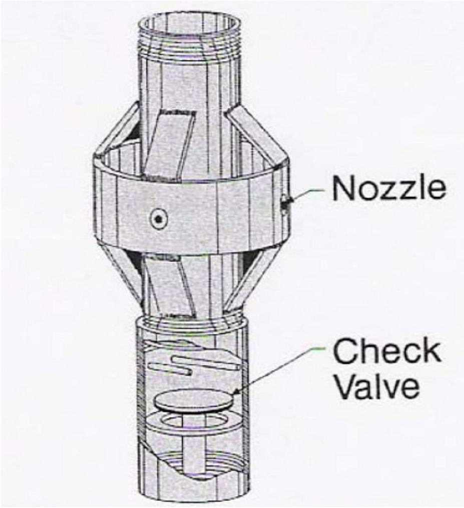


Fig. 5-4-b Four-nozzle Jetting Tool

Fig. 5-4-b shows a jetting tool with four nozzles. Nozzles should be spaced equally around the circumference of the jetting tool to hydraulically balance the tool during operation; for example, four nozzles should be spaced 90 degrees apart.

The outside diameter of the jetting tool must be 1 inch less in diameter than the screen inside diameter.

The minimum exit velocity of the jetting fluid at the jet nozzle should be around 45m/sec. The tool is rotated at a speed less than 1 rpm and positioned at one level for not less than 2 min and then moved to the next level, which is no more than 6 inches vertically from the preceding jetting level.

Pumping removes the loosened sand and mud as they enter the well screen. The jet stream can be directed at any part of the formation around the well for selective development.

Pumping from the well should be at a rate of 5 to 15% more than the rate at which water is introduced through the jetting tool. Water to be used for jetting must contain less than 1 ppm suspended solids.

Cage-wound screen is best for jetting because its design allows the jet to impinge directly on the gravel pack or borehole. Well screens that use louvered or bridge openings do not respond to this type of development because the opening design interferes with the jet of water. Jetting often is the most costly development method.

Appendices

Appendix-1

Borehole No. ....

IRRIGATION AND WATER DEVELOPMENT
GROUND WATER SECTION
BOREHOLE DRILLING REPORT

District: ....

T/A: ....

Locality ....

Constituency: ....

Grid Ref: .... UTM.........................

Elevation: ....m

Moved from: ....

Moving to: .... Distance ....kms

Client/Project: ....

Address: ....

Driller: .... Rig No: ....

Drilling company ....

Drilling Started: ....

Drilling Finished: ....

Supporting truck No.......... Compressor No.........

Drilling method ....

DAILY RECORD DURING DRILLING

Date	From (m)	To (m)	Hours Drilled	Other Works	hrs	Remarks-Daily drilling activities with times

DRILLING DETAILS

Hole diameter...............mm from..........m to.........m
Hole diameter...............mm from..........m to.........m
Hole diameter...............mm from..........m to.........m
Temporary casing.........mm from ....m to...........m
First water at.................m Interim yield...........(L/s)
Second water at............m Interim yield...........(L/s)
Third water at................m Interim yield...........(L/s)
Water level....................m (below ground level)
Interim Yield (final)..(L/s)
Hours cleaning and developing......................hrs
PVC plain casing.......................mm ....m
PVC slotted casing....................mm ....m
Total meters installed..m
Bottom cap No .... end cap No.................
Solvent cement...................(..............ml) tin(s)
Cleaning fluid ....(...............ml) tin(s)
Gravel pack............pails (20L pail) (................m³)
Grouting..........................m (bags of cement..........)
Water quality:- (pH=............., EC=..............,
TDs=......, salty=yes or no, good= yes or no)
Remarks ....
....
....

BOREHOLE DESIGN

General Geology

____

Supervisor

Site agent/client

Appendix-2: Format of Borehole Maintenance Sheet (Blank Sheet)

BORED—WELL NO. DISTRICT

GRAVEL PACKED YES/NO LOCATION T.A.

Depth Ft.	Tested Yield G.P.H.	Static Rest Level	Type Pump Head	Casings, size type and depth from surface	Size Rising Main	Size Rods	Date Constructed	Deposits from surface in feet		
								Surface Deposits and type	Weathered Rock and type	Fresh Rock and type
								From To	From To	From To

MAINTENANCE

Date	Repairs, depth and rest level	Materials	Date	Repairs, depth and rest level	Materials

BORED WELL NO. MAINTENANCE (*Continued*)

Date	Repairs, depth and rest level	Materials	Date	Repairs, depth and rest level	Materials

Appendix-3: Format of Borehole Maintenance Sheet (Example)

