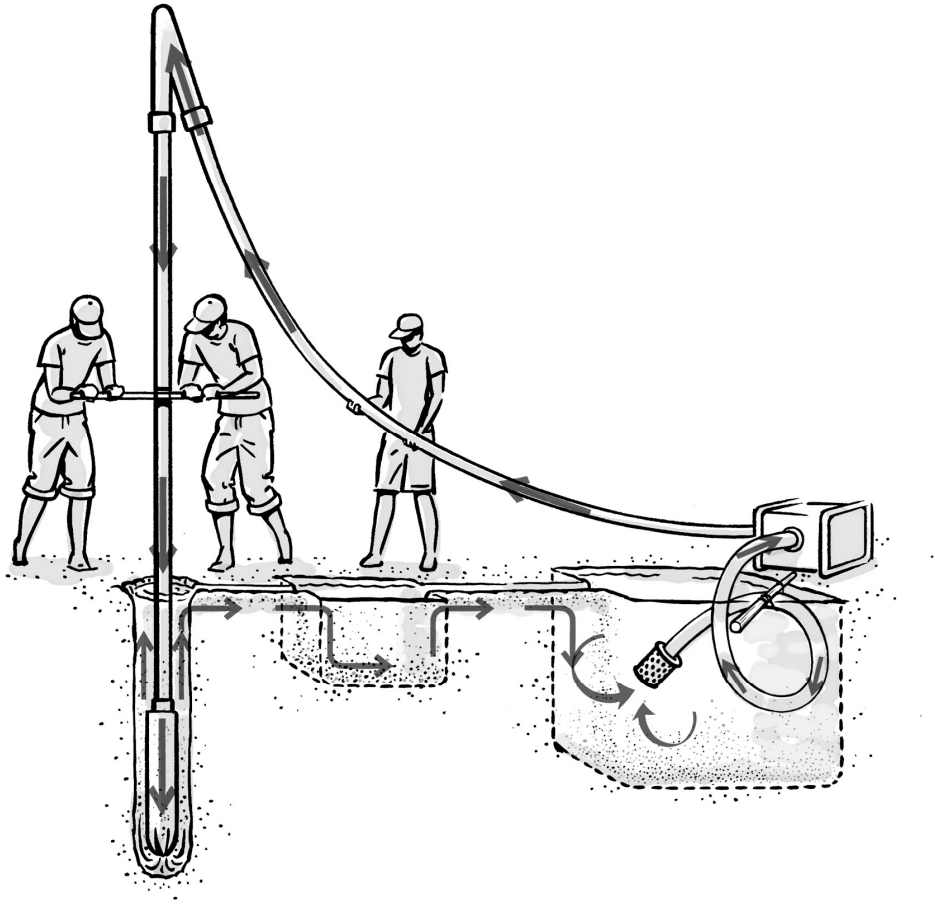
Emergency Rotary Jetting Kit

Field manual



PEOPLE NEEDED	DIFFICULTY	TIME NEEDED	WATER NEEDED	PETROL NEEDED	WEIGHT
		1day	3-4 m^3	16 L	<300 Kg

General view of the jetting kit

Field manual

This kit contains a professionalized rotary jetting kit for drilling wells manually. The kit is an upgraded version of a rotary jetting kit as used by enterprises in Africa, though adapted to meet emergency settings. Human power is used for the rotational and the up and down movement of the drill string to cut the ground formations. A motor pump circulates a large volume of water from the mud pits through the drill string to the bottom of the borehole and back to wash out the drilled material. The borehole is kept full of water mixed with additive to prevent it from collapsing. The kit is able to drill a well up to 30 meters deep.

This field manual explains how to use this rotary jetting kit for drilling and installing a well manually. It is a guideline only. There is additional information available on the accompanied CD/USB: a detailed rotary jetting manual; a manual on geo-hydrology, hygiene and installation. These will enable you to increase the quality of work and the success rate of drilling. It is highly recommended to use experienced trainers that can provide hands-on courses when you intend to use manual drilling more frequently as part of emergency relief work. PRACTICA has a team of trainers that can help in starting up a drilling program and train local staff.

All parts in the professionalized rotary jetting kit are selected based on robustness, transportability, ease of use and safety. Yet, the kit is made such that repairs and replacements can be done with local materials. In addition, the optional high quality consumables can be replaced with locally obtainable consumables. In appendix 1, information is supplied on how one can repair and replace broken parts using locally obtainable materials. In appendix 2 alternatives for high quality drilling polymer and casings are described.

Where does this kit work?

It is best suited for drilling through unconsolidated formations that consist of loose sand, silt, clay or thin layers of small size gravel. The kit cannot be used for drilling in hard formations of any type. If such formations are encountered, re-siting is needed.

Consult local drillers, evaluate drilling logs and maps or observe existing hand dug wells to determine good drilling locations. Riverbeds, floodplains and valley bottoms are generally the easiest to drill.

Never drill next to sources of pollution: keep a distance of at least 30 meters from latrines. If possible drill in upstream direction from the source of pollution. Never drill near petrol stations, garbage dumps, fire places, etc. This can lead to serious health risks.

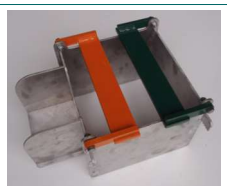
What can it make?

