



PERCUSSION

Manual drilling series



TECHNICAL TRAINING
HANDBOOK ON
AFFORDABLE MANUAL
WELL DRILLING



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TECHNICAL TRAINING HANDBOOK ON AFFORDABLE MANUAL WELL DRILLING

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PRACTICA Foundation develops and disseminates low-cost appropriate technology in water and renewable energy in developing countries. We focus on technology that responds to local cultural contexts, can be locally produced and maintained, and supports existing markets.



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This instruction manual is available in English and in French and has been developed for use in **technical training courses** organised for the intended users. In case you want to organize such training, you may contact the PRACTICA Foundation for further information and support.

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The United Nations International Children's Fund (UNICEF), PRACTICA Foundation and Enterprise Works/Vita have developed a toolkit for African countries wishing to embark on the professionalization of manual drilling. This toolkit includes Technical Notes, Technical Manuals including this publication, Advocacy Materials, Mapping of suitable areas for manual drilling, Case Studies, and Implementation and Training Manuals. This initiative builds the capacity of the local private sector in order to respond to the ever increasing demand for safe water in rural areas.

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Foreword

The high cost of developing potable water sources prevents many rural people from gaining access to clean, safe water supplies. Increasing access to improved water supply for under-served people and communities while keeping up with growing populations will require serious consideration of lower cost alternatives to the existing expensive water supply options. The manual drilling sector has proven itself as a successful, lower-cost approach with great potential under suitable conditions. In numerous countries manual drilling techniques are used as an alternative or to complement machine drilling. Drilling 'shallow' water wells by hand using local enterprises, can reduce the cost of a well by a factor 4 - 10 compared to a machine-drilled borehole. This cost reduction not only enables NGOs and Governments to construct more water points, but also 'opens the door' to villagers, farmers, schools and small communities to finance well construction independently through the private sector. Strategies and programs should be adopted to professionalize the manual drilling sector in order to scale-up rural water supply for drinking and irrigation purposes.

Variations of four manual drilling technologies are being used, each with their own advantages, disadvantages and suitability for different geological conditions. This handbook describes the practical aspects of the drilling technique Percussion and is part of a series of 5 handbooks providing the basis for local entrepreneurs to start practicing affordable well drilling.

We suggest that this drilling handbook is used in combination with the manual: **'Understanding Groundwater & Wells in manual drilling'**.

READERSHIP

This handbook can be used as a guide during training sessions for well drillers, local trainers and quality controllers. It also serves as a reference for drilling supervisors, NGOs, development agencies, manual drilling teams and enterprises during the entire drilling process. The handbook consists of three sections that can be read together, or used and printed separately for the various target groups.

NOTE

Technical terms and the way in which subjects are explained are based on the average expected educational level of the intended users. Sometimes, the use of complicated geological and technical terms has been avoided to create better understanding. Please keep in mind that the objective of the handbook is to create better understanding of well drilling in practice, aimed at technical workers of manual drilling teams who may have a limited educational background.

Colophon

AVAILABLE MANUALS IN THIS SERIES:

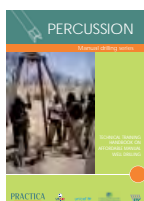
Technical training handbooks on affordable manual well drilling.

These practical handbooks create awareness of manual drilling for affordable water supply and a roadmap for implementation of manual drilling programs. The manuals provide an extensive and detailed guide for trainers and drilling teams in the use of various drilling techniques for making affordable boreholes. The techniques are explained in simple and understandable language, using clear illustrations and drawings.



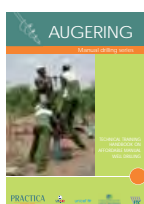
1. Manual drilling series: JETTING

This handbook describes in detail the various jetting techniques that can be used to drill wells in loose and soft soil formations. With this technique, wells are drilled in a number of hours rather than days.



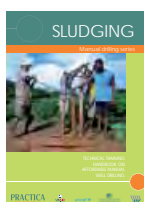
2. Manual drilling series: PERCUSSION

This handbook describes in detail the percussion technique. Although the technique is slower than other drilling techniques, it is the only manual drilling technique that is able to drill through consolidated rock layers.



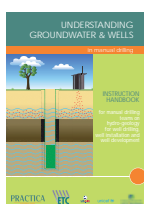
3. Manual drilling series: HAND AUGER

This handbook describes the hand auger technique. This cheap and effective technique is very suitable for sinking shallow wells in soft soils and is excellent for soil surveys. Many drilling teams have this technique in their toolkit to complement other drilling techniques.



4. Manual drilling series: SLUDGING

This handbook describes the sludging technique, and in greater detail the ROTA-sludge technique. It is a combination of sludging and percussion and is particularly useful due to its versatile application for a range of soil formations.



5. Manual: 'Understanding Groundwater and Wells in manual drilling'

The manual 'Understanding Groundwater & Wells in manual drilling' complements the 4 technical training handbooks and highlights those essential subjects which are relevant to manual drilling, geo-hydrology, hygiene, well installation and well development in practice, in simple and understandable language.

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This module creates awareness on manual drilling and provides a road-map for implementation. It is meant for NGO's, governments and implementing organisations and those interested in using manual drilling for affordable water supply.

Module 2

USING THE PERCUSSION TECHNIQUE

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Module 2 describes the drilling technique in detail and includes: how the technique works and where it can be used. This module is a step-by-step explanation that makes use of cartoons to illustrate the drilling process. This module is designed to be used by technical trainers and as a reference for manual drilling teams.

Module 3

MAKING THE DRILLING EQUIPMENT

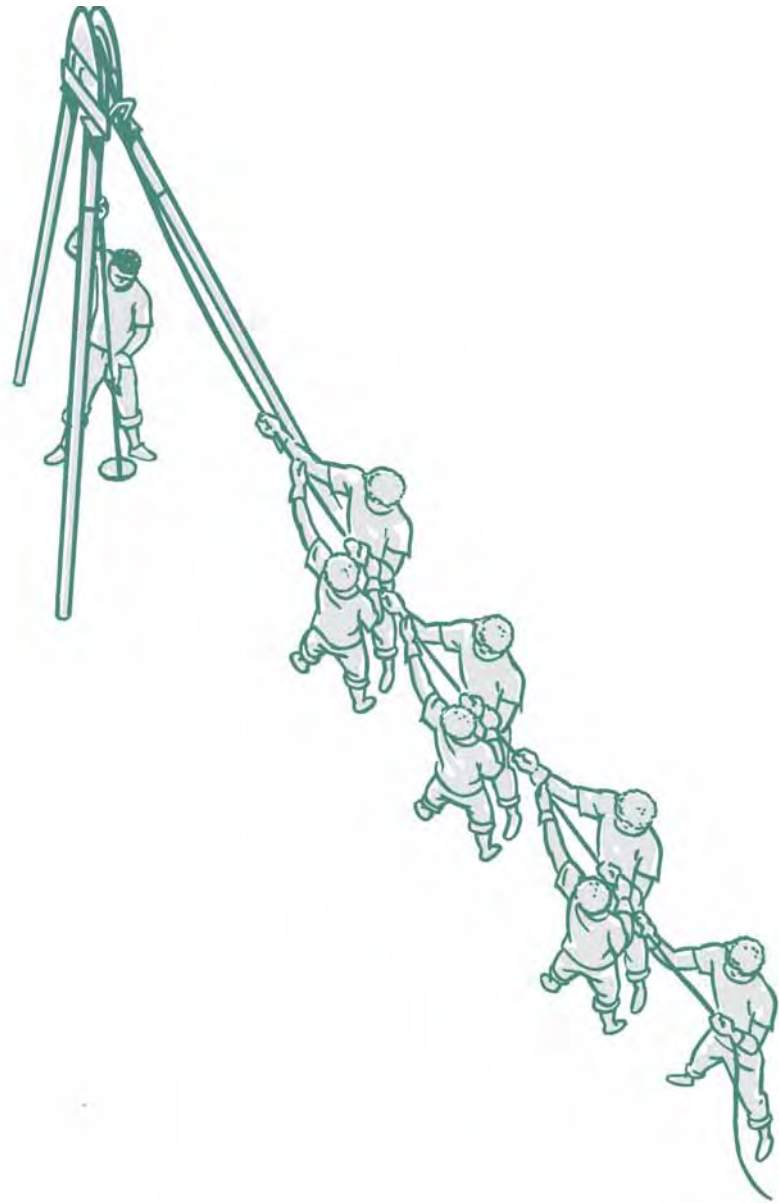
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Module 3 is meant for local workshops that want to fabricate drilling equipment. It consists of a package of technical drawings, tips for construction and a list of materials that are necessary to make a complete set of drilling equipment.



PERCUSSION

Module 1



THE CONTEXT OF MANUAL DRILLING



1. WHAT IS MANUAL DRILLING

Affordable water

Manually drilled wells for water supply are more affordable than machine drilled wells and more productive than hand dug wells, thereby providing access to improved sustainable water points at a lower cost. This module describes the context in which manual drilling is used in various countries and elaborates on the techniques and its implementation. It gives insights and creates awareness and is meant for NGO's, governments, implementing organisations and those interested in using manual drilling for affordable water supply. This module might also be interesting for the manual drilling teams themselves, especially once they have gained more field experience in well drilling.

Manual drilling is a practical and affordable solution for wells less than 40 meters deep in alluvial soils (loose material, such as clay and sand) and soft weathered rock formations (such as soft sand stone and lime stone). There are many areas around the world where it can effectively provide water for drinking and for irrigation to un-served rural populations at a fraction of the cost of conventional drilling. This is especially true in small isolated communities that will never benefit from the large donor funded drilling programs because they are often not included in national plans.

WHY MANUAL DRILLING?

- Cost savings: 4-10 times cheaper than a machine drilled well of the same depth.
- Better access to drilling sites with lightweight equipment, remote communities can now be reached.
- Locally manufactured drilling equipment, under € 2,000 initial investment for start-ups.
- Ready-to-go in emergency situations and in politically unstable countries.
- It creates jobs and knowledge remains in the country, even after donor projects are finished.
- Overcomes problems in water quality and quantity in comparison with hand-dug wells.
- Can be used for both drinking water and irrigation.

Machine drilled wells are high in quality, but also very expensive. Hand dug wells are lower in cost and very useful in formations with a low permeability due to their capacity to store water which seeps in through well walls overnight. However, the total yield/day may be low, and water quality may be poor because the water comes from an open source allowing pollutants to enter easily. Hand dug wells also often collapse if not properly lined. A hand dug well lined with concrete rings, preventing it from collapsing, has a high yield, but the price will come close to that of a machine drilled well.

The cost of wells vary among countries and will generally be in the range of € 5000 – 15000 for a 30-meter deep machine drilled well and € 2500 - € 8000 for a lined hand dug well. In many countries manual drilling techniques are used as an alternative.

Costs of 30 meter deep manually drilled wells vary from about € 100 - 2500, depending on geology, country and application (i.e. small scale irrigation to high quality community wells for potable water). The equipment for manual drilling can be locally manufactured, transported and maintained.

2. CHOICES: THE 4 MANUAL DRILLING TECHNIQUES

When a borehole is drilled, different types of geological formations (soil layers) can be encountered. To drill through these diverse formations a range of different manual drilling techniques have been developed and are used around the world. In each case the drilling technique must (a) break or cut the formation, (b) remove the cut material (the soil) from the hole, and (c) if necessary provide support to the walls of the hole, to prevent collapse during drilling.

Each drilling technique has been developed for either one or a range of specific formations (soil layers); therefore it may be possible that combinations of different drilling techniques are used to drill a single borehole. All existing drilling techniques can be divided into four main drilling principles: Hand Auger, Manual Percussion, Sludging and Jetting. Within these four main drilling principles, a wide range of variations have been developed in various countries.

THE HAND AUGER consists of extendable steel rods, rotated by a handle. A number of different steel augers (drill bits) can be attached at the end of the drill rods. The augers are rotated into the ground until they are filled, then lifted out of the borehole to be emptied. Specialized augers can be used for different formations (soil types).

Above the water table, the borehole generally stays open without the need for support. Below the water table a temporary casing may be used to prevent borehole collapsing. Drilling continues inside the temporary casing using a bailer until the desired depth is reached. The permanent well casing is then installed and the temporary casing must be removed. Augers can be used up to a depth of about 15-25 meters, depending on the geology.

Geological application; suitable for unconsolidated formations: Sand, silt & soft clay.



MANUAL PERCUSSION uses a heavy cutting or hammering bit attached to a rope or cable and is lowered in the open bore hole or inside a temporary casing. Usually a tripod is used to support the tools. By moving the rope or cable up and down, the cutting or hammering bit loosens the soil or consolidated rock in the borehole, which is then extracted by using a bailer. Just as with hand augering, a temporary casing of steel or plastic may be used to prevent the hole from collapsing. When the permanent well screen and casing are installed, this temporary casing has to be removed. Manual percussion drilling is generally used up to depths of 25 meters.

Geological application; suitable for unconsolidated and consolidated formations: Sand, silt, stiff clays, sandstone, laterite, gravel layers and small stones

SLUDGING uses water circulation to bring the cuttings up to the surface. The drill pipes are moved up and down. On the down stroke, the impact of the drill bit loosens the soil and on the up stroke, the top of the pipe is closed by hand (or valve), drawing up the water through the pipe and transporting the cuttings to the surface. On the next down stroke, the hand (valve) opens the top of the pipe and the water squirts into a pit, in front of the well. In this pit, the cuttings separate from the water and settle out, while the water overflows from the pit back into the well. The borehole stays open by water pressure. Thickeners (additives) can be added to the water in order to prevent hole collapse and reduce loss of working water (drill fluid). Sludging (with or without rotation) can be used up to depths of about 35 meters.

Geological application; suitable for unconsolidated formations: Sand, silt and clay. If rotated (including a drill bit) it may be possible to penetrate softer-consolidated formations such as stiff clays, soft sandstone, and weathered laterite.