W.D. 166/40/1M/1.56 U.T.M. REFERENCE

BORED-WELL No. G. 55 SHEET No. DISTRICT NCHEU

GRAVEL PACKED YES/NO. LOCATION WESTON / CHIKADYA N.A. GEORGE

Depth Ft.	Tested Yield G.P.H.	Static Rest Level	Type Pump Head	Casings, size type and depth from surface.	Size Rising Main	Size Rods	Date Constructed	Deposits from surface in feet. Surface Deposits and type	Weathered Rock and type	Fresh Rock and type
180	350	95	C.Max	180x4	140x2	140 x 5/8	AUG 52	From To	From To	From To

MAINTENANCE

Date	Repairs, depth and rest level	Materials	Date	Repairs, depth and rest level	Materials
23.1.59	Inspection		~~23.8~~		
9.6.59	157'·71'	2 FV. Rubbers leather gasket.	22.8.66	Good	Grease + oil
8.10.60	156 – 71' leathers diff rubber	leather oil	16-5-67	Good Service	oil
13.7.61	152 – 72 diff. service good.	oil	13/9/67	85' level + Good	2x3" cup leathers
6.10.62	155 – 71 Good	2+3 cup leathers 2 diff, rubbers, oil			2 R/valves 3/4
10.5.63	153 - 67 leathers rubber				Diff reg complete
17.5.63	153 - 67. 2" coupling				10x2" R/main
9.12.64	Good	Grease & oil			Grease + oil
10 5 66	157 – 57 Good leather	Spring Rubber	24/1/68	Inaccessible	
	Diff. leather	Grease and oil	10/8/68	Good, Service	grease + oil
30 7 66	Good	Grease & oil			
23/5/68	Good, Service				

BOREHOLE No. G. 55 N.A. George NCHEU MAINTENANCE (Continued) V.G. Weston / Chikadya

Date	Repairs, depth and rest level	Materials	Date	Repairs, depth and rest level	Materials
8.7.69	180'·85' Good	2x3" c/leathers, 2 R/valves.	5-9-72	Good	Serviced
		Springs for Buckets,	21-9-72	157'/46'	2L 2R 12' P/R
		Grease & oil	27-12-72	Good	Serviced
31/10/69	Fair.	oil	28-3-73	Inaccessible	
2/4/70	Good	Base plate nuts	1-6-73	154'/57'	2 Leathers
		Loose oil.			2 Rubbers.
16-7-70	Good	oil			2" Socket joining
[illegible]	[illegible]				~~ring~~ G + oil
25-9-70	157' 56'	2L, 2R, 1Lx	31-7-73	150'/45'	
28-4-71	157/57'	4R/m 4 Rods	12-9-73	Good	Serviced
		1 packet Cement	3-12-73	✓	✓
21-8-71	Good	Serviced	27-3-74	145'/42'	2L 2S 2R
23-9-71	151/48	2L	16-5-74	Good	Serviced
15-2-72	No visit heavy rains.		12-9-74	✓	✓
21-3-72	Good	Serviced	4-12-74	168'/39'	2L 2R 2S 2 P/L
28-4-72	✓	✓			1 Stud 1 Disc
19-6-72	✓	✓	19-9-75	Good	10' R/M
26-8-72	157/57'	2L 2R 2S	31-5-75	✓	Serviced

Appendix 4: Pumping Test

IRRIGATION AND WATER DEVELOPMENT, GROUNDWATER DIVISION, P/B 390, LILONGWE 3

PUMPING TEST RESULTS

Locality.......................................T/A......................... District...............................

Bh No.................. Bh depth .... Description of the Datum..........................

Pump Set at................. Test Pumped by.............................Date of Test....................

Main Test

Time Since test Start (Min)	Pumping Water Level (m)	Drawdown (m)	Q (l/sec)	Time Since test Start (Min)	Pumping Water level (m)	Drawdown (m)	Q (l/sec)	Recovery (m)
0				300				
1				330				
2				360				
4				420				
6				480				
8				540				
10				600				
12				660				
14				720				
16				780				
18				840				
20				900				
25				960				
30				1020				
35				1080				
40				1140				
45				1200				
55				1260				
60				1320				
70				1380				
80				1440				
90				1560				
100				1680				
110				1800				
120				1920				
135				2040				
150				2160				
165				2280				
180				2400				
210				2520				
240				2640				
270				2760				
				2880				

IRRIGATION AND WATER DEVELOPMENT, GROUNDWATER DIVISION, P/B 390, LILONGWE 3

PUMPING TEST RESULTS

Locality……………………………….T/A……………………. District………………………..

Bh No………………. Bh depth ………….. Description of the Datum……………………….

Pump Set at……………. Test Pumped by………………………..Date of Test………………..