The kit is able to drill a well up to 30 meters deep with a diameter of 7 inch. Casings up to 5 inch can be installed. See page 5 for a schematic overview of a basic borehole design. Any type of hand pump and most mechanized pumps can be installed depending on user requirements.

What is needed in addition to this kit?

1. *People:* a minimal of 4 workers is generally sufficient. To secure the quality of the well, it is advised that at least one person has a background in well drilling and/or geo- or hydrology.
2. *Water:* generally 3-4 m^3 is sufficient for one well. In worst cases this amount can be a multiple of this figure. Make sure there is a water source near your drilling site. If there is no water available, water will need to be transported to the drilling site.
3. *Petrol:* generally 16 liter is enough to drill 1 well. One tank is about 6 liter and the hourly fuel consumption is about 2 liter per hour.
4. *Casings, filterscreen & gravel pack:* 30 meter of 5 inch/125 mm casings/screen with sufficient gravel pack (1-3 mm) is supplied as an additional consumable module. Both can also be sourced locally (see appendix 2).
5. *Cement:* This is used to make seals around the well casing and top seal. Amounts depend on local standards. Two bags of each 25 kg are a minimum.
6. *Submersible pump or compressor:* In case of an expected water level of more than 8 meter, a submersible pump or compressor is needed to develop the well after construction to improve the yield of the borehole.

What is included in the kit?

Name	Picture	Description
Drill rods		Drill rods of 75 cm length each. 40 pieces with a total length of 30 meter (=maximum depth borehole). Each rod weights approximately 2.3 kg. Copper grease is supplied to lubricate the couplings.
Pump	  	Honda centrifugal pump (1x) with: - Storz coupling with two valves (1x) - Straight storz coupling (1x) - Oil (1x)
Rotary arm		Rotation arm (1x) to be used on drilling rods to give manual rotational and lifting action.
Hoses	 	2 types of hoses with camlock couplings: - 6 meter suction hose (1x) for the connection from pump to swivel - 2 suctionhoses (ca 2 x 1 meter) for connection from pump to in/outlet
In/outlet		In/outlet (1x) to be used in mudpit. Bottom caps can be unscrewed for cleaning.
Pit box		Pit box (1x) to be placed over bore hole. Can be used to prevent top of bore hole to collapse. The flaps can be used for lifting drill rods safely from bore hole.
Drill bit		7 inch drill bit (1x) which will allow an installation of a 5 inch/125 mm casing

Name	Picture	Description
Swivel		Swivel (1x) which allows a rotational movement of drill rods.
Safety equipment	 	- Hardhats (4x) - Gloves (4x)
Tools (1)	  	- Spade/shovel (1x) - Steelbrush (1x) - Hacksaw (1x) - Jerry can (10 l) - 2 spanners, size 55 - Copper grease (1x) - 1 adjustable spanner - Buckets (2x) - PVC glue (1x) - File (1x) - Depth measuring tool (1x) - Funnel (1x) - Measuring tape (1x)

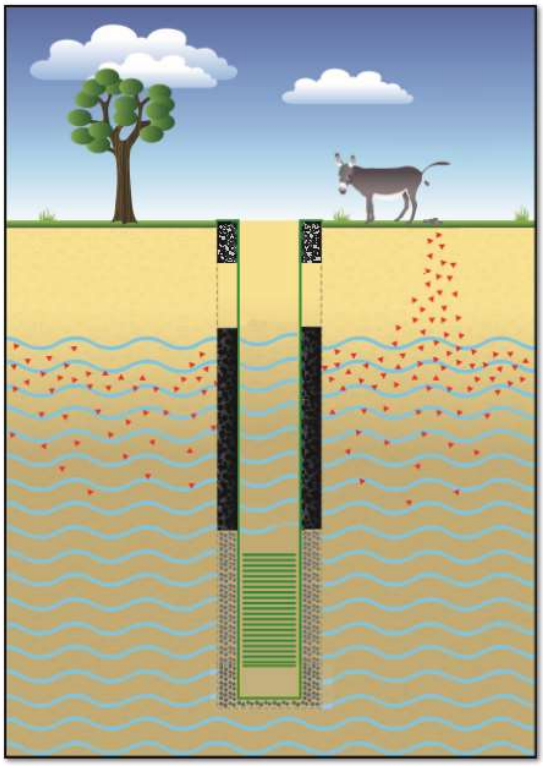
Consumables delivered with kit

Spare parts	  	- Spare pulling latch (1x) - Teflon tape (2x) - Plastic sheet (4x6 meter) - Bolts, nuts and hose clamps
Drilling polymer		- Bag of Barasol (2x 8 kg) to be added to the drilling water in order to increase the viscosity of the water. Generally this is enough for 2 wells.

