Hand Pumps: How to Repair Common Problems

After reading this you should know/be able to:

- **Understand the basic components of an Afridev Hand Pump**
- **Retrieve a broken or separated pump rod of a Afridev Hand Pump**
- **Retrieve a broken or separated riser pipe of a Afridev Hand Pump**
- **Repair common problems associated with an Afridev Hand Pump**
- **Understand the basic components of a Rope Hand Pump**
- **Replace warn washers with sustainable washers on a Rope Pump**
- **Repair common problems associated with a Rope pump**
- **Properly locate and design a hand pump's location**

Throughout the world, the ability to obtain adequate quality water is becoming a greater problem. With the earth's population still rising, the need for a sustainable way to bring higher quality water to the world's population is essential. In the developing world, many of the inhabitants are left without a way to provide this essential sustenance. In developing countries, the water that severs many of lives basic human needs is being met by unimproved water sources, such as local rivers and streams. In many cases, people in these developing countries are force to retrieve their drinking water from puddles on the sides of roads.

Introduction

In the last couple of decades, the water needs of developing nations are largely being met with the implementation of hand pumps. This large scale implementation of hand pumps has led to an increase of higher quality water for large portions of the world's population. Much of this population was once forced to drink from very low quality water sources. This quick implementation of hand pumps has lead to another unforeseen problem. At any time 30% of hand pumps are found nonfunctioning (Baumann, 2009). This problem is largely to blame on the user's inability to fix the downed pump. Time and again the same three reasons are respectively forthcoming: a lack of knowledge of the pump system, a lack of funding to fix the pump or a lack of available spare parts for the pump. The ability of a pump to deliver water and the initial cost of the pump are principally the only things that designers tend to look at when implementing a hand pump system. The lifecycle cost of having the pump has historically been forgotten.

This problem of unserviceable hand pumps has led to a new view on the installation of hand pumps in the developing world. The long term sustainability of the hand pump is now considered heavily before a hand pump is even chosen for a particular site. To keep an installed pump in an operational and serviceable manor, many outside factors are now taken into account. The availability of local resources has shown to be one of the best indicators of the pumps success rate. To help decide which pump is right for which location a few questions are commonly brought up during the design phase. Does the

local population have the ability of get replacement parts? If the pump goes down, how many days will the pump stay down before a replacement part can arrive on location? Is there any way for the users to fabricate their own parts? These questions have lead to the use of a few hand pump styles merging as the primary hand pumps in the developing world. This is due greatly to their ease of use and higher ability to be repaired. In this short technical brief, only two of these typically used hand pumps will be discussed, the Afridev hand pump and the rope pump. This brief will also principally focus on common breakages of these two pump varieties coupled with how to fix these breakages.

The Afridev Hand Pump

Fundamentals of the Afridev Hand Pump

The Afridev Hand Pump is a pump that utilizes pressure as a way to create lift to the ground water as a means of delivery. The Afridev Pump is an industrially made pump that is currently being manufactured in several developing nations in Africa and Asia. The idea behind creation of the Afridev was to develop a deep well hand pump that can be easily maintained by the local village level users. As an effort to make the Afridev hand pump a sustainable pump, it was designed to have durable, simplistic and affordable replacement parts.

For easiest explanation of the Afridev hand pump, it can be separated into four sections:

- The pump head, stand and handle assembly
- The pump rod
- The rising main and casing
- The piston, cylinder and foot valve assembly