JETTING is based on water circulation and water pressure. As opposed to sludging, water is pumped down the drilling pipes. The large volume of water has an erosive effect at the bottom and the 'slurry' (water and cuttings) are transported up between the drill pipe and the borehole wall. A motor pump is used to achieve an adequate water flow. The drill pipe may simply have an open end, or a drill bit can be added and partial or full rotation of the drill pipe can be used.

Thickeners (additives) can be added to the water in order to prevent hole collapse and reduce loss of working water (drill fluid). Jetting (with rotation) is generally used up to depths of 35-45 meters.

Geological application; suitable for drilling in alluvial material such as weakly cohesive sands, silts and thin layers of soft clay .

CHOICES FOR MANUAL DRILLING TECHNIQUES

Drilling Technique*	Equipment cost (€)	Average drilling speed for 15m in different geological formations (days)**				
		Weak cohesive sand, silt gravel	Soft clay <u>Stiff clay</u> formations	Soft consolidated formations	Soft weathered rock	Un-weathered Crystalline basement rock, e.g. granite
Hand auger	200 - 600	1	1-2 <u>2-4</u>	Not suitable	Not suitable	Not suitable
Percussion	300 -1200	2-3	2-3 <u>3-4</u>	> 3	> 8	Not suitable
Rotary Jetting	800 - 1400	1	1-2 <u>Less effective</u>	Not suitable	Not suitable	Not suitable
Rota Sludging	600 - 1000	1-2	1-2 <u>2-3</u>	> 3	Less effective	Not suitable

Drilling Technique*	Advantages	Disadvantages	Average drilling depth (m)
Hand auger	Easy to use above groundwater table. Cheap equipment	Use of the temporary casing if clay layers are penetrated is very limited If a collapsing sand layer is encountered below a clay layer (through which the temporary casing could not penetrate), the borehole does not stay open	15 - 25
Percussion	Drills hard formations	Slow and high equipment costs	25
Rotary Jetting	Quick	Lots of working water is needed at once	35 - 45
Rota Sludging	Easy to use Applicable in most soft formations	Highly permeable layers (coarse gravel) causes loss of working water and cannot be drilled	35

* Note: Drilling teams are keen on using a variety of drilling techniques to penetrate different geological formations.

**Note: Many different soil layers may be encountered during the construction of one borehole. The information given in the table is an indication of the drilling speed in one particular type of soil.

3. WHAT ORGANIZATIONS MUST KNOW

HOW TO IMPLEMENT MANUAL DRILLING

Using manual drilling as implementing tool for affordable water supply is possible for a wide range of qualities and scales. Before one can start the implementation of a manual drilling program there is a whole list of things to be considered. For example:

- What is the required quality of the wells?
- Who will pay for the construction of the water point?
- Who will be the end user of the well (households, community, farmers, refugees in camps, etc)?
- Are we drilling for potable water, irrigation water or multiple use?
- What is the number of wells that need to be drilled per year?
- Is there already an existing manual drilling sector present and what is their capacity?
- What is the need and scale for quality monitoring?
- What is the size of the project area?
- What is the hydro-geologic potential for manual drilling in the project area (type of soil and the depth of groundwater)?
- What is a sustainable number of drilling teams needed (based on the demand)?
- What is the relation between user density and hydro-geology in the project areas (how many people can we reach with manual drilling)?
- What are the objectives of the implementing organization?
- Etc.

The answers to all these questions (and the objectives for scale and costs) provide the basis for making the right choice of the approach for training and implementation. A few examples:

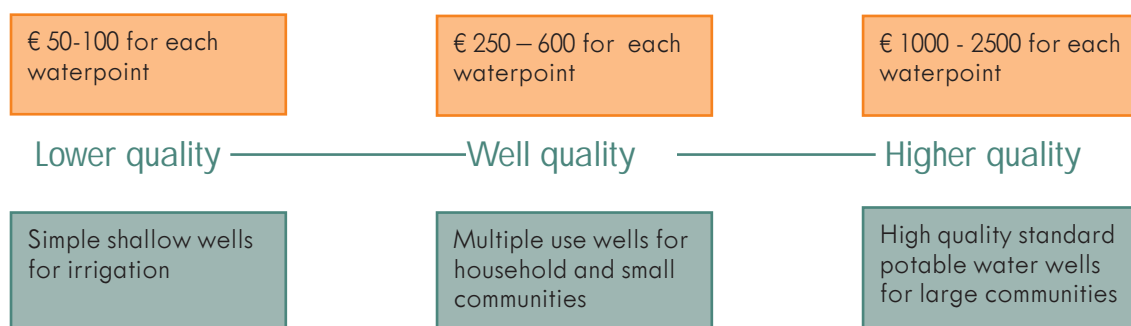
- a) For the introduction of shallow irrigation wells the following criteria are very important: The well has to be affordable for the farmer (i.e. low cost materials and shallow), while the water quality is of less importance. A training program in this case will focus on drilling affordable wells, using low cost materials in areas where shallow groundwater exists and where farmers have access to markets to sell their vegetables. Manual drilling enterprises will work directly with farmers.
- b) For a professional and sustainable water supply to large communities, the government and larger donors are often involved. The most important criteria here are: a very high quality of the well, high quality of drinking water (meeting all standards), sustainability of the well and sustainability of the whole drilling sector. A training program in this case will require a much larger capacity building road map with its focus on professionalization of the drilling sector as a whole, involving technical training, quality control, business skill training, social mobilization and social marketing. Making manual drilling enterprises ready to respond to large tenders and drilling high quality wells, generally through governments or donors.
- c) Multiple use of wells by households and small communities often requires a mix of both previous options: the well should still be affordable (or partly subsidized), but also have an acceptable water quality.

Always realize that the purpose of the well, the water quality, affordability and sustainability go hand-in-hand and that all are important for a right choice of the further approach in training and implementation.

GOING TO SCALE

Once a feasibility study has revealed that there is a high potential for manual drilling in a given area or country

Figure 1. Range of implementation possibilities



and the first team(s) have been drilling successfully, there is potential to scale up the capacity of the sector.

Scaling up is often explained as: training more teams. That is partly what it is, but be careful: training more teams alone is not enough to ensure the quality, affordability and sustainability of wells! When going to scale, not only the drilling enterprises are involved. Other actors play an important role in this process. To visualise this, let's go back to the three examples of the previous page:

a) shallow wells for irrigation, b) high quality communal wells and c) multiple use wells for households.

In all these three examples not only the purpose, quality and price of the wells are different, but also the actors involved. Example b for instance, has its focus on professionalization of the drilling sector as a whole. This involves of course the drilling enterprises, but also quality controllers, the government (responsible for a national quality control system and certification), social actors (to guide communities) and pump suppliers. While in example a, the drilling enterprises, farmer associations and pump suppliers play the biggest role.

Whenever starting a program to go to scale it is important to realize that such a program is not 'a borehole drilling program' only. Going to scale requires a capacity building process with its focus on training, repetition, quality and sustainability of the manual drilling sector. This may take as much as 3-5 years to develop. For an example of a more detailed roadmap on the implementation of larger manual drilling programs please read the manual; **'Professionalizing the Manual Drilling Sector in Africa'** A capacity building program to increase access to safe water in rural areas.

THE FIRST STEPS IN ANY MANUAL DRILLING PROGRAM

Feasibility study

A feasibility study will assess the potential for manual drilling and whether it is a practical solution for water supply under the given conditions. Collecting information on hydrology (depth, quality and quantity of groundwater), geology (soil type) and population density will provide a clear indication of areas with the highest potential. It is also of great importance to assess the existing drilling sector. Do manual drilling enterprises already exist? And if

so, what is quality of their current work? And what training is required? What are the roles of the other actors involved in the sector such as NGO's, workshops, well diggers, Governments, pump suppliers, etc? This information will be used to determine the right approach for training and implementation, building on- and reinforcing the existing local capacity.

Technical hands-on training on manual drilling

If there is not an existing manual drilling sector present or if there is a need for further improvement of technical skills, a technical hands-on training on a specific manual drilling method(s) is required.

The technical trainer will advise on the purchase of tools and well construction materials and assure that the drilling equipment is fabricated properly. During several weeks a hands-on technical drilling training is given to a team(s) of selected manual drilling trainees. During and after this first training several wells are drilled, allowing the teams to practice and improve their technical skills.

Follow-up and geo-hydrological training

Once teams have gained sufficient experience in the use of the equipment while drilling boreholes, they are ready for the next step: a technical follow-up training combined with a training on geo-hydrology, hygiene, well installation and well development.

Although most existing manual drilling enterprises are very capable of drilling a borehole, a lot of improvements can be made during the construction and development of the wells, resulting in a better water quality, quantity and hygienic use of the well. Most manual drilling teams experience problems with site selection, loss of working water, soil texture determination, logging, well casing installation, well development, water quality and well yield (flow rate of the well). These problems may occur when the drilling process is not completely understood and important steps are missed. The classroom training on geo-hydrology 'Understanding Groundwater & Wells in manual drilling', addresses the above issues. During this training, the drilling team will get a technical follow up training in the field to bring the theory and lessons learnt into practice.

Depending on the size and objectives of a program, additional training can be given on business skills and quality control for manual drilling teams.

4. GETTING STARTED

The construction of a well, using manual drilling techniques is a complicated process. Before drilling starts a good drilling site has to be selected, where experience suggests that there will be an adequate quantity of good quality groundwater. During the drilling process there are a lot of different aspects which require attention to prevent things from going wrong. Besides the practical drilling skills which are executed at ground level, attention also has to be paid to important processes which are happening below ground level during drilling. Water used in drilling (working water) could flow away or worse; the borehole could collapse, burying part of the drilling equipment. And finally, once the hole has been drilled, the well casing, screen and sanitary seals have to be installed at the right depth, preventing contaminated water from entering, and ensuring a sufficient yield. With this in mind, it becomes clear that the introduction of manual drilling needs adequate supervision, with proper training and guidance of the drilling teams.

PREPARATIONS AND THE FIRST TRAINING

Making the drilling equipment

The decision to use quality tools is one of the key factors for success that manual drilling teams can make. Although this looks obvious, the quality of the tools is often overlooked, resulting in loss of equipment and breakdowns in the field. How to avoid this?

All tools and equipment are purchased and made locally. It is important that a good workshop is selected to manufacture the drilling equipment. The workshop should have the right equipment and be skilled to do the job! Module 3 of this handbook has all the technical drawings of the equipment and will guide the workshop during construction. Although it may be expected that the workshop is able to make quality drilling equipment from the drawings, when it is the first time for them, additional supervision is useful. Guidance during construction and quality control of the equipment before it leaves the workshop is essential. At first this quality control can be done by a technical trainer. In a later stage, the drilling enterprises will take care of the quality control themselves.

Training the drilling team

Manual drilling must be understood as a profession that develops through training, hands-on experiences, successes and failures. Technical training sessions by experienced

drillers/trainers are an essential base for new teams to become professional manual drillers.

Make a selection of trainees before training starts: It is important that the trainees either have experience or affinity with wells (pump workshops, well diggers) and are motivated to run their own business. On average, a team consists of 5 or more workers and 1 team leader. During several weeks, hands-on technical drilling training is given to the manual drilling trainees. During and after this first training, several wells are drilled. It is good to provide the training and these first wells in an area that consists of loose soils, which are easy to drill. This will allow the team(s) to practise and improve their technical skills, without becoming frustrated.

Important: during this first practice period (a few months) the team(s) will come across problems, may have questions, experience difficult situations or worse may lose some of their equipment. Realize that this is all normal and part of the learning process! It is important that the team(s) are guided well and have access to experienced trainers. After a few months of practise a follow up training will evaluate the problems encountered with the drilling team(s).

GUIDING THE NEW TRAINED TEAM

Drilling in a new area

When a drilling team is new to an area, it is important for them to have information on the geology (soil type) they are going to drill. And how deep they have to drill. In other words: what is the depth of the groundwater and how deep do they need to drill into the groundwater to find a good yielding aquifer?

There are several ways to get this information: Ask villagers to show existing hand dug wells and try to talk with well diggers. They can give information on the different types of formations (soil) and the level of the ground water in dry- and in rainy season. To complement this information; the team should drill its first well to the maximum possible depth. During this exploration, soil sampling will help them to define the depth of a good aquifer. Note that drilling in valley bottoms, floodplains and riverbeds is likely to be more successful than high up in the hills.

Remember; there is NOT a standard for the depth of drilling. This always depends on the depths of an aquifer and the requirements of the users and the pump.

Selecting construction materials

For the well casing different types of PVC pipe are used. The quality can vary from cheap drain pipes with self made filter screens to expensive, high quality factory slotted filter screens and casing pipes.

Around the filter screen a gravel pack or filter cloth is placed to reduce the inflow of fine sand. A sanitary seal is placed to prevent pollution from entering the well. Find more information on construction materials in module 2, chapter 2: What the drilling teams must know.

Finalizing the well

Once installed the well should be further developed to maximize the yield of the well. Then an apron and a pump are placed.

For more details see the manual: **'Understanding Groundwater and Wells in manual drilling'**. An instruction manual on hydro-geology, hygiene, well installation and well development.