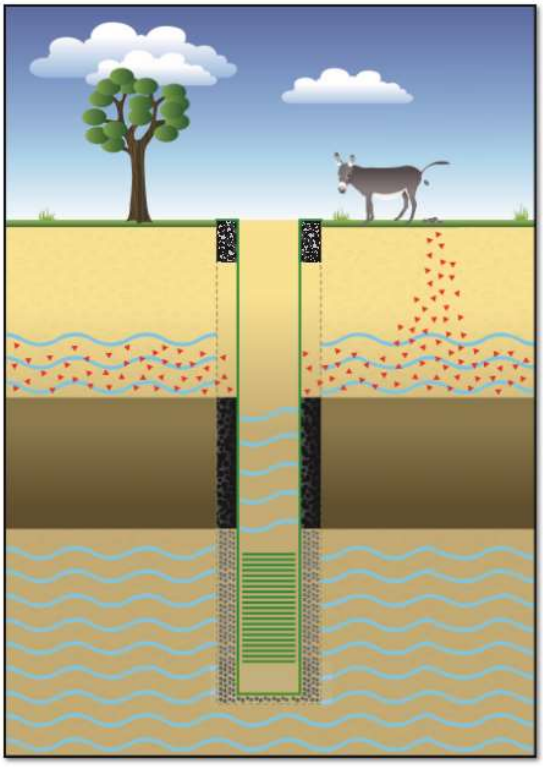
Consumables optionally delivered with kit

Casing, gravel and screen		- 30 meters of casing - Screen - Gravelpack - Extra drilling polymer

Basic borehole design



Borehole design in first aquifer



Borehole design in second aquifer

Top

LEGEND

- Top seal
- Sanitary seal
- Pathogen/pollution
- Filter screen
- Aquifer
- Gravelpack
- Impermeable layer
- Well casing
- Sump

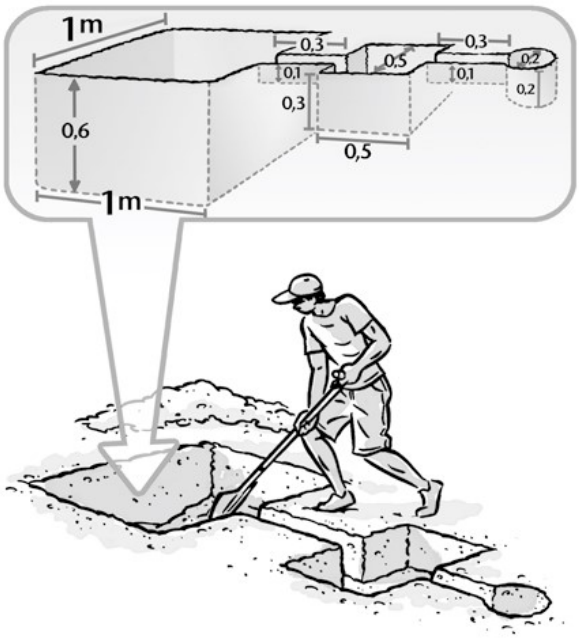
Most important things to remember

1. **Safety first:** Use the safety equipment and keep spectators at a safe distance.
2. **Always keep the borehole full of working water (water mixed with drilling polymer):** If not, the borehole can collapse and the drilling kit can be lost. Secure a safe supply of water during drilling.
3. **Always rotate clockwise:** If you rotate anti-clockwise, there is a chance to unscrew the drill string.
4. **Take drilling samples every 75 cm and log them**: this will tell you where to install the filter and sanitary seal(s). Samples can be taken from the first mud pit. Place the samples on a separate piece of plastic. Record the type of soil and the depth of the sample. Record the depth of the screen and seals after installation as well. An example of a drill log can be found in appendix 3. Empty drill logs are supplied in appendix 4.
5. **Drill deeper:** do not stop drilling when you have reached the water table. Aim to drill at least 4-6 meters into a permeable layer below the dry season static water table. If possible, drill to a second aquifer to place you screen.
6. **Keep the right speed of drilling**: If there is no progression, you have either reached a hard layer or your well is collapsing. In case of collapsing, add polymer. In case of a hard layer, make a pounding movement by lifting and dropping the pipes. Rotate after each pounding movement. Increasing the flow of the pump can help as well. Add polymers when cuttings are not reaching the surface. They might be too heavy, so you need to thicken your working water. If it goes too quickly (1 meter in 5 minutes), reduce the speed of the pump otherwise your equipment can get stuck.
7. **Empty mud pits:** Empty the mud pits with the shovel regularly and add water to the mud pits to keep them full of water.
8. **Take breaks:** if you need a break, lift the drill string a few meters and let it rest on the pit box. Let the pump run slowly during your break.
9. **Install sanitary seals:** this reduces the chance of pollutants to enter the well.
10. **Develop the well:** removing the fines and drilling fluid additives will maximize the yield of the well. It will also develop the gravel pack into a filter pack.
11. **Never leave an open well/casing alone**: close them before leaving as, particular children, like to drop stones in them.
12. **Avoid damage to the gear:** Always keep one valve open on the pump. To redirect the water from the pump to the drill string or mud pit, first open one valve, before closing the other. Apply copper grease on the couplings each time you use them. It is enough to only slightly fasten the drill rods with the spanners. Keep the pump full of water at all times: never let the pump run dry.
13. **Do regular maintenance on the equipment**: Drain the pump, check the oil level and remove sand particles. Lubricate the swivel. Clean the kit, dry the couplings to avoid rust and store it in a dry place.