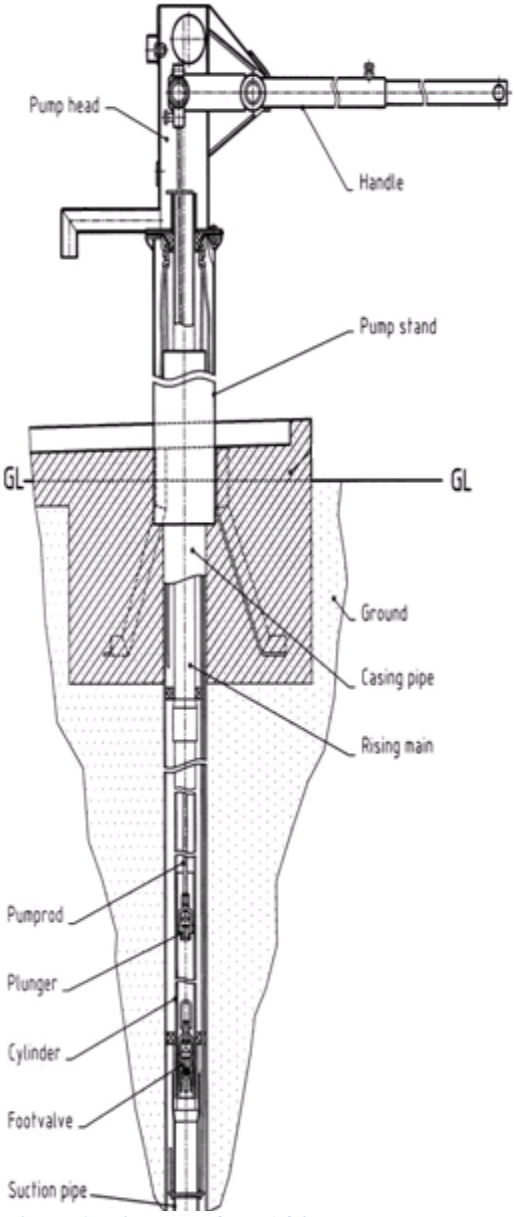


Figure 1: Diagram of the Afridev Hand Pump (Modified with Permission (Erpf, 2007))

The pump head stand and handle assembly is what most people think of when seeing a pump. It is the outside body of the pump that the user typically sees and utilizes while using the pump. The handle, connected to the pump rod, is moved in a vertical up and down motion by the pump's user. This causes the pump rod to move the piston assembly, which is attached to the piston assembly, below the water table, up and down. This up and down motion of the

piston assembly creates a suction of the ground water into the piston assembly. The water that is suctioned into the piston assembly is then passed through the rising main to the surface level. This is relatively a simple machined process that is easy for the local user to operate.

Construction

The rising main for the Afridev pump is usually made up of PVC. This is a relatively cheap portion of the initial cost and will last for an extended amount of time. The installation of casing can be a time consuming process that is done by boring a hole either manually or mechanically. There are several methods of this process and the chosen method will likely be determined by the local equipment options.

For the Afridev hand pump, the typical range of usage is between 10 to 45 meters (Afridev Pump, 2009). If the depth of the water table is below the 45 meter maximum suggested range, then the user's ease of water retrieval will be lessened. Also with the reliability of the pump is reduced.

Common Breakages, Maintenance and Sustainable Solutions

The Afridev hand pump is a high quality pump that can easily be implemented as part of a sustainable water delivery project. With that being said, there is some upkeep that is required in order to keep the pump in operational condition. Unfortunately, in rural areas, preventative maintenance seldom occurs which leaves maintenance operations strictly to fixing a downed pump.

Unlike some of the other hand pumps used around the world, the Afridev hand pump, regrettably, doesn't have any locally produced sustainable remedies to fix a nonfunctioning pump. This is due to the fact that the Afridev is an industrially manufactured pump with replacement parts that must be accurately produced. For this reason, a backup supply of recommended replacement parts should be on hand. This is to insure that the pump's down time is limited.

The more common maintenance issues associated with the Afridev pump has to do with the multiple seals throughout the pumps moving parts. This is because of the tendency of rubber to slowly wear over time. Most other parts of the Afridev have a much longer lifespan and only will need to be replaced as needed.

The Afridev pump comes with a set of specially designed fishing tool attachments. These tools are used to retrieve the piston assembly from the bottom of the casing or to retrieve a broken section of the rising main. The fishing tool has three attachments that can be used depending of the situation.

The first attachment is a perpendicular hook that is attached to the end of a pole. This attachment is used when a pump rod becomes disconnected from the other pump rods. The hook is designed so that it when lowered to the disconnected pump rod, the hook is turned clockwise until the rod's nut is secured into the hook. Once the rod is secured, the hook will be raised along with the entire rod and piston assembly. The disconnected section of the rod will then be reattached and the pump will be repaired. See Figure 2 and Figure 3 for an illustration of this process.