Giving a follow up training

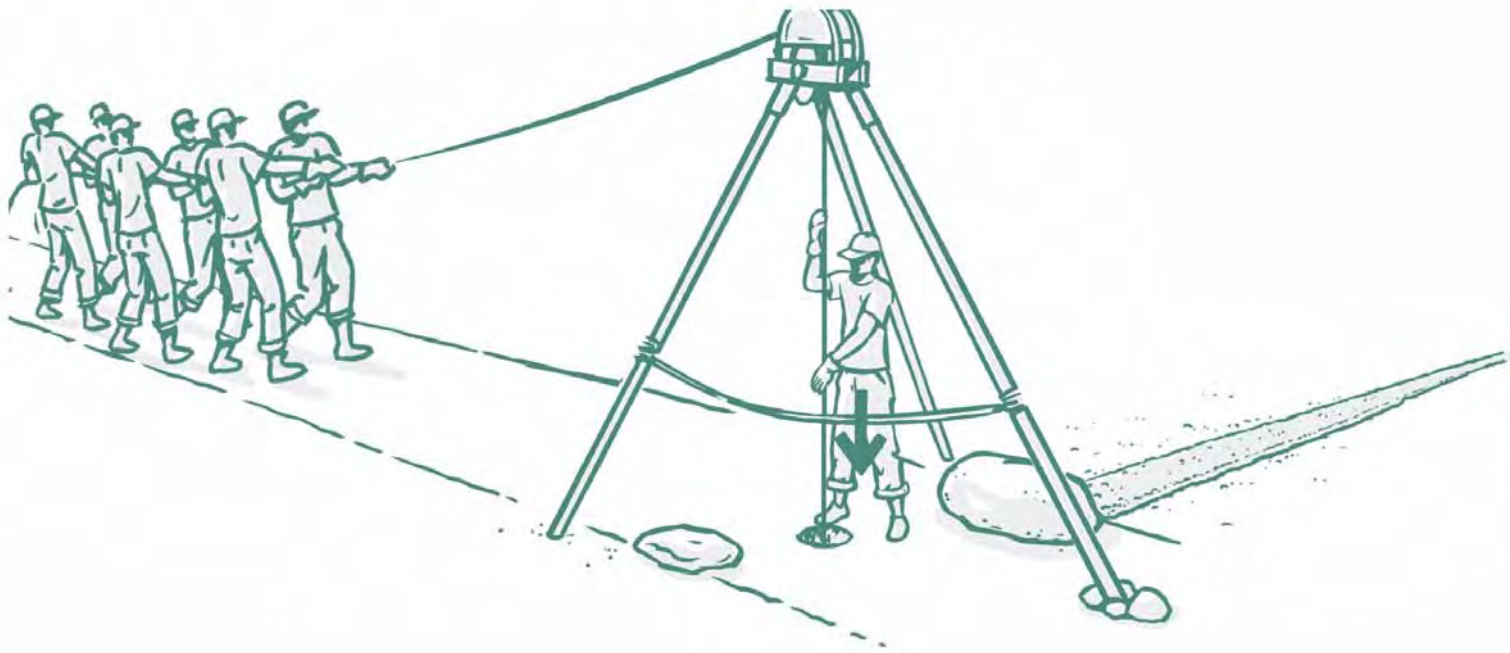
When the team has drilled a number of wells and gained practical experience, they are ready for a follow-up training 'Understanding Groundwater and Wells in Manual Drilling'. This training helps them to understand the drilling process and the theory behind it. It will allow the drilling teams to solve problems in the field. During this training, the teams will get a technical training in the field to bring the theory and lessons learnt into practice.





PERCUSSION

Module 2



USING THE PERCUSSION TECHNIQUE



1. WHAT IS PERCUSSION

This second module of the percussion handbook teaches entrepreneurs and technical trainers how to use the drilling equipment and how to drill wells for drinking and irrigation water, using the **manual percussion technique**.

HISTORY

Percussion drilling is the oldest manual drilling technique and dates back to 1100 B.C China, where they used bamboo strips attached to a heavy weight to drill wells. Percussion gets its name from the movement of the drill bit as it rises and falls on the bottom of the well to chop up rock and soil. Percussion drilling exists in many variations, such as: the Chinese springboard, the American spring pole, the stone hammer and the walking beam. They all perform the same functions: lifting and dropping the drill tools to cut the earth and turn it into mud or rock chips so it can be lifted to the surface. Percussion drilling was used to drill the first oil wells in the 1800's. The more modern mechanized version is called 'Cable Tool Drill', which uses heavy machinery to lift and drop bits of more than 1000 kg.

This practical module is created with information compiled from available literature, field observations in various African and Western countries, discussions with local drilling teams and interviews with percussion experts. One manual: *Drilling wells by hand with Hand Powered Percussion Drill*, written by Cliff Missen of Wellspring Africa, has been particularly useful. Missen has among others introduced manual percussion in Africa. Nowadays manual percussion is being used in: Niger, Chad, Nigeria, Liberia, Ghana, India, Sudan, Central America and western countries.

This module summarises best practices in drilling with the manual percussion technique.

HOW DOES IT WORK?

With percussion drilling a heavy cutting or hammering bit attached to a rope or cable is lowered in the borehole. Usually a tripod is used to support the tools. By moving the rope or cable up and down, the bit loosens the soil or breaks consolidated rock in the borehole. Water is added to the hole



and is mixed with the cuttings to become a mud. This mud is essential in the drilling process. It plasters the wall of the borehole and lifts up small rock chips that have been drilled. The mud (cuttings and rock chips) is then extracted by using a bailer. Then the bit is lowered into the borehole and the drilling process begins again. A column of mud or a temporary casing of steel are used to prevent the hole from collapsing. For more information on the use of a column of mud or a temporary casing see chapter: 'Specific situations and common pitfalls', at the end of this module.

Manual percussion drilling for drinking water wells is generally used up to depths of 25 meters, but deeper wells are possible. Percussion drilling can be combined with other manual drilling techniques such as the hand auger. This technique rapidly drills the first meters in soft formations until harder formations are found which require the use of the percussion technique.

Where does it work?

Manual percussion is suitable for drilling in unconsolidated and consolidated formations: sand, silt, stiff clays, gravel, sandstone, laterite and weathered rock. Unlike any other manual drilling technique, it can drill through several types of rocks, but not all! Chapter 5 'Specific situations and common pitfalls' gives a detailed explanation on your chances of success for drilling in rock.

ADVANTAGES & DISADVANTAGES

Advantages of manual percussion

Unlike any other drilling method, percussion can break through boulders and cut harder formations. Percussion drilling can in principle deal with most formations, from soft and loose sand and clay to hard and consolidated rock. Unskilled labour, for example villagers, can contribute during the drilling of the well. This can increase their 'ownership' and may make them more aware of maintaining the well.

Disadvantages of manual percussion

The equipment can be very heavy and the method can be slow (weeks, rather than days) when drilling hard formations, resulting in high cost / drilled meter. When temporary casings have to be used, the time taken driving and removing it can significantly increase drilling time especially when drilling through clay layers as it sticks to the borehole walls.

2. WHAT DRILLING TEAMS MUST KNOW

BEFORE YOU START DRILLING

Before you start drilling, there are some important things you need to know. First; a good drilling site needs to be selected, where a good quantity (high yield) and quality (no pollution) of groundwater is expected. Second; some knowledge of construction materials such as PVC casings and also of soil sampling and drilling safety could help you to become a better driller.

Selection of the drilling site

Selecting a good location for the well is not always easy and depends on: needs and preferences of the users, expected groundwater level, type of formation (soil) and any nearby sources of pollution (latrines) that may be harmful.

Some tips to help you in site selection:

- o The needs, preference and ideas of the users should be placed first when you select a location.
- o Always discuss advantages and disadvantages of the selected location with the users (you are a specialist who has knowledge about the expected quantity and quality of water in relation to the selected site).
- o Ask villagers to show existing hand dug wells and try to talk with well diggers. They can give useful information on the different types of formation (soil) and the level of the ground water in dry- and in rainy season.
- o Note that drilling near valley bottoms and riverbeds is likely to be more successful than high up in the hills. Make sure that the selected site is not likely to flood during the rainy season (if it is the lowest point in the landscape).
- o Always choose a site at least 30 m away from a latrine. Avoid other possible sources of pollution such as waste dumps, fire places and fuel stations.

MATERIALS

For the **permanent well casing** that is installed you can use different types of PVC. The quality can vary from cheap drain pipes with self made filter screens to expensive, high quality factory slotted filter screens and casing pipes. The choice of pipes depends on: diameter of the pump (the pumps should fit the pipe), type of the well (irrigation or potable water), user intensity (household or communal)

and the users budget (low or high).

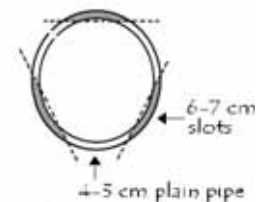
Buying the pipes

You can buy high quality factory slotted pipe in a specialized hardware store. The pipe has a thick wall, is strong and has a lot of slots per meter filter screen, resulting in a high water inflow. The pipes are expensive and are often used for large communal wells. When you are drilling wells of a lower quality, you can also buy cheaper PVC pipes. You can find these regular pipes in almost any hardware store; these pipes should have a wall thickness of 3 mm or more. In this case you have to make the slots of the filter screen yourself.

Making the slots in the filter screen

Use a hacksaw to make slots in the pipe. For a 4-inch screen, 6 parallel lines are drawn along the full length of the pipe. The spaces between the alternate lines should be about 4-5 and 6-7 cm (see drawing). The slots are sawn between 6-7 cm lines. The distance between the slots should be about one centimeter.

Guideline: the length of the filter screen should be at least 3 meter. The last meter of pipe has no slots. This is called the sump in which fine particles which enter the well screen can settle, without blocking the filter screen. The bottom is closed with a PVC cap or by cutting and bending the bottom of the PVC pipe.



Gravel pack

Coarse river sand in the range 1.5-3 mm is used as a gravel pack. The gravel pack fills the space between the borehole wall and the filter screen. It may also serve to filter some of the fine sand particles from entering the well. Use a minimum and a maximum sized sieve to prepare the 'gravel'.

Sanitary seal

During installation a sanitary seal is placed on top of the gravel pack to prevent pollution entering the well. A sanitary seal is made of clay or cement grout. If cement is used for the seal, a half meter of clay is backfilled on top of the gravel pack to prevent the cement from penetrating the gravel pack.

TO REMEMBER DURING DRILLING

Take soil samples

Soil sampling helps you to understand what material you have been drilling through and helps you to decide when you have reached the final depth of drilling.

Sampling is also a good way to determine where the different layers of soil are located. Sand and gravel are very *permeable*. They allow the water to flow easily through the pores (open space) and are therefore suitable layers for placing the filter screen. If the drilled material is very fine, such as silt and clay, it will not transmit water easily and is called *impermeable*. Do not install the filter screen in this formation.

Field tricks

Take a sample of the soil and squeeze it into a ball, between your hands. Then drop the ball from a height of one meter above ground level.

- o If the ball consists of non cohesive (non-sticky) particles, the ball totally falls apart. In this case the material is permeable. The particles of sand or gravel will be easily visible.
- o If the ball falls apart only partially, the soil contains some silt or clay and sand. The formation has a low permeability.
- o If the ball only deforms and remains more or less in shape, it is composed of clay, and is described as impermeable.

Drilling safety

When you have to leave the site overnight during drilling, you need to take important precautions:

- o Take the percussion bit or bailer out of the borehole. This will prevent it from getting stuck in the mud at the bottom.
- o Protect the borehole. Take measures to prevent children and animals from stepping in.

Please be aware that drilling can be a dangerous activity. Watch each other and ask villagers (especially children) to watch you from a safe distance.



NOTE

These are a few guidelines to help you during drilling. You can find more information on soil, groundwater, hygiene, sampling, well installation and well development in the manual '[Understanding Groundwater and Wells in manual drilling](#)'.

3. WHAT TO BRING

Tools & materials



Tripod poles (3 piece)



Jarhook (1 piece)



Bailer (1 piece)



Drilling bit (1 piece)



Hacksaw (2 pieces)



Shovel (1 piece)



Toolbox (full) (1 piece)



Inner tube (2 meters)



Buckets 12 liters (2 pieces)



Sieves 1,5 & 3 mm (2 types)



Depth measuring tool
(1 piece)



PVC casing



Gravel pack (50 kg bag)



Pulling rope (50 meters)



Crowbar (1 piece)



Fishing hooks (2 pieces)



Tripod pulley (1 piece)



Safety pins pulley
(5 pieces)



Rope eye (2 pieces)



Chain shackle
(2 pieces)

4. HOW TO DRILL A BOREHOLE

STEP 1 PREPARING THE SITE



Clear up the site

Clean the working area and prepare a runway. The length of the runway will be equal to the total depth of the borehole.

Tip!

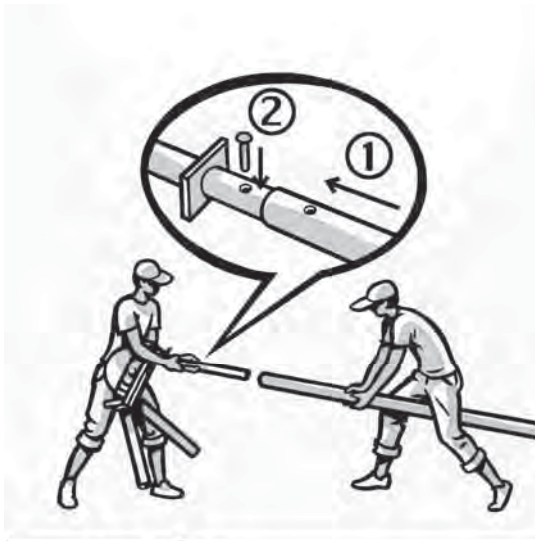
- o You need enough space to lengthen the runway in case you need to drill deeper.
- o Water and mud that is used during drilling should drain away from the working area.
- o Assure that the runway is not made uphill.