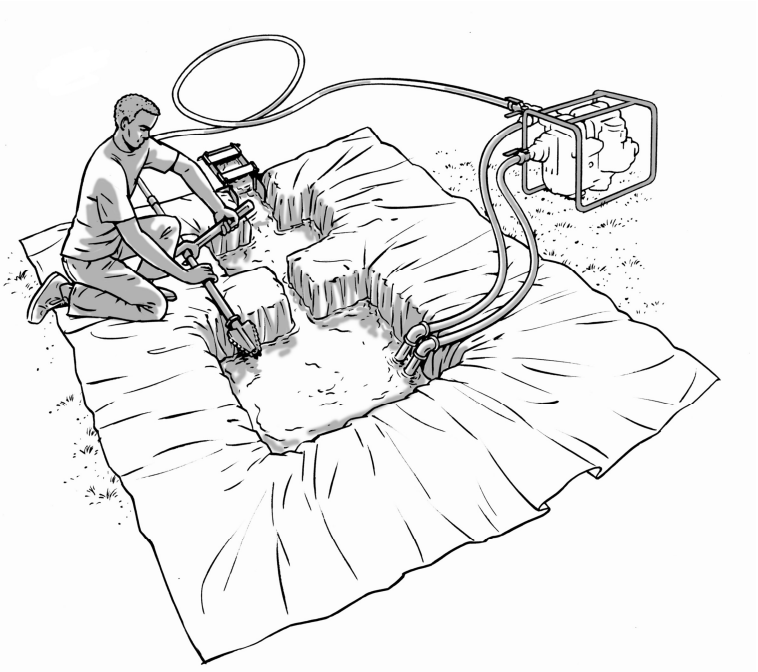
Specific instructions

Step 1 Set-up the site

Dig the mud pits and cover it with the plastic sheet.



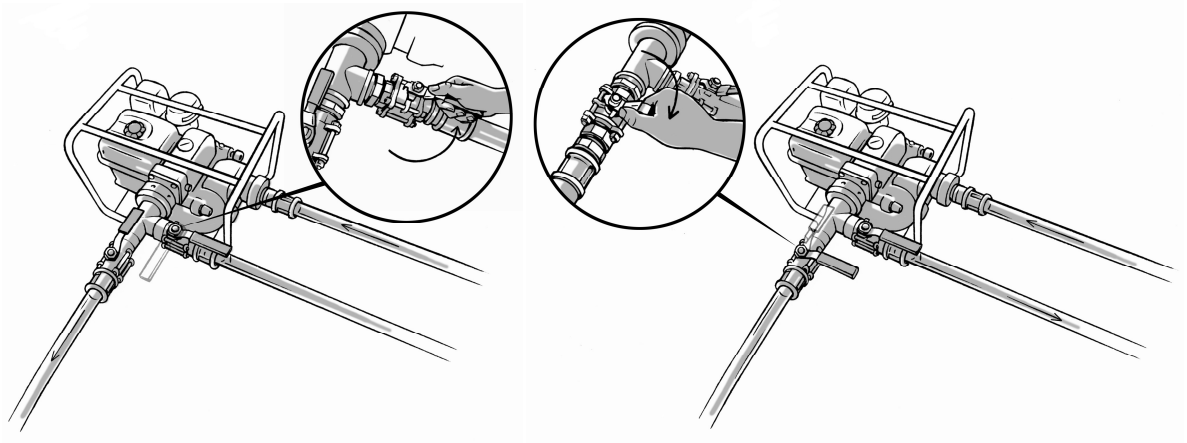
Fill the pits with water. Setup the equipment and connect 3 lengths of drill pipes to the swivel and the drill bit. Make sure the pump is filled with water.



Step 2 Make the drilling fluid

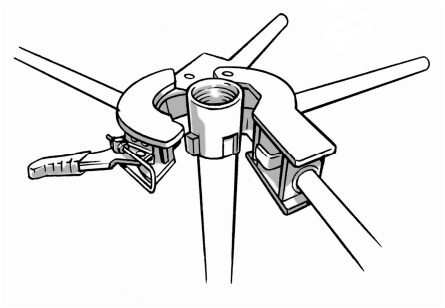
Set the valves on the pump so the water will flow from the mud pit to the drill pipes (**drilling mode**). Start the pump and add drilling polymer to the water until it becomes gluey.

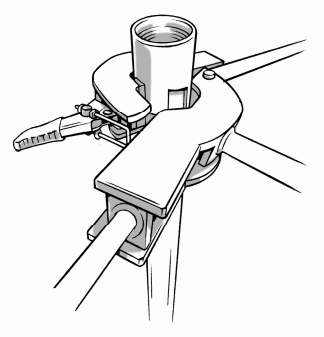
Set the valves on the pump so the water circulates within the mud pits (**circulation mode**). To redirect the water first open one valve, before closing the other to avoid damage to the pump.

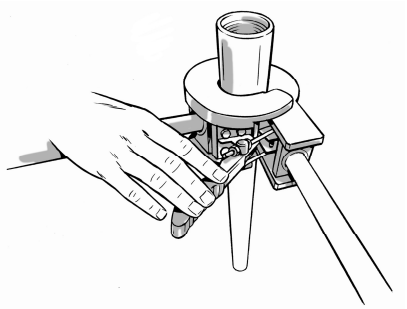


Step 3 Start drilling

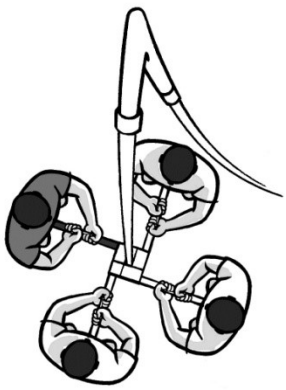
Put the drilling pipes straight up in the pit box and attach the rotation arm.