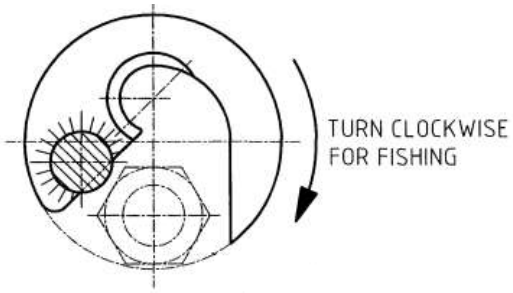


Figure 3: Vertical View of the Hook Fishing Tool Attachment (Modified with Permission (Erpf, 2007))

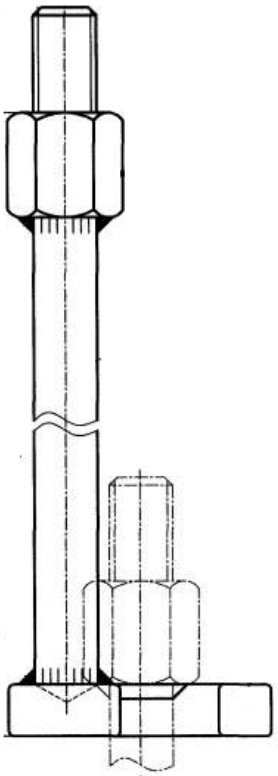


Figure 2: Side View of the Hook Fishing Tool Attachment (Modified with Permission (Erpf, 2007))

The second attachment is a cup shaped tool that can be used if the pump rod breaks and the hook fishing tool attachment cannot be used to recover the broken section. This cupped tool has a hole in the top so that when lowered around the broken rod, the rod is secured to the fishing attachment. The rod can them be easily lifted and repaired. Figure 4 shows this attachment with the broken rod in place.

The third attachment is another cup shaped retrieval device. This cupped attachment is designed to be used when the rising main becomes broken or separated from the rest of the ring main piping. This cup attachment is simply lowered around the broken section of the rising main until a secure connection is made. When this occurs the separated portion of the rising main can be lifted to the surface for repair and reattachment. See Figure 5 for a picture of this attachment process.

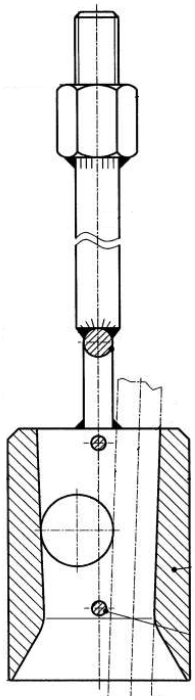


Figure 2: Fishing Tool for Broken Pump Rods (Modified with Permission (Erpf, 2007))

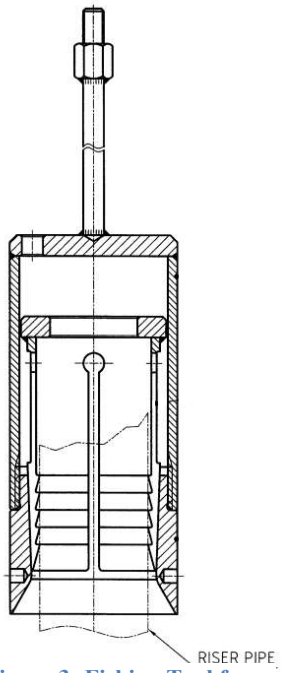


Figure 3: Fishing Tool for Disconnected or Broken Riser Pipes (Modified with Permission (Erpf, 2007))

There are several other breakages that can occur with the Afridev hand pump. Some of these will occur more often than others because of the expected life expectancy of each part of the pump is different. While many of these breakages can be prevented with preventative maintenance, Table 1 can be used as a reference to determine how to fix a determined problem.

Table 1: Common Breakages and Repairs for the Afridev (Modified with Permission from Trouble Shooting Chart and Replacement Intervals Chart (Erpf, 2007))

Pump Sections	Common Breakage (Warning Sign)	Suggested Repair Method
Pump head, Stand and Handle Assembly	1. Bearings are warn – (Handle is shaky when in use) 2. Fulcrum pin or Hanger pin is loose – (Handle is shaky when in use) 3. Flanges are loose – (Pump head is shaking while in use) 4. Pump platform is cracked – (pumps stand is shaking)	1. Replace Bearing sets 2. Check pins for nuts, fully tighten if nuts still are intact, else replace missing nuts and fully tighten 3. Tighten all nuts and bolts of the flanges 4. Repair or replace pump platform or well covering
Pump Rod	1. Pump rods are disconnected - (No Water from pump) 2. Pump rods are rubbing riser pipes – (Unusual noise during pumping operation)	1. Pull out Pump Rods, replace broke or corroded rods (use fishing tools if needed) 2. Straighten are replace fault pump rods
Rising Main and Casing	1. Riser pipe is disconnected - (No Water from pump) 2. Leakage of rising main - (slowed water retrieval time)	1. Pull out entire rising main, repair or replace pipes as needed ensuring to solvent cement all joints 2. Pull out entire rising main, repair or replace pipes as needed ensuring to solvent cement all joints
Piston, Cylinder and Foot Valve Assembly	1. Seals are warn- (No Water for pump) 2. Leaking of Piston Valves - (slowed water retrieval time or reduced amount of water flow) 3. Foot Valve O-ring leak - (slowed water retrieval time) 4. Cup Seal is warn - (Reduced amount of water flow)	1. Pull out piston assembly and replace warn seal(s) 2. Pull out piston assembly and check Plunger and Foot valve for signs of repairs needed, replace as needed 3. Pull out piston assembly and replace O-ring 4. Pull out piston assembly and replace seal