STEP 2 PREPARING THE TRIPOD

Setup the tripod

1. Connect the front post to the pulley and secure this with a bolt and nut.
2. Put the rope through the pulley

1



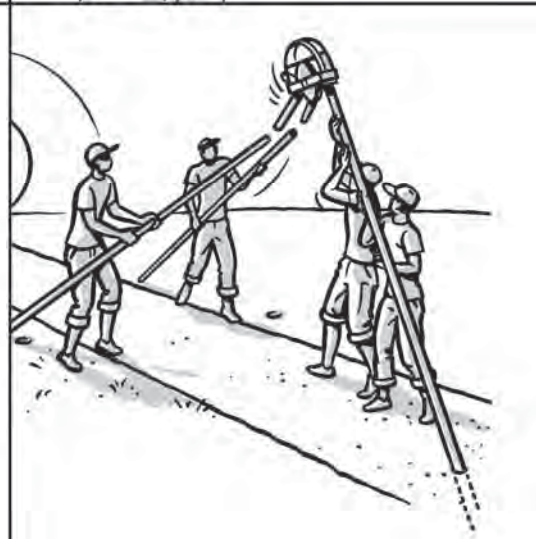
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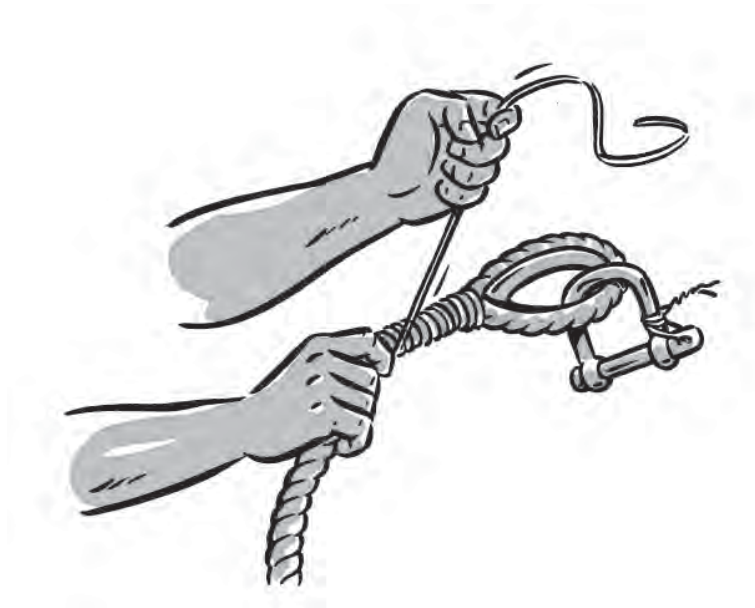
4



3. Dig a hole of 1 meter deep and place the front post in the hole.
4. Lift up the pulley and the front post and attach the 2 other poles to make a tripod. Dig 2 other holes of 1 meter deep and place the 2 poles in the holes. The tripod is now ready to use.

Tip!

Make sure that the distance between the 3 poles of is more or less equal.



Prepare the rope eye and the jarhook

1. Take a steel rope eye and put the rope around it.
2. Push the end of the rope to the main rope and connect the two tightly by winding a small rope or wire many times around it. Make sure that the rope eye cannot move or turn in the rope.
3. Insert a shackle in the rope eye



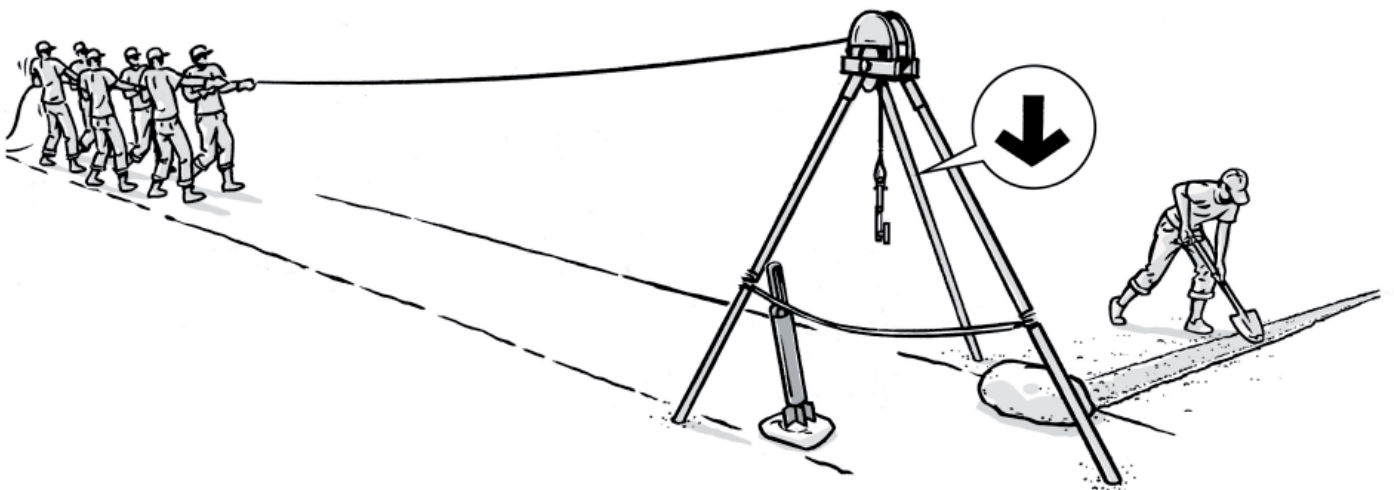
The shackle can now be attached to the jarhook

Tip!

The best rope for manual percussion is a braided nylon rope. It provides the best strength and will not unravel like a twisted rope.

Dig a drainage

Dig a drainage away from the working area of the team members. This is to drain away water and mud that is used during drilling.



Then lower the jarhook to connect the drill bit.

Tip!

Attach a pole (or a rope) between the front pole and one of the other poles of the tripod. The bailer or drill bit can be placed against the pole when it is not being used.

Connect the jarhook to the drill bit

1. Take the jarhook.
2. Turn it horizontal.

1



2



3



4



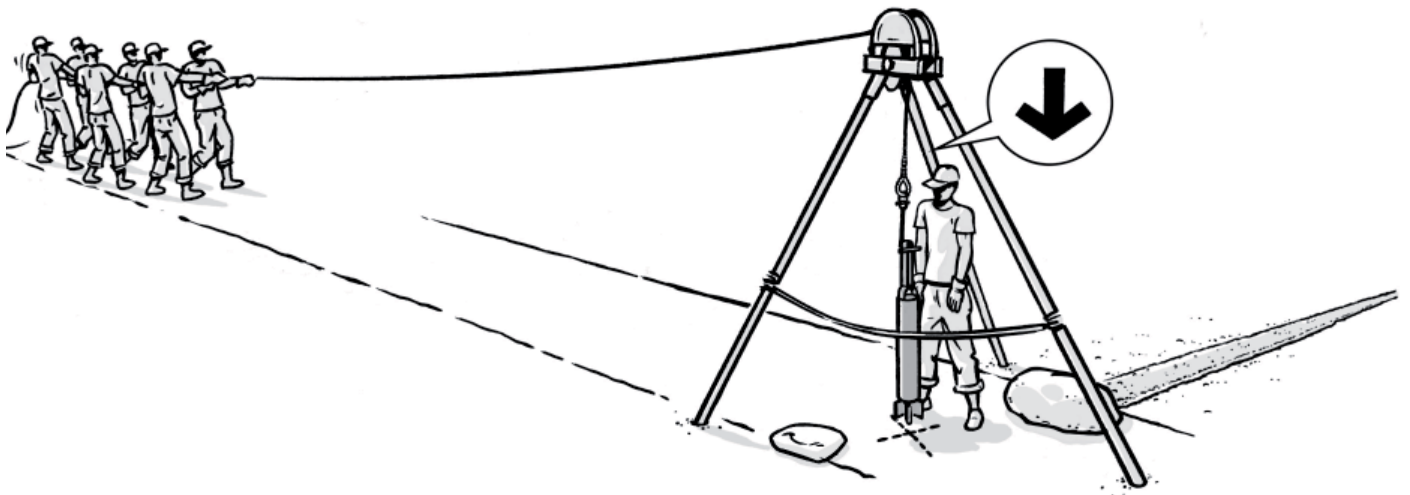
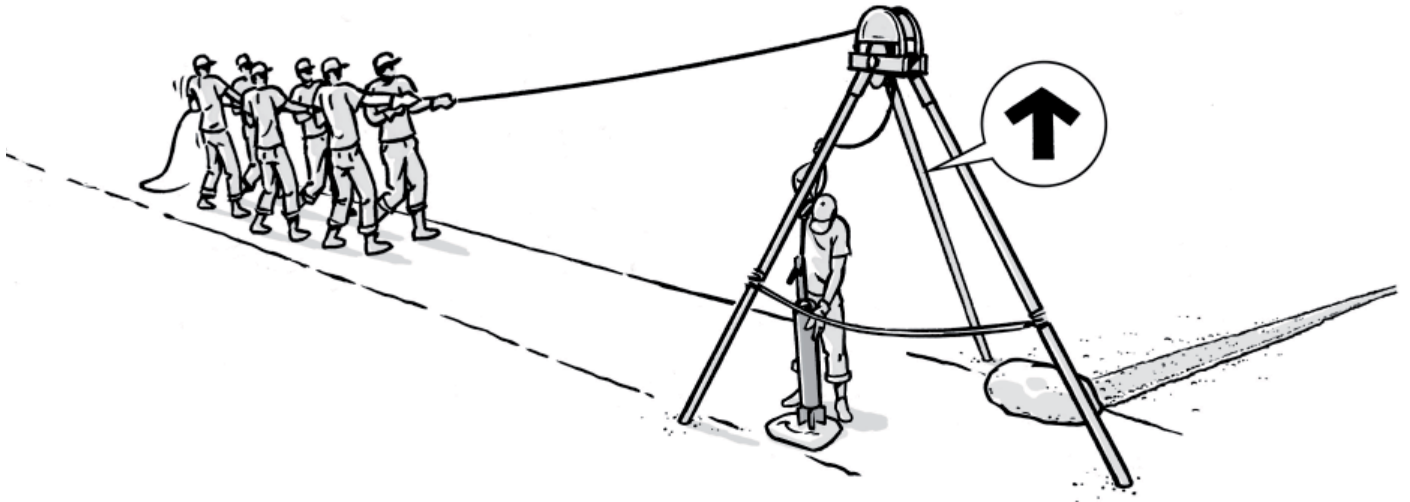
3. Slide the jarhook into the drill bit.
4. Rotate it back and lift up the rope.

Tip!

The jarhook cannot get loose by itself during drilling, because the diameter of the drilled hole is too small for the jarhook to rotate.

Mark the position of the starter hole

1. Lift up the drill bit by pulling the rope.



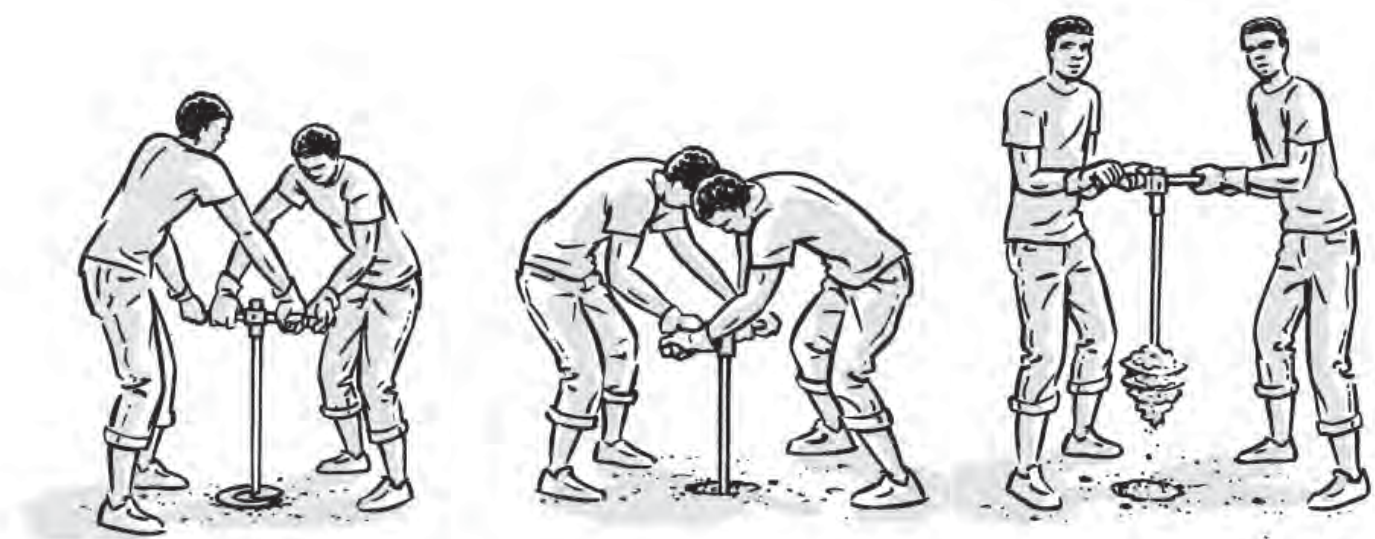
2. Lower the drill bit and let the drill bit hang until it stops swinging (let it hang just above the ground and do not hold the drill bit).
3. Mark the position of the starter hole on the ground. The center of the drill bit will be the center of the starter hole.

Make a starter hole

Make a starter hole on the marked position in the center of the tripod.



Use a simple crowbar or a hand auger and drill a 2 meter deep starter hole.



STEP 3 ALMOST READY TO START!

Measure the depth

Measure the depth of your starter hole.



Tip!

During drilling measure regularly to check the progress that has been made.

Make a mud

Pour a few buckets of water inside the starter hole.

The water will soften the soil and helps you to make a mud during drilling. The drilling mud will plaster the wall of the borehole and lift up small rock chips that have been drilled.



Tip!

Pour the water or mud carefully in the center of the hole. This will prevent soil from the walls being washed into the bottom of the hole.

When you are drilling in clay or silty material, just add water in the starter hole. This will make a mud during drilling.

If you are drilling in sand or gravel, it is important to bring clay from another location to make a mud.