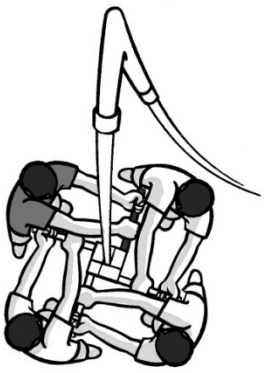


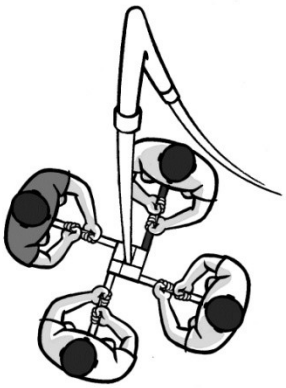




Put the pump valves in drilling mode and start drilling!
Rotate the drill rod clockwise by handing the rotary arm to the next person whilst keeping your own position. Move the rotation arm to a more comfortable position if needed.

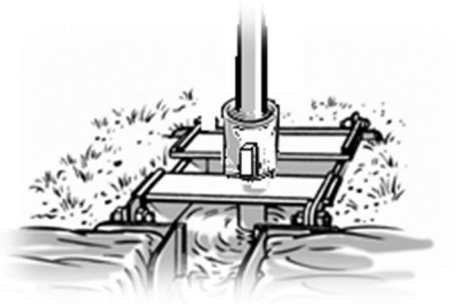




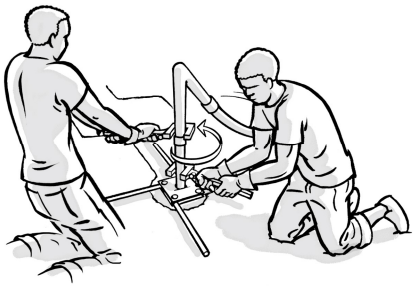


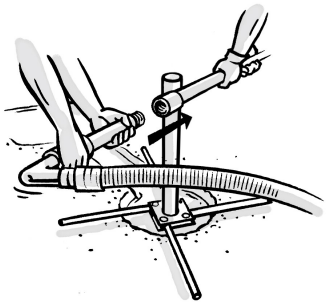
Step 4 Add more pipes

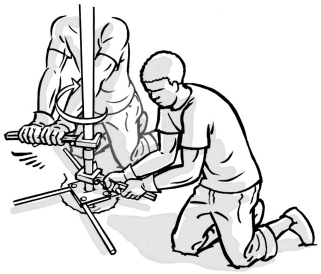
When you have drilled 3 lengths of pipe, close the flaps on the pit box and lift the drill string for 1 meter. Let the drill pipes rest on the pit box. For safety reasons always make sure the small welded bar on the coupling is facing the outlet of the pitbox.



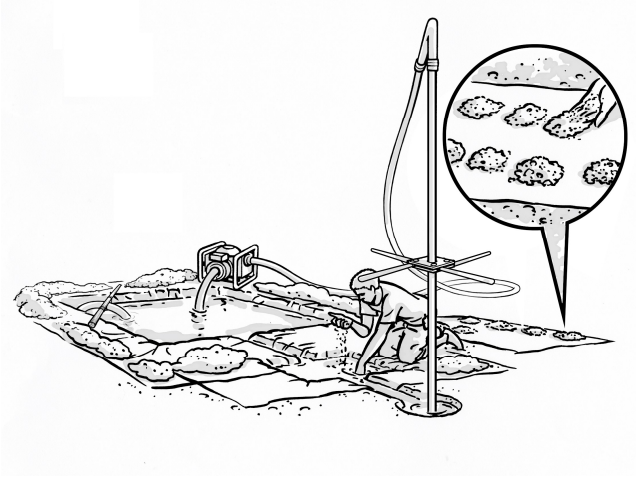
Slow down the engine pump. Put the pump valves in circulation mode. Remove the swivel and attach 2 new pipes to the swivel. Connect it back to the pipes in the borehole. Put the pump back into drilling mode and continue drilling.







Take and log a sample of the drilled soil, every meter or every time before a new pipe is added. Take the soil sample from the upper part of the smaller mud pit.