Step Drawdown Test

Time Since test Start (Min)	Pumping Water Level (m)	Drawdown (m)	Pumping Water level (m)	Drawdown (m)	Pumping water Level (m)	Drawdown (m)	Recovery (m)
0							
1							
2							
4							
6							
8							
10							
12							
14							
16							
18							
20							
25							
30							
35							
40							
45							
55							
60							
70							
80							
90							
100							
110							
120							

Appendix-5

IRRIGATION AND WATER DEVELOPMENT

GROUND WATER SECTION

CIVIL WORKS AND PUMP INSTALLATION

DETAILS OF MATERIALS

Location:	Client/Project..
T/A:	Address: ....
District:	....
Grid Ref: 36 L..	....
UTM...	Work done by: ....
Altitude..M	Date Installed: ....
Borehole No:	Date finished: ....
Borehole Depth: ....M	Vehicle No..
Water Level: ....M	....
Pump Set at: ....M	....
No. of Stroke:	**Remarks**
Estimated Yield:...........................L/S	....
No. of rising main 63mm...............M	....
No. of pump rods.............................M	....
No. of Cement used.............................	....
Solvent Cement......................................	....
Cleaning fluid...	....
No. of bricks..	....

Appendix-6

MALAWI STANDARD FOR BOREHOLE AND PROTECTED SHALLOW WELL (MS733:2005)

PARAMETER	MAXIMUM ALLOWABLE LEVELS
pH Value	6.0-9.5
CONDUCTIVITY (µS/cm at 25^0C)	3,500
TOTAL DISSOLVED SOLIDS, mg/l	2,000
CARBONATE (as CO_3^{2-}), mg/l	-
BICARBONATE (as HCO_3^{2-}), mg/l	-
CHLORIDE (as Cl^-), mg/l	750
SULPHATE (as SO_4^{2-}), mg/l	800
NITRATE (as NO_3^-), mg/l	100
FLUORIDE (as F^-), mg/l	3.0
SODIUM (as Na^+), mg/l	500
POTASSIUM (as K^+), mg/l	-
CALCIUM (as Ca^{++}), mg/l	250
MAGNESIUM (as mg $^{++}$), mg/l	200
SOLUBLE IRON (Fe $^{++}$), mg/l	3.0
MANGANESE (as Mn^{++}), mg/l	-
TOTAL HARDNESS (as $CaCO_3$), mg/l	800
TOTAL ALKALINITY (as $CaCO_3$), mg/l	-
SILICA (as SiO_2) mg/l	
TURBIDITY, NTU	25
SUSPENDED SOLIDS, mg/l	-
Faecal coliform, count/100ml	50
Faecal strept, count/100ml	0

Glossary

Classification of Wells

Name	Factor of Classification					
	Depth	Diameter	Shape	Structure	Construction methods	Targeted aquifer
Shallow Well	Shallower than 15m	100 to 2,000mm (Normally 1,000 to 2,000mm)	Dug well, Open well	Open hole, Brick or concrete lining, uPVC casing (VONDER)	Mainly digging by hand held tools, sometimes digging by manual operated augers (VONDER)	Unconfied water
Borehole (Deep Well)	Deeper than 15m	100 to 300mm	Tube well	Casing/screen pipes	Machine drilled well ~~including Hand augered well~~	Confined water including Fissure water

Definitions

Shallow Well	Depth is generally shallower than 15m. This technology is applicable in shallower water tables called unconfined water, hence often in soft soil/sandy formation. Due to their shallowness, shallow wells are prone to pollution from seepage of polluted water and drying up during dry season. There are two types of shallow well by digging method as follows; Hand dug: A shallow well dug by hand held tools (eg hoe, shovel etc., local available tools) with wide-diameter. Machine dug: A shallow well dug by a mechanized or manually operated machine with small diameter (VONDER). Process of construction: Site location of well is normally decided based on discussion among beneficiaries without any scientific consideration.
Borehole (Deep Well)	Depth is generally deeper than 15m. This technology is applicable in moderate to deeper water tables called confined water including fissure water, hence often in hard formation. Due to their deepness, boreholes are anually stable in both water quality and quantity. A borehole is drilled by a mechanized operated machine (drilling rig) with small diameter. Process of construction: Site location of well is normally decided based on beneficiaries' convinience and scientific consideration. And location of screen is at least decided based on the result of geophisical soundings.

Name of Water Source

No.	Type
1	Borehole
2	Protected shallow well
3	Protected spring
4	Unprotected shallow well
5	Unprotected spring
6	Dambo
7	Lake shore
8	River
9	Rainwater collected
10	Piped supply