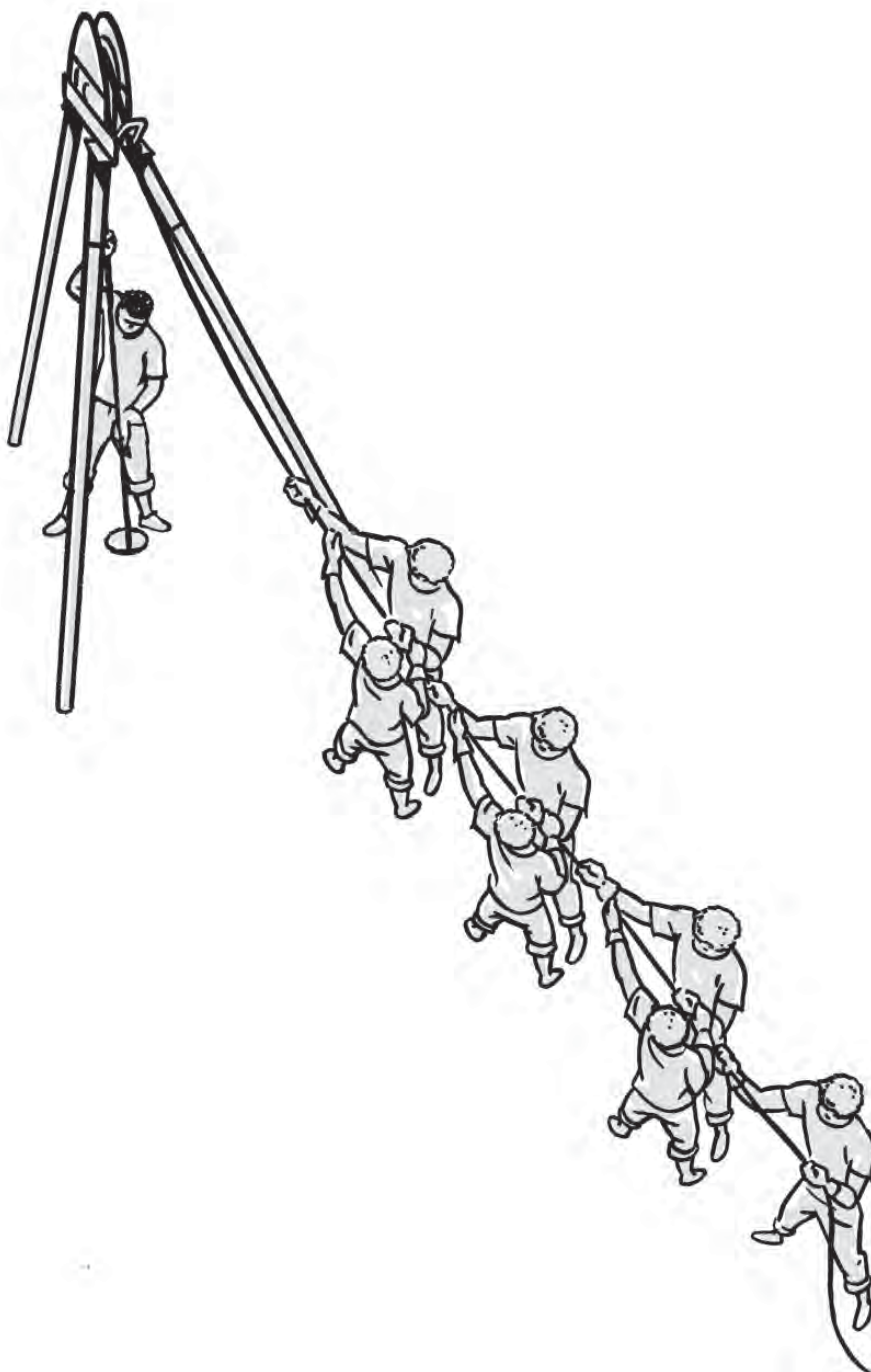
STEP 4 PREPARING TO DRILL

The position of the team

The team consists of 1 driller and 6 to 8 pullers.

The driller's job is to direct the pullers and gently guide the drill bit or bailer. The driller is standing under the tripod, facing the pullers.

The pullers lift and drop the drill bit or bailer by pulling on the rope. They are standing on the runway.



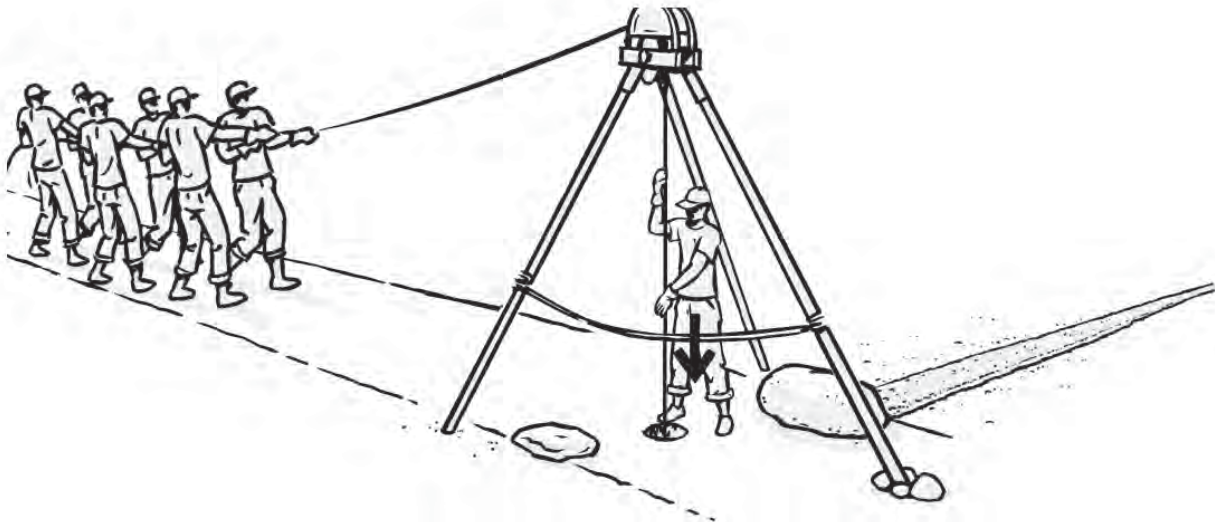
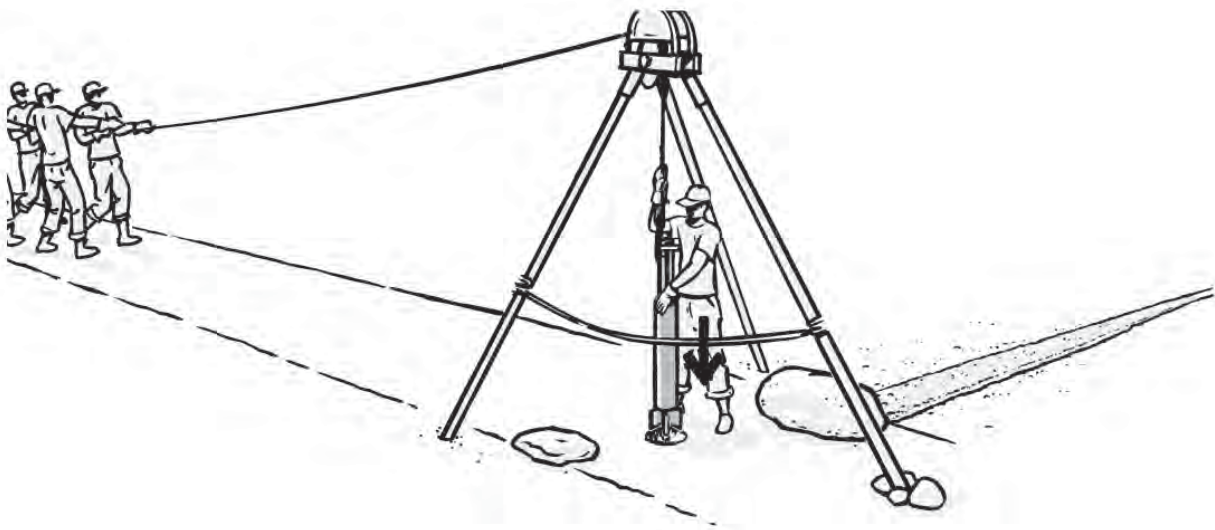
Lower the drill bit

The last puller now marks his position on the runway by drawing a line.

After a sign from the driller, the pullers walk slowly towards the tripod to lower the drill bit inside the starter hole.

Tip!

- o Never let go of the rope.
- o If the drill bit is swinging the bit can damage the edges of the hole. The driller needs to guide the bit gently back to the centre of the hole.



Walk towards the tripod until you feel a change in weight and the driller calls, "OK."

Stop walking forward and hold the rope. The drill bit has now reached the bottom.

Tip!

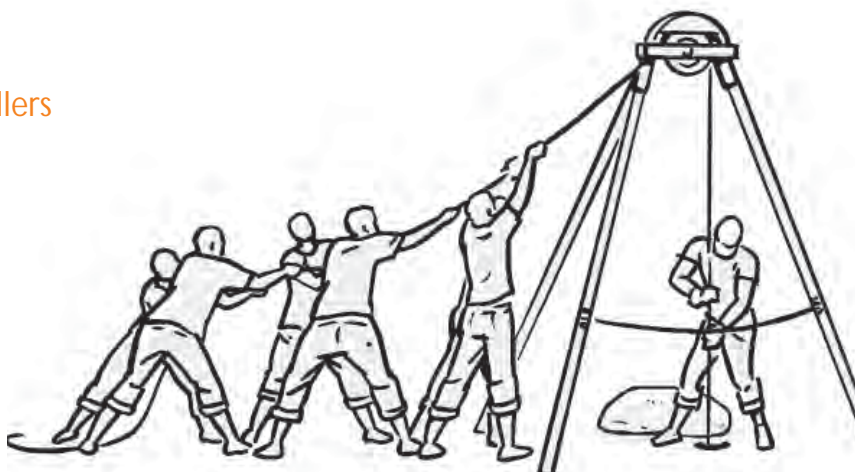
Keep tension on the rope to prevent the bit to fall sideways. This can damage the walls of the hole

STEP 5 STARTING TO DRILL

The drilling movement of the pullers

For drilling a long stroke is used.

Start with your arms in front of you.



Pull the rope until your arms are behind your waist.



Return your arms quickly to the start position so that the weight of the drill bit causes it to fall easily to the bottom of the hole.



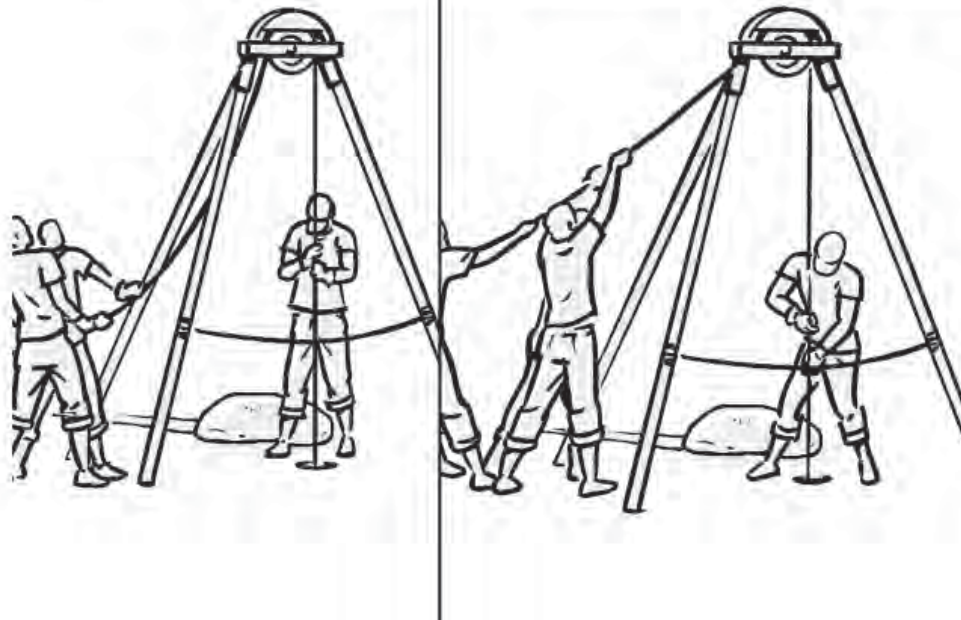
Repeat this cycle until the driller gives the signal to stop.

Tip!

Pull and release together at exact the same time. Assure that the drill bit is not slowed down by the weight of all the arms.

The movement of the driller

Use both hands to gently guide the rope and keep the drill bit centered.
You are NOT lifting or dropping the bit, that is the job of the pullers.



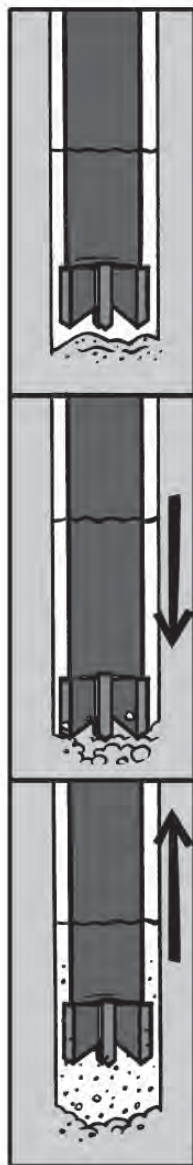
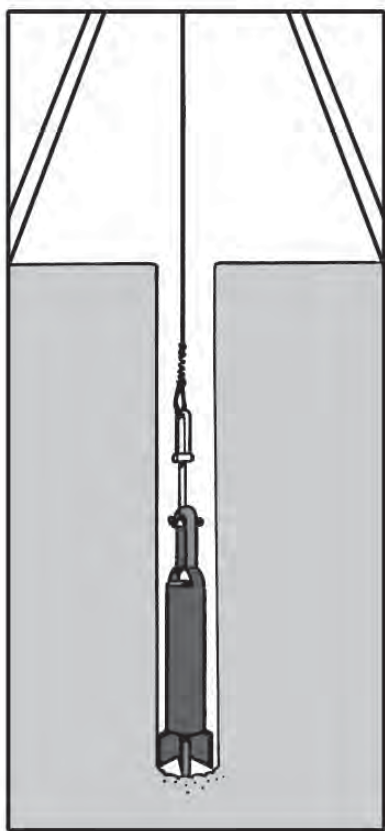
Tip!

Agree with the team on short 'commands' that you can give during drilling.

For example: "Up" to lift the tool. "Down" to lower the tool. "Again," to lift and drop the bit or bailer. "Go easy," to reduce how high they lift the bit before dropping it. "All the way," to pull until the bit is out of the hole. "Stop," to tell that the bit has reached the surface.