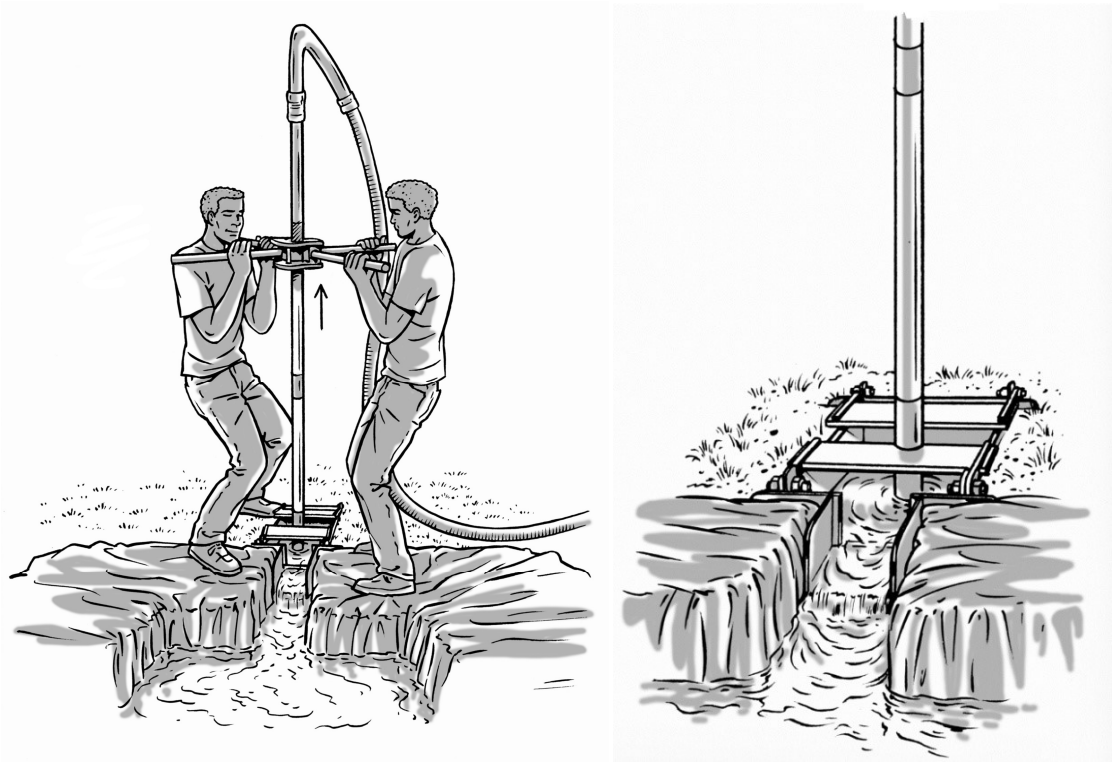
Empty the mud pits from the cuttings regularly. Be careful not to damage the plastic sheet.

Continue this process until you have reached the final depth.

Step 5 Reaching the final depth

If you have reached sufficient depth in the aquifer (=as deep as possible), lift the drill rods about 1 meter and let it rest on the pit box. Let the water circulate continuously for at least 5 minutes until the water is relatively clean (=no cuttings in the water). Shut down the pump.

Remove the swivel and the drill rods one by one. Let the drill string rest on the pit box during this process.

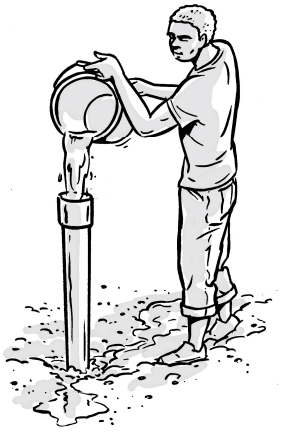


Tip: Keep your borehole full of water during this process! **Don't take a break now**; the chance the well collapses now is at its highest.

Step 6 Installation of casing, screen and sump

Start with a piece of casing of 1-2 meters and close the bottom. Then glue or screw the screens on it and continue with the plain casings, while lowering it into the borehole.

Tip: preferably install 3-6 meters of screen at the best permeable layer below the water table.



Drain the dirty water away from the mud pits. Pour clean water into the casing and allow dirty water to overflow the borehole until clean water comes out of the borehole.

Step 7 Fill the annular space

1) Gently pour in gravel pack around the PVC pipe while shaking the PVC pipe from side to side in the borehole. Keep adding gravel pack until you have reached 1-2 meters above the top of your filter screen.

Tip: Use the measuring tool of the kit to determine the various depths during backfilling. A drilling log can be of great help in the borehole design.

2) Place a sanitary seal of 3-5 meters on top of the gravel pack.

Tip: Use 26 liters of water to one 50 kg bag of cement for the sanitary seal. Make small balls (3-4 cm diameter) of the wet cement when backfilling. This prevents blockages. Backfill half a meter of clay on top of the gravel pack to prevent the cement grout from penetrating the gravel pack.

3) Backfill the well with the cutting, but leave 2 meters for a top seal.
4) Place the top seal with cement.

Step 8 Develop the well

This should be done after 24 hours of the well completion. Place a submersible pump just above the (highest) screen. If the water level is not deeper than 7 meters, the supplied motor pump with the hoses attached can be used. Start the pump at a discharge of 2.5 m^3/hr and let it run for 1 hour. Increase the discharge to 5 m^3/hr. Let it run for one hour again. Reduce the speed of the pump to a flow to that of the expected flow during use (e.g. 3 m^3/hr). Continue this until the water is clear and free from particles.

Appendix 1: Repairs and replacements of drilling kit with local materials

This rotary jetting kit is a professionalized version of jetting kits used throughout Africa. All parts in the professionalized version are selected based on robustness, transportability, ease of use and safety. Yet, the kit is made such that repairs and replacements can be done with local materials. This appendix shows how parts can be repaired and/or be replaced locally. All technical drawings mentioned can also be found on www.practica.org.

Flying in new parts is an option as well. Please contact the PRACTICA office (info@practica.org) to enquire.

Drill rods: The aluminum drill rods are connected to the couplings by means of a BSP thread (=standard thread used on GI pipes). These aluminum rods can be replaced by 1 ½ inch threaded GI pipes if needed. Use thick walled GI pipes (wall thickness > 3 mm). If the couplings wear out over time, the complete drill string can be replaced according to drawings 003 and 004 of the jetting manual as supplied on CD/USB. Once the couplings are replaced, the rotary arm will need to be replaced as well. Technical drawings of the rotary arm can be found on drawings 001 and 002 of the jetting manual as supplied on CD/USB.