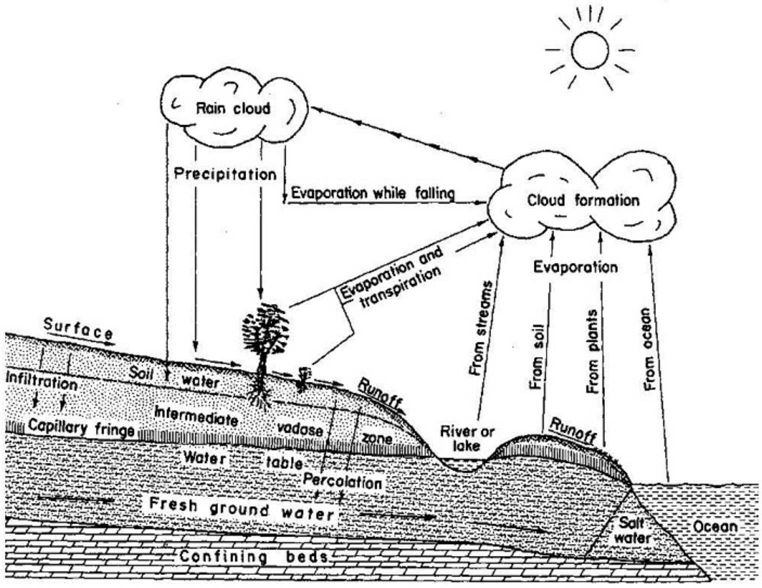
(A Guide to Integrated Rural Accessibility Planning in Mallaw i ILO/Department of District and Local Government Administration, June 2000)

Drinking-water Ladder
(WHO/UNICEF JMP, 2010)

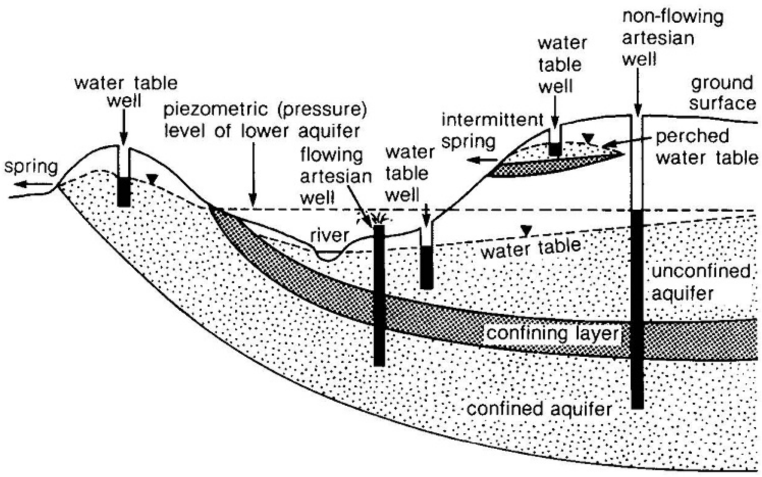
Unimproved drinking-water	**Unimproved**
	Unimproved drinking-water sources; Unprotected dug well Unprotected spring Cart with small tank/drum Surface water - river - dam - lake - pond - stream - canal - irrigation channels Bottled water*
Improved drinking-water	**Other improved**
	Other improved drinking-water sources; Public taps Standpipes Tube wells/boreholes Protected dug well Protected spring Rainwater collection
	Piped into swelling, plot or yard
	Piped water on premises; Piped household water connection located inside the user's dwelling, plot or yard

*: Bottoled water is considered to be improved only when the household uses drinking-water from an improved source for cooking and personal hygiene: where yhis information is not available, bottoled water is classified on a case-by-case basis.

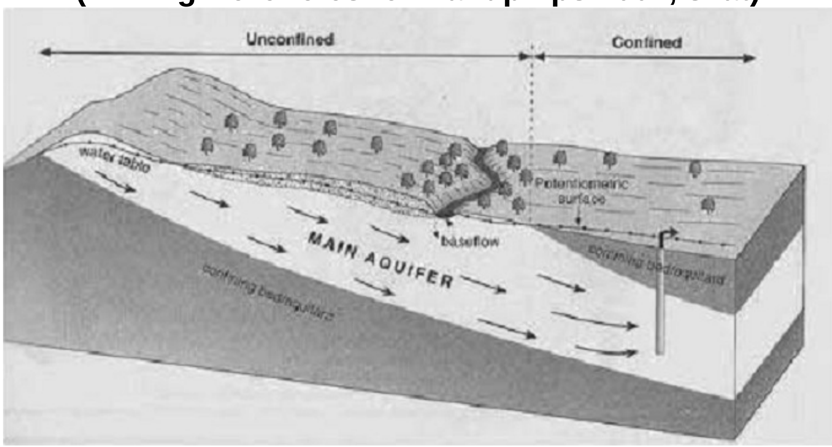
Occurrence and Disposition of Groundwater



Hydrological Cycle
(Drilling Boreholes for Handpmps 2001, skat)



Disposition of Groundwater and the Boreholes
(Drilling Boreholes for Handpmps 2001, skat)



Groundwater System
(Groundwater Theory 2007, RWSN & skat)

Rural Water Supply Operation and Maintenance Series were developed for planners, managers and practitioners for the practices of operation and maintenance of boreholes fitted with Afridev hand pumps in rural Malawi.