Drilling strokes

Soil that is hard and compact needs more drilling strokes to drill through than softer soils. Sometimes the bit may only have to be lifted and dropped 12 times, but in rock over 100 strokes may be required.



One drilling stroke:

The drill bit goes down in the hole through the water or mud.

It hits the bottom and breaks the soil or rock.

When the bit goes up, the cuttings mix with the water creating a mud.

Watch the progress

Make a mark on the rope before you do the first drilling stroke to watch the progress of drilling.

Feel the impact and listen to the sound of the impact. If the impact is being absorbed and no more progress is made, you need to empty the borehole with the bailer.

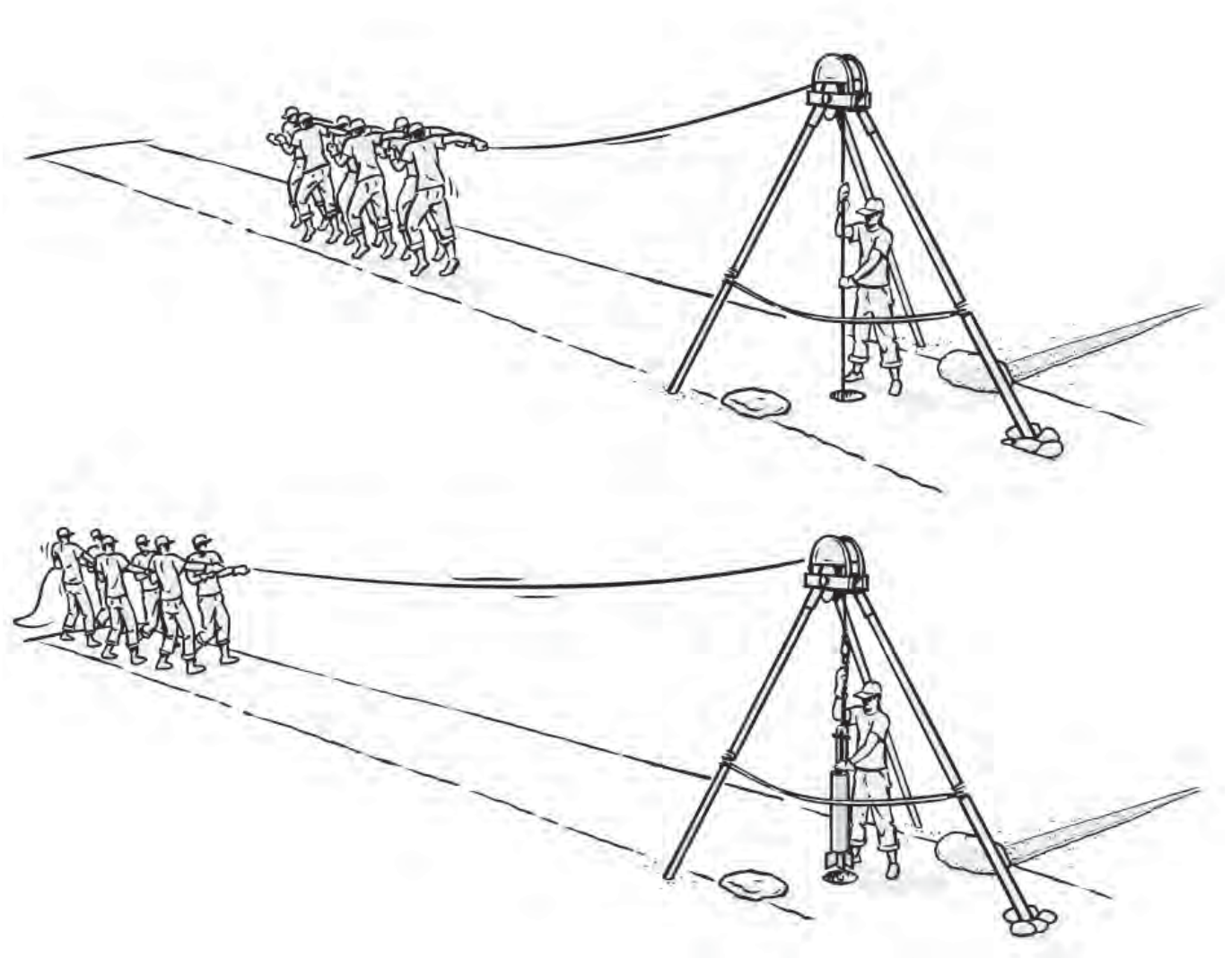
Tip!

Be careful that the drill bit does not get stuck in the soil at the bottom of the hole. If that happens it is better to use shorter strokes.

STEP 6 REMOVING THE DRILL BIT

Lift up the drill bit

Walk with the rope to the line that has been drawn on the runway the last time a tool was changed. Listen for the driller to call "Stop" when the tool has made it out of the hole.



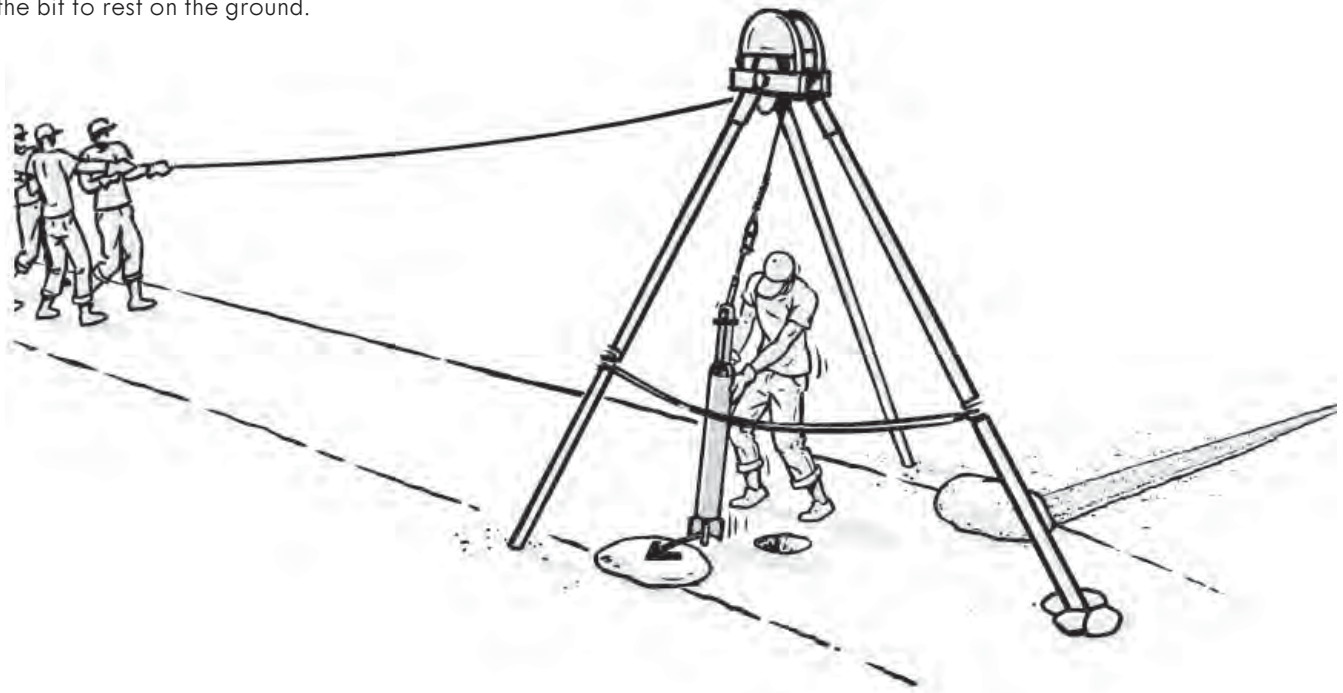
Tip!

Pull the last part SLOWLY and watch the bit come up the hole.

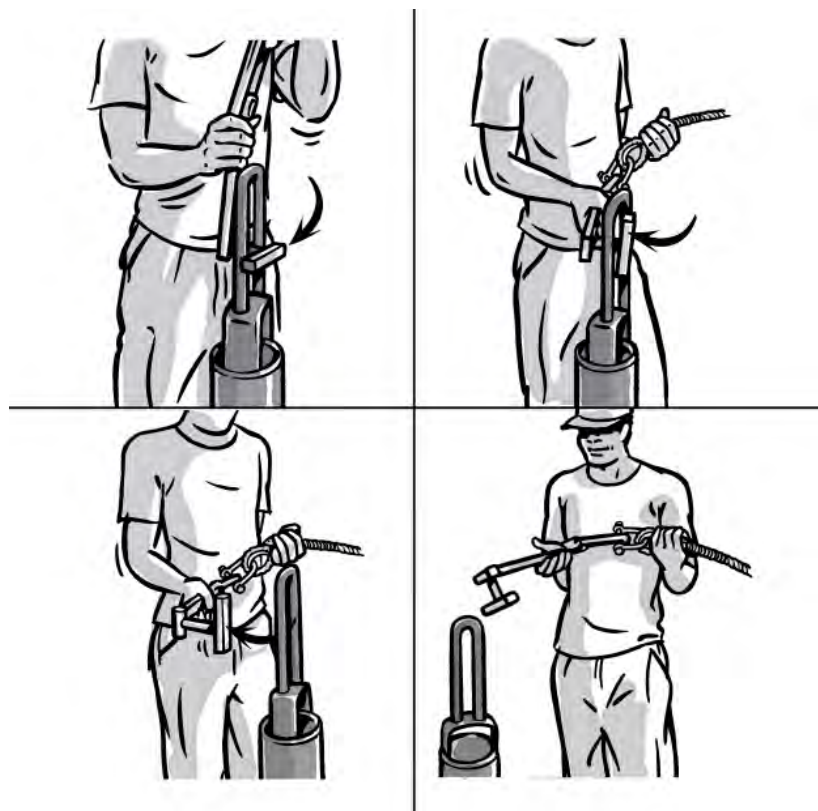
When you pull too fast, there is a risk that the drill bit can damage the tripod and pulley or injure the driller.

Remove the drill bit

Push the drill bit against the rope or pole between the tripod poles. Let the pullers slowly give more rope to allow the bit to rest on the ground.



Turn the jarhook 90 degrees and remove it from the drill bit.

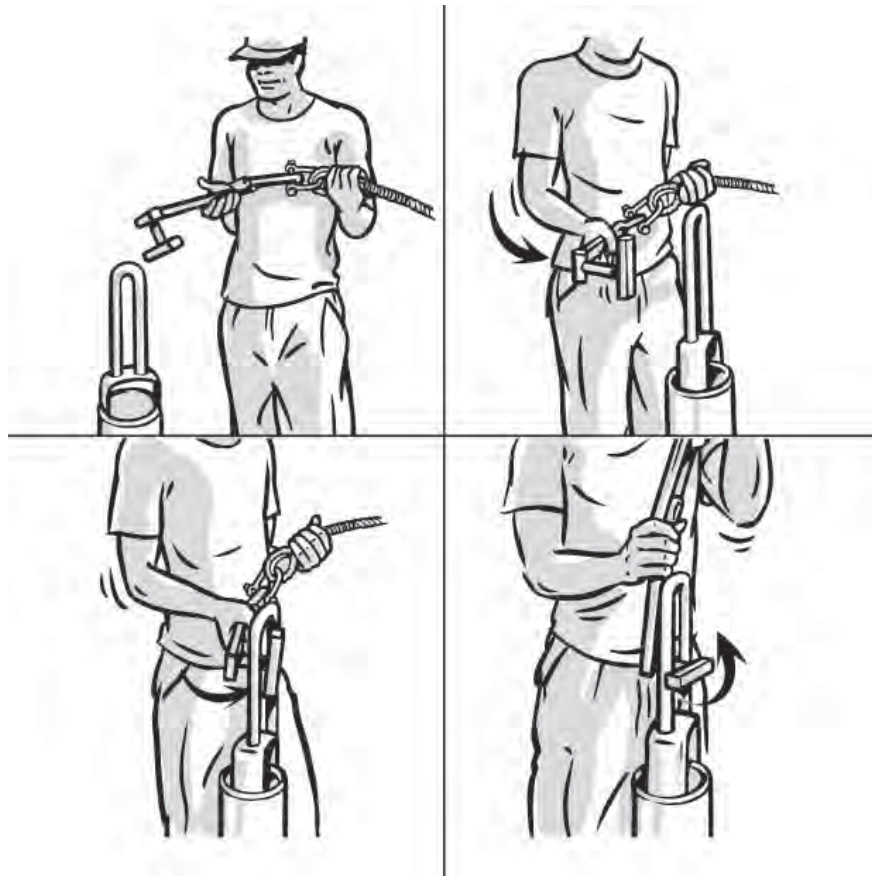


STEP 7 USING THE BAILER

Use the bailer when you want to remove the cuttings from the borehole.

Connect the jarhook to the bailer

Connect the jarhook to the bailer and lower it down to the bottom of the hole.

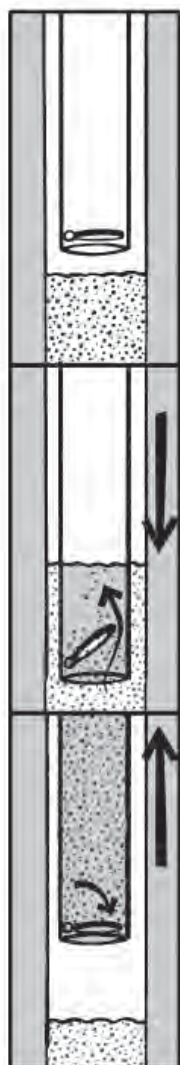
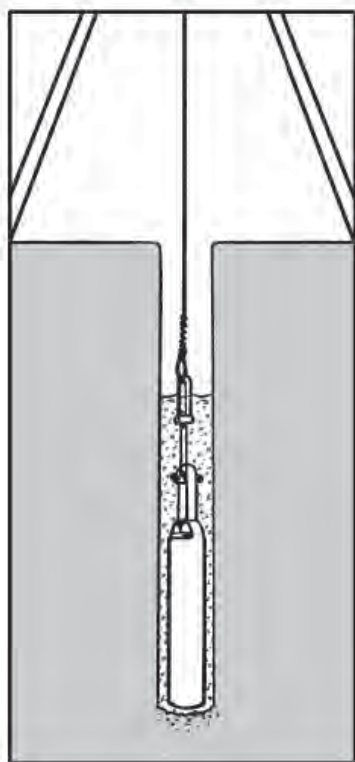


The movement of the bailer

Lift and drop the bailer a few times to stir up the cuttings at the bottom of the hole, (especially the larger pieces that settled on the bottom).