Affordability

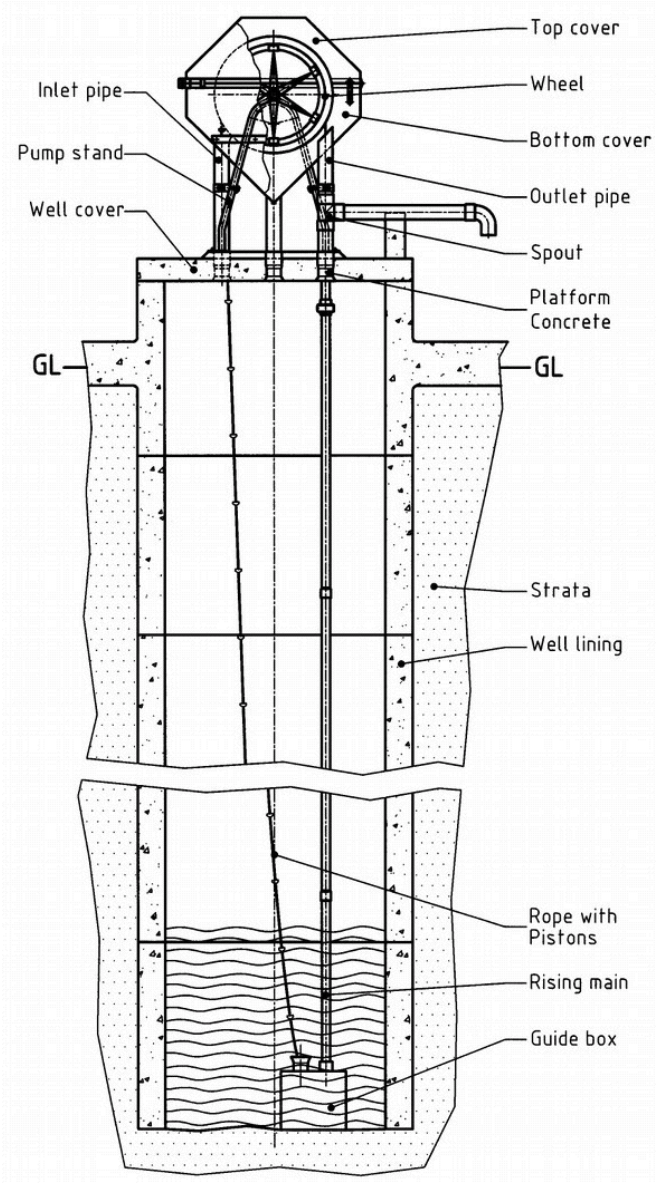
Other than the initial cost of the Afridev hand pump, it is a relatively affordable hand pump. The Afridev pump periodically requires low cost replacement parts on a yearly basis. Rarely the occurrence of higher value replacement parts is required. This is typically every few years though. The ease of accessible replacement parts is what has lead to the overall success of the Afridev. This is due to the Afridev's manufacturing facilities being located in the countries of use. As a way to facilitate the wide spread accessibility of the spare parts in Mozambique, PRONAR (the National Rural Water Programme) has distributed an initial stock of parts to local vendors free of charge (Obiols & Baumann). As the supplies are used the vendors are able to restock the parts at a predetermined price. This serves as a way to keep prices at an affordable level.

The cost of maintenance and repair of the Afridev pump is around $50 to $65 U.S. dollars a year. This roughly works out to approximately U.S.$ 0.05/household/month (Obiols &

Baumann). This is a reasonable cost for the local community for the availability of higher quality water.