Swivel: To replace the swivel, fabricate the swivel as specified on drawing 007 on page 60-61 of the jetting manual as supplied on CD/USB. Drawings of an improved version of a swivel can be requested by contacting Practica. The locally made swivel is connected with a 1 ½ inch BSP thread that fits into the drill couplings and stainless steel elbows/socks.

Drill bit: To replace the drill bit, fabricate the bit as specified on drawing 005 on page 58-59 of the jetting manual as supplied on CD/USB. A more common (and preferred) design of a 'cross-bit' is shown on the picture. It uses leaf springs from cars or excavators to create the wings of the drill bit. Weld the wings of the drill bit directly on a socket. Welding them on a thick walled (preferred wall thickness> 4 mm) threaded 1 ½ inch GI pipe is an option as well. Use welding rods for stainless steel to make the drill bit more durable. The drill bit diameter should be 2 inch larger than the intended casing to be installed.

Pump: The mechanical seal is most likely to break first on the pump. If possible, try to replace it. If this is not an option, standard similar size pumps are often available on local markets. As these pumps are clean water pumps of less quality (depending on what's available), expect more frequent replacement of the mechanical seal. Yet, good results are booked with locally obtained pumps in the field.

Appendix 2: Replacement of consumables by local materials

For high quality wells, high quality consumables are recommended. Nevertheless, there are locally available alternatives. Be aware that these alternatives are often not accepted by NGO's or local water agencies.

Particular the alternatives for high quality drilling polymer are known to limit the potential yield of the well as they can partially block the aquifer. Extensive/additional attention will need to be given to the development of the well.

In addition, some alternatives introduce pathogens to the (working) water. Shock chlorination of the well after development and chlorination of the water used for consumption that is withdrawn from the well is highly recommended. Although no scientific papers are available on the subject, it is suggested that the pathogens significantly decrease over time and eventually disappear while using the well.

Alternatives for drilling polymer: There are many local alternatives that can be used as drilling polymer. Drilling polymer is used to increase the viscosity of the working water to bring up the cuttings and temporarily seal the walls of the well to prevent the collapse of the well during drilling. For this bentonite (clay), termite clay, clay mixed with saw dust or grain husk, starch or *fresh* cow dung can be mixed with water. Particular fresh cow dung is favored in the field (yet depending on local acceptance) as it is easily removed during the development of the well compared to the clay based alternatives. When using cow dung, premix the dung in buckets and remove big particles before adding it to the working water. Generally 4 big buckets are needed when one starts drilling. Ad more during drilling.

Alternatives for high quality casing and screen: PVC pipes can be used as an alternative for high quality casings. Use PVC with a wall thickness of at least 3 mm to prevent the pipes from breaking. A screen can be made by cutting slots in the PVC using a hacksaw. Consult page 15 of the jetting manual on the supplied CD/USB for a more detailed explanation.

Appendix 3: Drilling log example

Drilling log

District	South Holland, Netherlands	Starting & end date (d/m/y)	11/06/2015 - 12/06/2015
Village	Dordrecht	Drill method	Sludging
GPS	N 51 49.775, E 4 43.363	Diam casing (mm)	120
Company	Practica	Well development (method & hrs)	5 hrs compressor
Name supervisor	Berry van de Pol	Static WT (m)	5
Tel. Supervisor	3128053297	Yield (litres/min)	120

Layer	Geo-hydrological information				Well design	
Depth (m)	Soil type & color	Hard/soft Fine/coarse	Drilling time	Permeability	PVC pipe	Backfill
	Sand, yellow	Fine	2hrs			
	Sand, yellow	Fine				
	Sand, yellow	Fine				
	Sand, yellow	Fine				
	Sand, yellow	Fine				
	Sand, yellow	Fine				
	Sand, yellow	Fine				
	Sand, yellow	Fine				
	Sand, brown	Fine				
	Sand, brown	Fine				
10,5	Sand, brown	Fine				
	Sand mixed with clay, grey	Coarse sand fine clay	1 hr			
12,3	Sand mixed with clay, grey	Coarse sand fine clay				
	Clay, grey	Fine & soft	3 hrs			
	Clay, grey	Fine & soft				
	Clay, grey	Fine & soft				
	Clay, grey	Fine & soft				
	Clay, grey	Fine & soft				
18,5	Clay, grey	Fine & soft				
	Sand, yellow	Coarse	1 hr			
	Sand, yellow	Coarse				
	Sand, yellow	Coarse				
	Sand, yellow	Coarse				
	Sand, yellow	Coarse				
	Sand, yellow	Coarse				
25	Sand, yellow	Coarse				
	Bedrock	Hard	4hrs			

Obervations

Legend

Permeable
Semi permeable
Impermeable
Plain pipe
Screen
Pump
Static WT
Gravelpack
Sanitary seal
Cuttings

Appendix 4: Drilling logs empty

Drilling log

District	.....	Starting & end date (d/m/y)	.....
Village	.....	Drill method	.....
GPS	.....	Diam casing (mm)	.....
Company	.....	Well development (method & hrs)	.....
Name supervisor	.....	Static WT (m)	.....
Tel. Supervisor	.....	Yield (litres/min)	.....