The bailing movement is similar to the drilling movement, but with a **shorter stroke**.

- o Start with your arms in front of you. Pull the rope until your arms are at your waist. Now move your arms back to the start position.



One bailing stroke:

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

On the downward movement the valve at the bottom of the bailer will open. The mud will enter the bailer.

On the upward movement the valve will close. The mud is now inside the bailer.

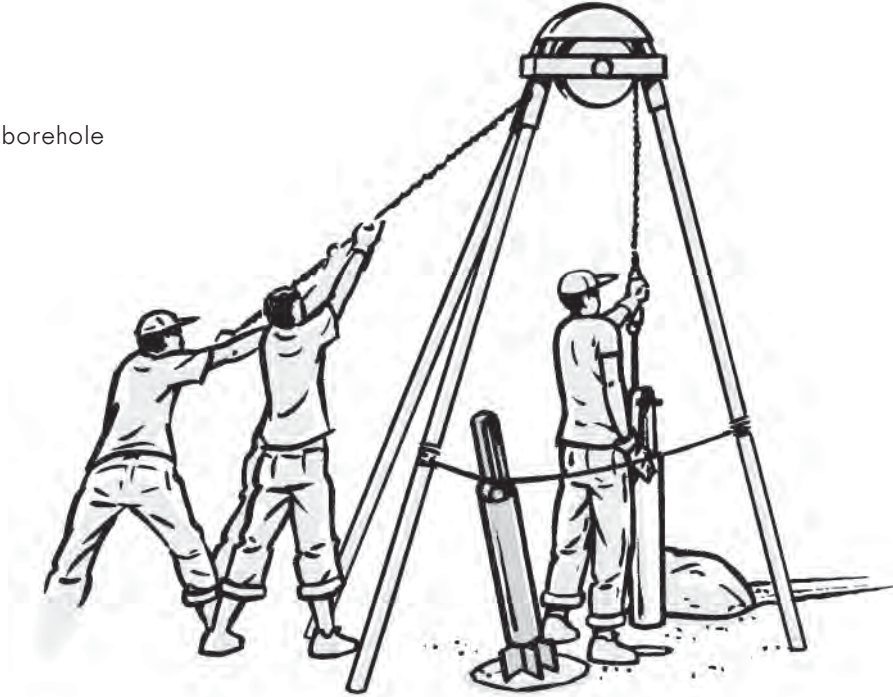
Repeat this cycle 2 or 3 times. The bailer is now full and can be lifted out of the borehole (the driller will give a signal to lift).

Tip!

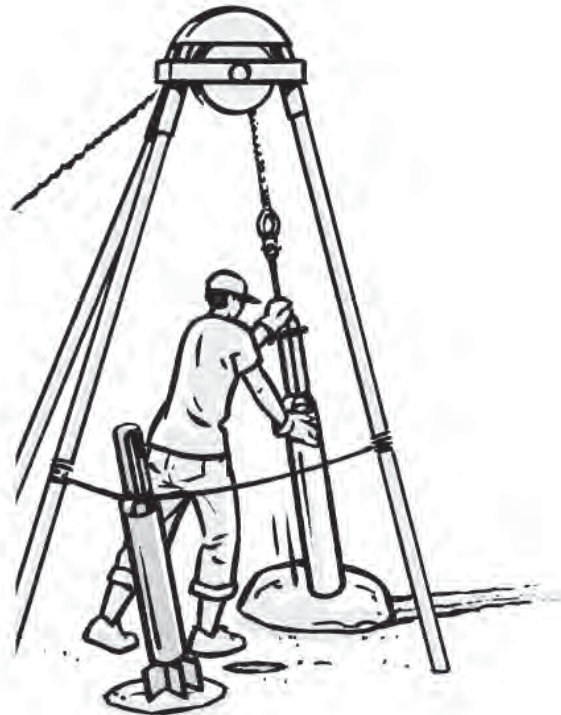
Use the bailer immediately after you have been drilling. In this way you will catch most cuttings 'floating' in the drilling mud.

Empty the bailer

Lift the bailer out of the borehole



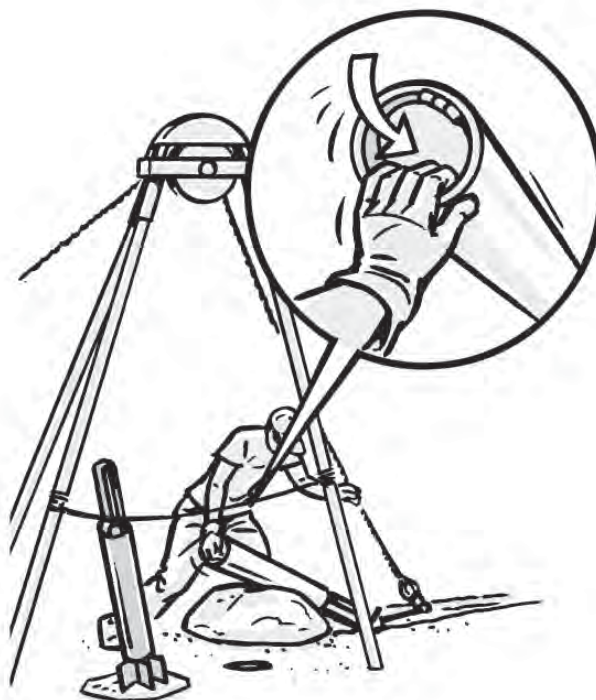
Ask the pullers to give more rope and push the bailer over to the stone.



Ask the pullers to loosen the rope and push (flip) the top of the bailer over the stone.



Let the top of the bailer rest on the ground. Check the bottom of the bailer and push open the valve to make sure it is loose (not blocked by cuttings).



Take soil samples

Take a sample of the drilled soil, every time you empty the bailer.



Place all samples on a piece of plastic and write down the depth



Continue with the drilling

Continue bailing until most of the cuttings have been removed.

Attach the drill bit and continue drilling. Repeat this cycle (drilling and bailing) until you reach the water table.

Tip!

Take the sample from the middle of the bailer as it is emptying. If the sample is covered with mud, wash sample in water.

STEP 8 DRILLING BELOW THE WATERTABLE

Drilling above the water table

When you are drilling above the water table the borehole generally stays open (as long as there is enough mud used during drilling the walls will not caving in).

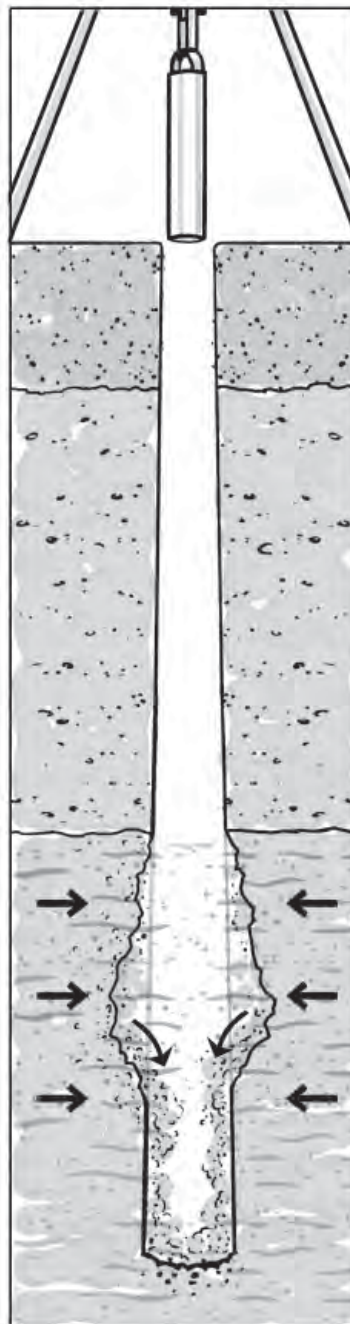
Drilling below the water table

In rock or clay a small column of water is sufficient to keep the borehole open during drilling.

In most cases you will find sand or gravel. Sand and gravel are not cohesive (sticky) and the groundwater will easily 'push' the sand inside the borehole. The walls of the borehole will start caving in.

Sand and gravel will collapse easily!

You can prevent this by adding water or mud.



Tip!

You will notice collapse of your borehole; when you are bailing out a lot of material, but not drilling any deeper (no progress).

Add water or mud

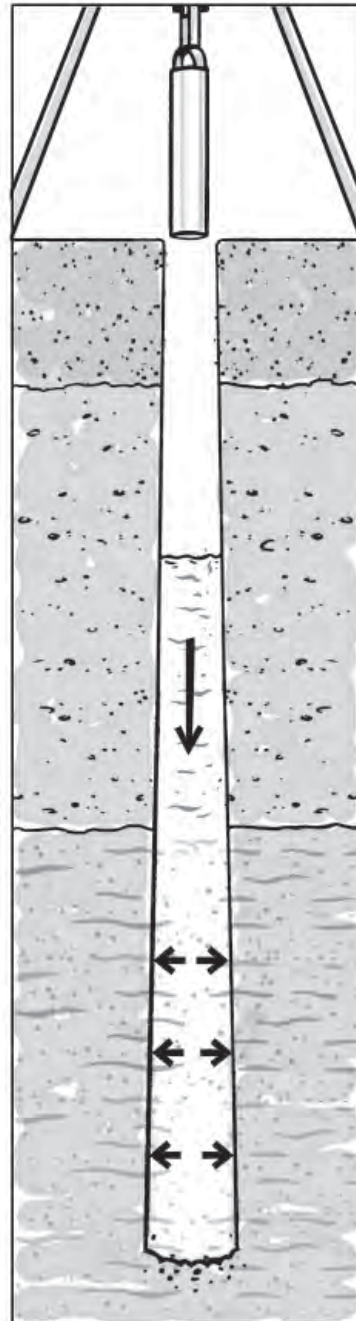
Pour a few buckets of water or mud in the borehole.



The level of mud and water in the borehole will now be higher than the groundwater level.

The mud will plaster the walls of the borehole (water will stay in the borehole and not flow away)

The weight of the column of water will push against the walls of the borehole. The borehole will not collapse.



Tip!

Pour 2 -3 buckets of water in the hole each time you have removed the bailer.

Tip!

A water/mud column of 3 meter above the watertable will prevent collapse

STEP 9 THE FINAL STEPS

The right depth of drilling

Continue drilling until you have reached the final depth. Generally, the final depth of drilling is reached when you have drilled at least 4 meter into a coarse layer of sand/gravel.

Only continue with the next step if you have reached the final depth of drilling

Clean the borehole

The next step is to clean the borehole

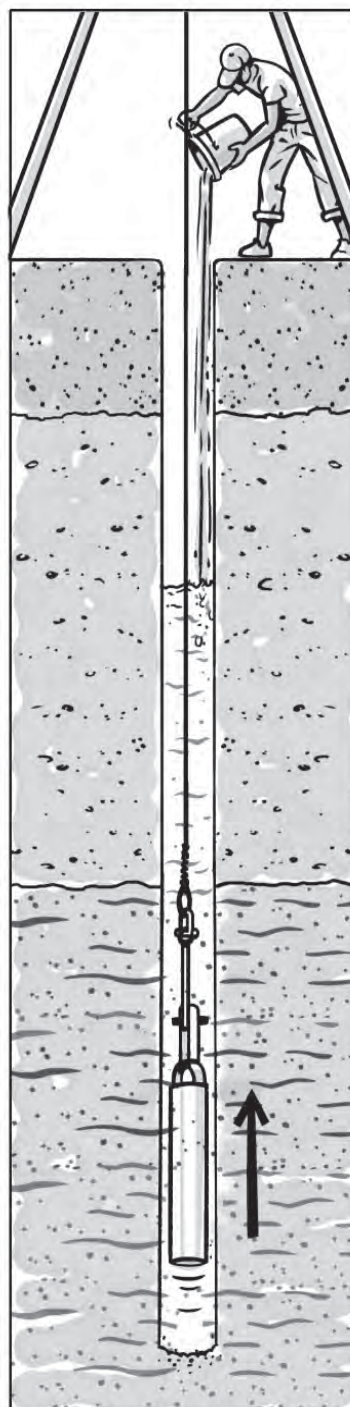
- o Pour a few buckets of water into the hole.
- o Remove all the mud and cuttings from the bottom of the borehole with the bailer. This time, move the bailer SLOWLY up and down. DO NOT drill any deeper.
- o Keep on adding clean water in the borehole during bailing.
- o Do this until the borehole is clean. Remove the bailer from the borehole. The final installation can begin.

Tip!

Always make sure that the water level in the borehole is higher than- or equal to the level of the groundwater. Do NOT remove all the water from the hole during bailing, to prevent the hole from collapsing.

Tip!

Make sure that you have all your PVC casing pipe on the side and your filter screen prepared, before you start cleaning the borehole. After cleaning there is a higher risk of collapse. The final casing needs to be installed immediately.



Measure the depth of drilling

Measure the exact depth of your borehole. This gives you information on the total length of casing pipes needed.