One of the largest factors of concern with the hand pumps is over use. With the higher initial cost and the local population's inability to afford a second installation of another pump, many of the Afridevs are being overused. This does cause more wear and tear on the pumps, which lead to more maintenance cost. Even with this, the success of the Afridev undeniable.

The Rope Pump



Fundamentals of the Rope Pump

The rope pump is a type of hand pump that retrieves water from a well or borehole. The rope pump utilizes a direct lift method of water retrieval, unlike the Afridev hand pump which uses a suction

method of water retrieval. The rope of the rope pump has a series of washers that are spaced apart along the entire length of the rope. The rope and washers are then pulled through a pipe which is below the ground water level. The rope is continuously retrieved by a human powered wheel as the washers trap and lift the water to the top of the well. The washers normally fit loosely in the pipe but still snug enough to prevent the water from falling back down the pipe. The washers are commonly made up of a coned rubber but can be made of different locally available products, which will be discussed later in this section. A diagram of a rope pump can be found in Figure 6.

Construction

The rope pump is a water retrieval system that is typically attached to a well or a borehole. The pipe that the rope pump utilizes to lift the water from the bottom of the well is most commonly made of PVC. PVC is a relatively cheap material to use but will have to be monitored for wear.

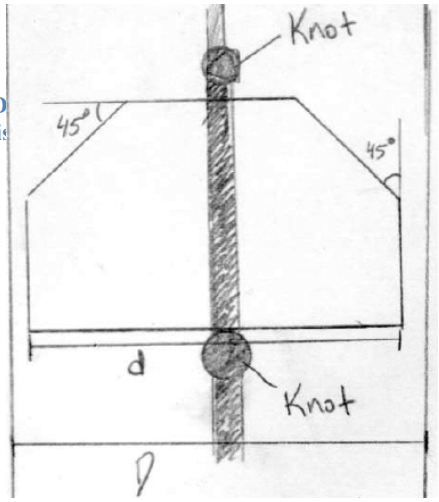


Figure 4: D
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The maximum depth that a rope pump can retrieve water from is sixty meters but the commonly used maximum depth is thirty meters. An adult can extract 11 gallons per minute from a 10 meter deep well, 5 gallons per minute from a 20 meter deep well and 2.2 gallons per minute from a 50 meter deep well (Thomas Walder, 2004). If the ground water level is below this depth then a different pump should be chosen for the site.

At the bottom of the well, just before the pipe entrance, a guide block is commonly used. This guide block not only enables a smooth transition from downwards direction of the rope to upwards direction but it also reduces ware and tear on the pipe entrance.

Common Breakages, Maintenance and Sustainable Solutions

The rope pump has a reputation of being a highly efficient and sustainable hand pump. Even with this being said the rope pump does need some maintenance and up keep from time to time. Unlike many of the world's other hand pumps though many of these maintenance needs can be fixed using local materials instead of factory made replacement parts.

The first of these replacement parts that can be locally fabricated is the washer. Essentially the washers are the most important part of the rope pump. The washers are what actually lift the ground water to the surface. Commonly the washer is a plastic cone shaped piece that is held in place on the rope by a knot tied directly below it. See Figure 5 for an idea of a common factor made washer. Over time this piece is subject to wearing which leads to a need for a replacement. When it is time to replace one or more of the washers there are a few options that can be utilized. The first one would be to use a

factory made replacement washer. This is normally the easiest but most costly way to upkeep the system.

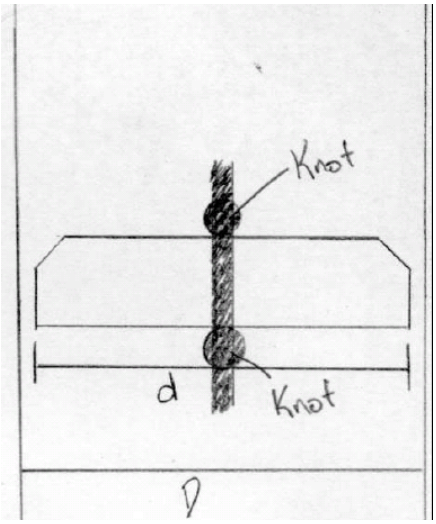
Figure 6: Example of Washer made from Used Tires (D>d by 1-2 mm typically)

The second way is to construct a replacement washer out of a used tire. This is done by cutting a circular washer out of an old tire with a diameter that is slightly smaller than the diameter of the pipe. The new rubber washer is then placed on the rope in the place of the warn washer. If there is not a knot in the rope at this location, or something else to keep the washer in place, a knot should be tired in that location (see Figure 6 for example). This is a sustainable option that can be utilized to keep the rope pump in operation.