Layer	Geo-hydrological information				Well design	
Depth (m)	Soil type & color	Hard/soft Fine/coarse	Drilling time	Permeability	PVC pipe	Backfill
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
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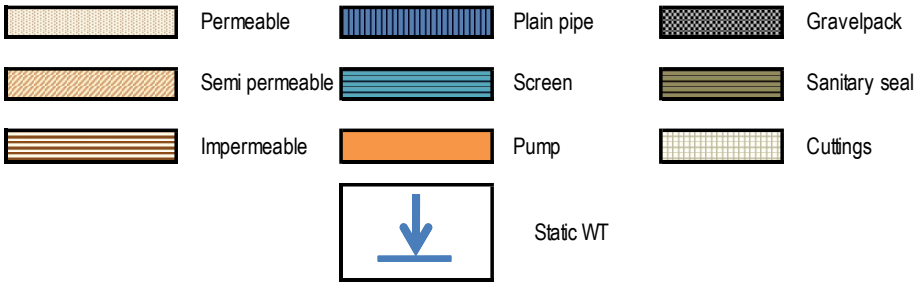
Obervations

Legend



Drilling log

District		Starting & end date (d/m/y)	
Village		Drill method	
GPS		Diam casing (mm)	
Company		Well development (method & hrs)	
Name supervisor		Static WT (m)	
Tel. Supervisor		Yield (litres/min)	

Layer	Geo-hydrological information				Well design	
Depth (m)	Soil type & color	Hard/soft Fine/coarse	Drilling time	Permeability	PVC pipe	Backfill
0						
1						
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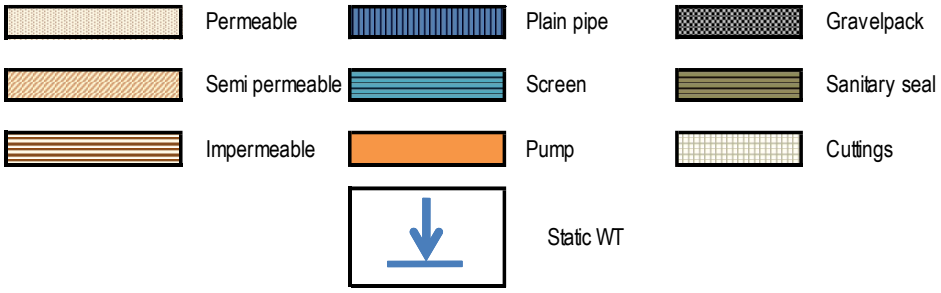
Obervations

Legend



Drilling log

District		Starting & end date (d/m/y)	
Village		Drill method	
GPS		Diam casing (mm)	
Company		Well development (method & hrs)	
Name supervisor		Static WT (m)	
Tel. Supervisor		Yield (litres/min)	

Layer	Geo-hydrological information				Well design	
Depth (m)	Soil type & color	Hard/soft Fine/coarse	Drilling time	Permeability	PVC pipe	Backfill
0						
1						
2						
3						
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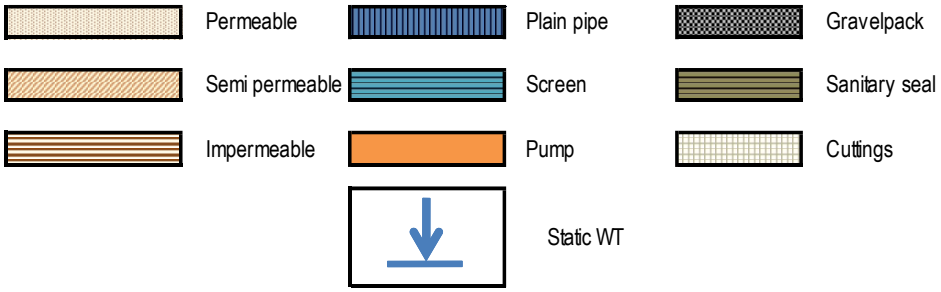
Obervations

Legend



Drilling log

District		Starting & end date (d/m/y)	
Village		Drill method	
GPS		Diam casing (mm)	
Company		Well development (method & hrs)	
Name supervisor		Static WT (m)	
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Depth (m)	Soil type & color	Hard/soft Fine/coarse	Drilling time	Permeability	PVC pipe	Backfill
0						
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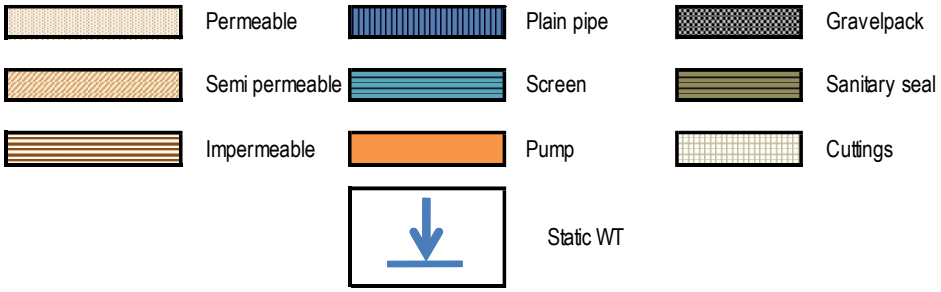
Obervations

Legend



Drilling log

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Obervations

Legend