A third option to the warn washer dilemma is to construct a washer out of spare rope. The spare rope can be constructed in to a knot that can perform the same function as the previous two washers. This method is a little more complicated than the other alternatives but it is an option none the less. This third option can be easily implemented if the knot making skill is taught to the local women, whose job it is to normally collect the water (Demotech). This type of repair should only take a matter of minutes and should not create a need to take the pump out of operation. An example of this knot can be seen in Figure 7.

Figure 7: Example of Knot Made Washer (Used with Permission (Demotech))

Another portion of the rope pump that is prone to wear and tear is the rope itself. After constant usage sections of the rope may become warn and in need of repair. In order to keep the rope pump in constant operation the rope should be replaced before the rope is severed. Ideally the replacement of the entire rope should take place before the warn or fraying sections snap. Unfortunately, this might be a more costly fix than is actually required. As an option to save resources and money, the replacement of the sections of warn rope is all that is required. To do this, a piece of rope similar to the rope in use and a little bit of knot tying knowledge is needed. The section of the warn rope should be cut out and replaced with the new rope. The connections between the new rope and the old rope should be a secure knot that does not impede the rope pump's function.



There are a few other problems that are associated with the rope pump. Although many of these problems are seldom, a need to mention them is still necessary. A table of these problems has been compiled along with suggested maintenance that is associated with each problem. Also on this table, some of these previously mentioned problems that can be fixed using less costly and sustainable solutions.

Table 2: Common Breakages and Repairs for the Rope Pump

Problem or Breakage	Suggested Maintenance	Sustainable Solution
▪ **Worn, cracked or missing washers**	▪ Replace with Factory made replacement washer	▪ Replace worn washers with washer made from old tires, see Figure 6 ▪ Replace worn washers with washers made from Knots, see Figure 7
▪ **Fraying or broken rope**	▪ Replace rope as ware appears	▪ Replace sections of the rope with new rope ensuring proper knot connections
▪ **Rope Pump wheel moves backwards after pumping**	▪ This occurs because of the weight of the water that is still suspended in the rising main pushes the washers backwards through the rising main ▪ Engage break device after each use (MacCarthy, 2004)	
▪ **Turn handle broke off the wheel**	▪ Depending on damage, replace handle or entire wheel assembly	▪ Have a local welder reattach the piece ▪ If this is not possible, a spare piece of metal may be able to be substituted
▪ **The Rope is Catching in between the two rims of the pulley wheel**	▪ Attach a piece of rubber in the middle of the wheel and slow revolutions from 90 rpm to 40-60 rpm (MacCarthy, 2004)	▪ Cut an old tire inner tube in half and tie it around the center of the pulley wheel, this will fill the space where the problem is occurring and provides some grip from the wheel to the rope (MacCarthy, 2004)
▪ **Rope is fraying at the connection ends**	▪ After the connection is made melt the ends of the rope. This can only be done nylon ropes.	
▪ **The pulley wheel is not gripping the rope**	▪ Ensure that the rope is tight enough If not - tighten the rope at its connection. This normally occurs within the first few weeks of a new rope. This is typically due to the tightening of the knots in the rope.	
▪ **Rope is stuck in the pipe**	▪ Lightly pull \ backwards on the rope ▪ If it stays stuck the entire pipe must be removed from the well and manually fixed.	
▪ **Wheel is difficult to move**	▪ Grease the wheels axel	

Affordability

As with most projects in life, the cost of the project, not just the upfront cost but also the annual maintenance cost, often determines the overall success and longevity of the project. This is what has led to the overwhelming success of the rope pump. The initial cost of the rope pump, in a study that occurred in 2001, is around $110. Also the annual maintenance of the rope pump, in most cases, is less that $5 a year. This is significantly low when compared to the popular India Mark II, which is a factory made pump with factory made replacement parts. The initial cost of the India Mark II was $750 for an equivalent pump's flow rate to the compared rope pump. Also the yearly maintenance of the India Mark II ranged between $59 to $107 (Münger, 2001). Keep in mind that many of these replacement parts for the India Mark II have to be factory made. This can lead to

a complex supply chair for spare parts. Alternatively many of the rope pumps replacement parts can be fabricated by local users.

The rope pump is an affordably and sustainable hand pump that has the ability to have a long service life. The public's acceptance of the rope pump has lead to the overall success of the pumps system. In many cases, the rope pump is simply the best choice for the job.

Other Hand Pump Related Problems to be Addressed

Since hand pumps can be attached to wells, the need to install an approved well cover is imperative. The well's surroundings must also be designed to eliminate the surface runoff that flows back into the well from community washing stations and animal drinking troughs. In addition, the locations of possible groundwater contamination facilities, i.e. latrines and animal pens, must also be taken into consideration. These design criteria implementations, found in Figure 8, will reduce the chances of bacterial contamination and maximize the wells water quality. The quality of the water that comes out of the pump is directly related to the practices of the pump's users.

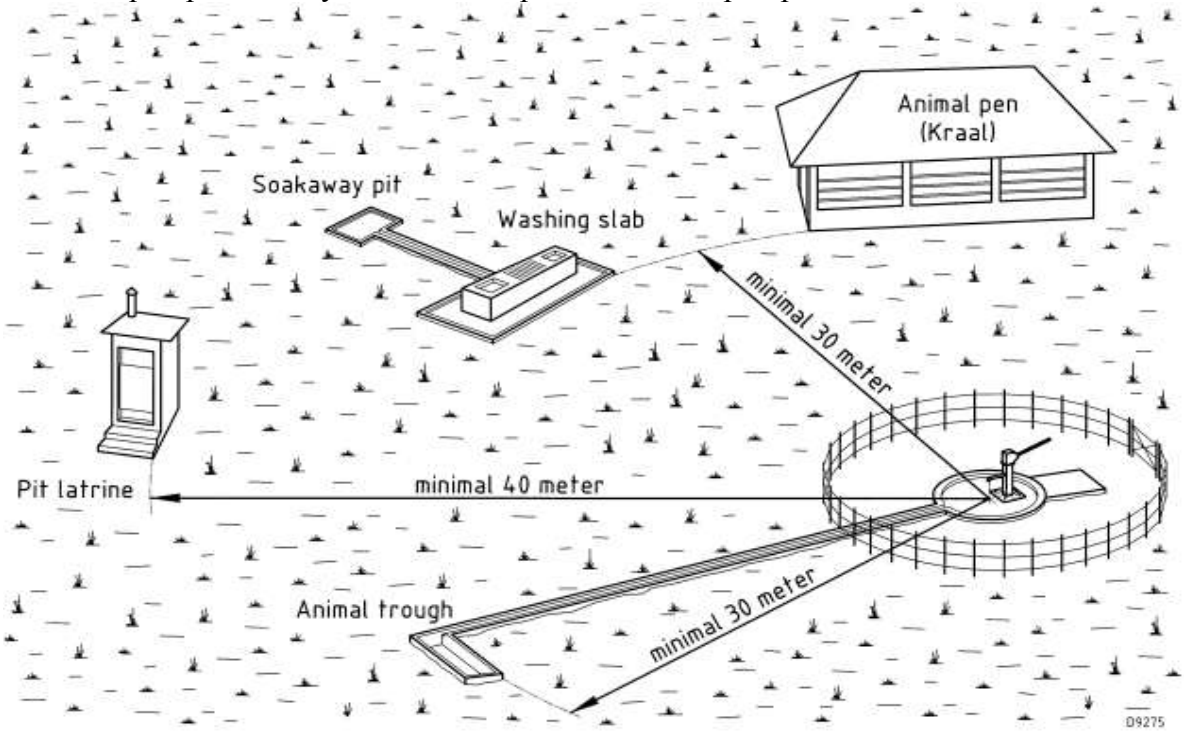


Figure 8: Example of a Properly Designed Hand Pump Station (Used with Permission (Erpf, 2007))

Further Reading

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Disclaimer

Statement of how this brief was prepared as part of class (I will provide this language)

Contact

This document was prepared for one of the following two classes at the University of South Florida (Tampa): CGN6933 “Sustainable Development Engineering: Water,

Sanitation, Indoor Air, Health" and PHC6301 "Water Pollution and Treatment". Please contact the instructor, James R. Mihelcic (Department of Civil & Environmental Engineering) for further information (jm41(at)eng.usf.edu. (learn more about our mission and development education and research programs at: www.cee.usf.edu/peacecorps).