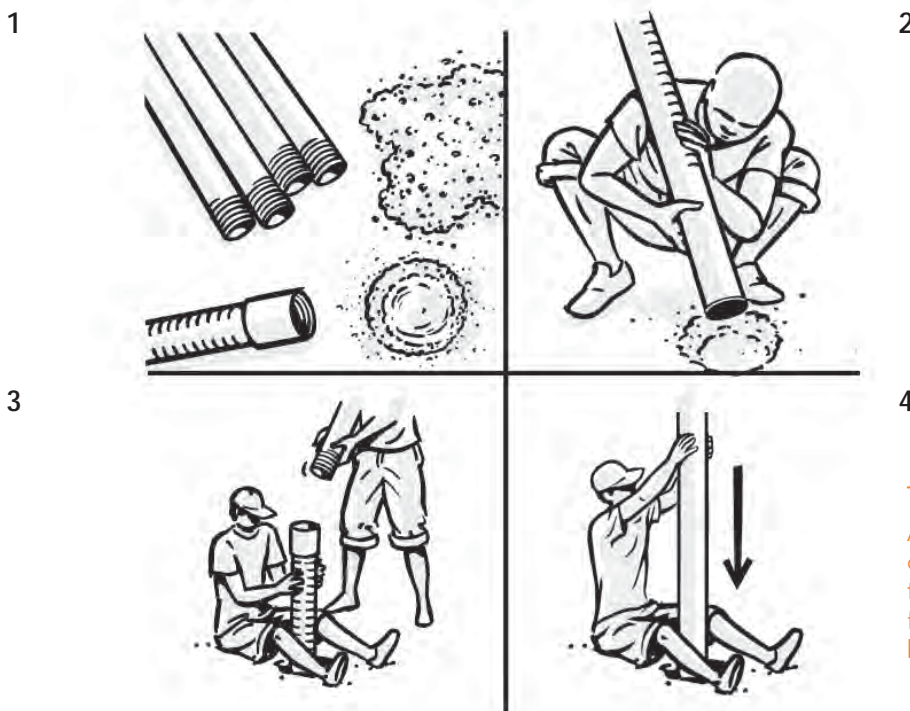
Tip!

For measuring; use a rope with knots at every meter or long measuring tape with a small weight attached.

Install the final casing

Prepare the filter screen, the sump (with a closed bottom) and the casing, before you start the installation (1).

Lower the filter screen into the borehole (2). Then screw or glue the first PVC casing pipe to the screen (3). Lower the casing further into the borehole (4). More PVC pipes are added one by one.



Tip!

Always make sure that one person is holding the casing to prevent it from dropping into the borehole.

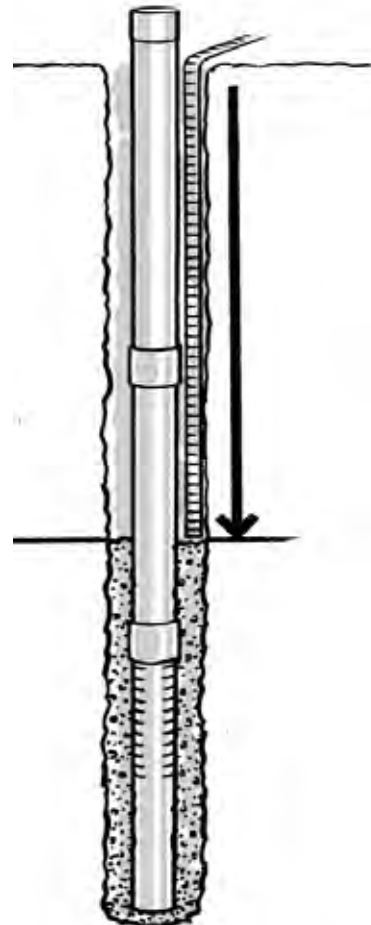
Gravel packing

Start slowly pouring in the gravel, all around the pipe. While putting the gravel in, keep moving the PVC pipe from side to side in the borehole.



Measure the depth of the gravel pack

Measure regularly to check if the right depth of gravel packing has been reached. Fill the open space between the casing pipe and the borehole wall for 1-2 m above the top of the filter screen.



Backfill

After you have installed the gravel pack, you can install the sanitary seal and the rest of the backfill.

Leaving the well behind

When the drilling is finished and you are leaving the site, remember to cover the PVC casing!

This can be done with a PVC cap or plastic bag tightly wrapped with inner tube. It is needed to assure that nothing can be dropped into the well by children.



5. SPECIFIC SITUATIONS AND COMMON PITFALLS

Drilling in rock

Although percussion drills through some rock types, it is recommended to check your chances of success and do a few simple tests. If you find rocks in the drilling area, observe if they have a layered structure. A rock with layers, that breaks easily or crumbles when hit by a hammer, is a rock that you can drill through. Rocks that are solid and that will not chip may be difficult to drill through. This is the same for larger stones, or boulders. The smaller stones also need to fit inside the bailer. If there are many very large and solid rocks in an area, you can probably not drill.

If you are not sure, try to drill the rock for at least a full day. If you can drill 1,5 to 3 meters a day, you are making excellent progress and it is worth continuing. If you encounter a large boulder, you can move your drilling a few meters in any direction and drill right past the buried boulder.

In soil, the drill bit may only need to be raised 30 centimeters during drilling, in harder material a full meter may be required. You do not need to lift and drop the bit very far to cut rock or soil. For example: a worker who is breaking stone is using a 7kg sledge hammer only lifts and drops it one meter. So when you are using a 45kg drill bit, you only need to lift the bit less than a meter to cut stone.

The drilling mud

The secret to percussion is to focus on making mud (mixture of water and cuttings) and lifting it to the surface. Knowing the right mixture is very important for the speed of drilling and is recognised by sound and observations.

In practice this means 2 things:

1. The mud should not be too thick; otherwise the drill bit will move slowly during drilling. In this case there is too much clay and you should add water to make a thinner mud. When the mud becomes too thin, the chips of rock can sink to the bottom of the hole and temper the impact of the bit on the rock. Then you have to pour mud into the hole to thicken the water and to stir this up with the drilling bit or bailer.
2. The mud should keep the cuttings in suspension, long enough to extract the bit and drop in the bailer. The best kind of mud is made from fine clays with no rocks or organic matter found in dry puddles or river beds. Mix the clay with water at the surface to make a thick slurry of mud and pour it into the hole.

The size of the cuttings will determine the thickness of your mud. In soils with clay and fine sand this means that you can just work with water. This will make a mud during drilling.

With coarse sand and rock cuttings you may need to thicken the mud at the bottom. Then it is important to bring clay from another location to make a mud.

It will take practice to learn which thickness of mud works best, but remember: The secret to percussion drilling is to focus on making mud.

Temporary casing?

If you are drilling in highly collapsing soils, for example pure sands, and you don't have any clay or water to create mud for drilling, than a temporary casing is needed. A temporary casing is a 1,5 meter pipe made of steel that is lowered in the borehole to prevent collapse. Each time you use the bailer, the temporary casing will go down at the same time (by its own weight). You can keep on adding temporary casing pipes until the final depth is reached. After the installation of the permanent well casing the temporary casing is removed.

For the temporary casing, steel pipes are used with a wall thickness of 3 mm or more. If steel pipes are not available, try to find sheet metal and shape this into a pipe. Alternatively, thick-walled imported threaded pipes can be used, but those are very expensive. PVC pipes can not be used as they will easily break during drilling. Please note: drilling with temporary casing is not further explained in this manual.



Fishing when the bit or bailer has dropped

Sometimes the drill bit or bailer has dropped in the hole because the rope around the rope eye was broken or the driller was not paying attention when connecting the jarhook. When the drill bit or bailer has fallen back into the borehole, it needs to be recovered quickly!

Solution:

Buy a chain hook or bend a hook (make it so that the hook will fit the inside of the top of the bailer) out of 12mm round bar. Attach the hook to a rope. Lower the hook in the borehole to 1 meter above the bottom of the hole and try to find the top of the bit or bailer. Then slowly lift the bit again.

Tip!

Always do regular maintenance and replace the rope around the rope eye if you see that it is damaged.

Never forget!!

1. Always choose a site at least 30 m away from a latrine and other sources of pollution.
2. If you pause drilling, lift out the drill bit or bailer. This will prevent it from being buried by a collapsing layer.
3. When leaving the site always cover the borehole, so children or animals cannot fall into the hole!
4. When drilling in hard rock, vary the height of your stroke to chisel through it more quickly.
5. When drilling in soft rock and clay, use short strokes so that the bit does not stick in the bottom of the hole.
6. When using the bailer, a short stroke is used.
7. Always take soil samples. Place them on a plastic sheet and write down the depth. This will help to determine the depth of your drilling.
8. Always place your filter screen in the coarsest layer of sand or gravel.
9. Use a sump (blind pipe) below your filter screen to collect any fine material that enters the well.
10. A guideline for the length of the filter screen is 3 meter.
11. The secret to percussion drilling is to focus on making mud.
12. When the drilling is finished and you are leaving the site, remember to cover the PVC well casing. This is needed to assure that nothing can be dropped into the well by children.

Tool maintenance

- o Regularly sharpen the teeth of the drilling bit using an angle grinder.
- o Do a welding inspection on all the tools at a regular basis.
- o Check if the tools are complete and purchase or replace if necessary.
- o Check regularly if the valve of the bailer is functioning properly.
- o Replace the rope around the rope eye if you see that it is damaged.
- o Clean the tools and the rope at the end of each day. The rope will last much longer if all the mud is cleaned off and it is hung to dry out.

NOTE:

The manual: Drilling wells by hand with Hand Powered Percussion Drill, written by Cliff Missen of Wellspring Africa, has been very useful. We thank Cliff Missen for his permission to use some parts out of his manual in this publication.



PERCUSSION

Module 3



MAKING THE PERCUSSION DRILLING EQUIPMENT



1. WHAT TO BUY

This module explains how to fabricate all drilling equipment. It consists of a materials list for the drilling equipment and tools and a package of technical drawings, including tips that are necessary to make a complete drilling set.

Material list for the construction of drilling equipment

	Part	Material	Dimension (mm)	Thickness (mm)	Amount	Additional information
Percussion tripod	poles	pipe	Ø50 x 4 x 12250	4	1	Steel or wood
		flat bar	100 x 50 x 5	5	3	steel
	pin	round bar	10 x 100	10	3	steel
	pulley	pipe	Ø 58 x 200 x 3	3	3	steel
		angle iron	50 x 50 x 1480	4	1	steel
		round bar	Ø 14 x 1000	14	1	steel
		round bar	Ø 20 x 310	20	1	steel
	wheel	pipe	Ø 35 x 100	3	1	steel
		sheet metal	Ø 300	2	1	steel
		flat bar	30 x 950	3	2	steel
	bearing	80 x 21	21	1		
						must fit around pipe 35 mm
Jar hook	hook	flat bar	50 x 450	5	1	steel
		round bar	Ø 20 x 90	20	1	steel
Bailer	handle	round bar	Ø 20 x 850	20	1	steel
	pipe	pipe	Ø 120 x 800	4	1	steel
	valve	sheet metal	95 x 108	4	1	steel
		pipe	Ø 14 x 85	2	1	steel
		round bar	Ø 10 x 90	10	1	steel
	pipe	Ø 112 x 30	6	1	steel	
Percussion bit	handle	round bar	Ø 20 x 850	20	1	steel
	weight	round bar	Ø 75 x 900	75	1	steel
	teeth	leaf spring	100 x 105	12	1	spring steel
		leaf spring	100 x 46,5	12	2	spring steel

Purchase list for additional tools

	Part	Material	Dimension (mm)	Thickness (mm)	Amount	Additional information	
Tools	hacksaw				2	(buy also spare blades)	
	shovel				1		
	toolbox (full)				1	basic use (rope, glue, spanners)	
	wire				1	nylon, galvanized and galvanized	
	inner tube	rubber			2m		
	buckets	plastic	12 liters		2		
	sieves		mesh 1mm and 3mm		2		
	measuring tool	metal	pipe Ø 50 x 80 mm		1	steel	
		metal	round bar 8 x 1000		1	steel	
		nylon rope		6mm	30m		
	crowbar	steel	2,8m	30mm	1		
	pulling rope	braided nylon		5/8"	30m	take nylon if not available	
	Materials	PVC casing				1	size depends on pump/user requirements
		gravel pack		1mm and 3 mm		50 kg	

2. TIPS FOR CONSTRUCTION

Read the following tips together with the technical drawings at the end of this module. These tips will help you in the fabrication of the temporary casing and the measuring tool. The other drilling equipment can be made with the technical drawings only.

TIPS FOR MAKING THE DEPTH MEASURING TOOL

Take a rope (6mm) of about 35 meters long and make knots at every meter.

Option 1: measuring the depth of the water table. Use a short piece of pipe (\varnothing 50 x 80 mm) and close one side, by welding on a small plate. Drill a hole in this side to attach the rope.

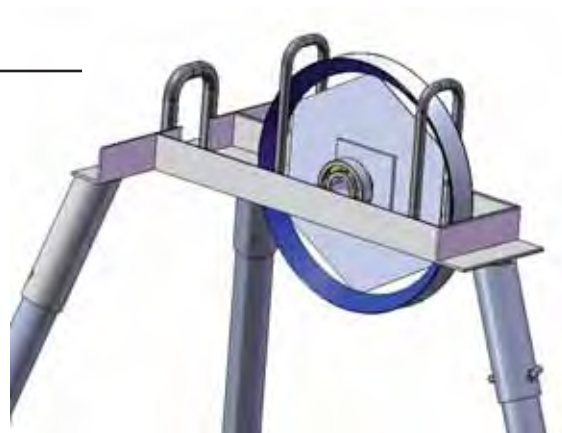
Option 2: measuring the depth of the gravel pack. Take the same rope, and remove the short piece of pipe that was used in option 1. Attach a long re-bar (\varnothing 6 x 1000 mm).



3. TECHNICAL DRAWINGS

Pulley
Drawing 002, 003

Tripod poles
Drawing 001



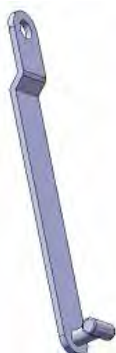
Bailer valve
Drawing 005



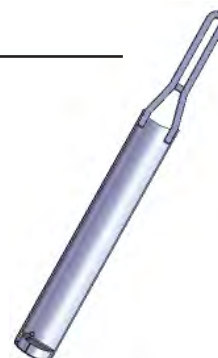
Percussion bit
Drawing 006



Jar hook
Drawing 004



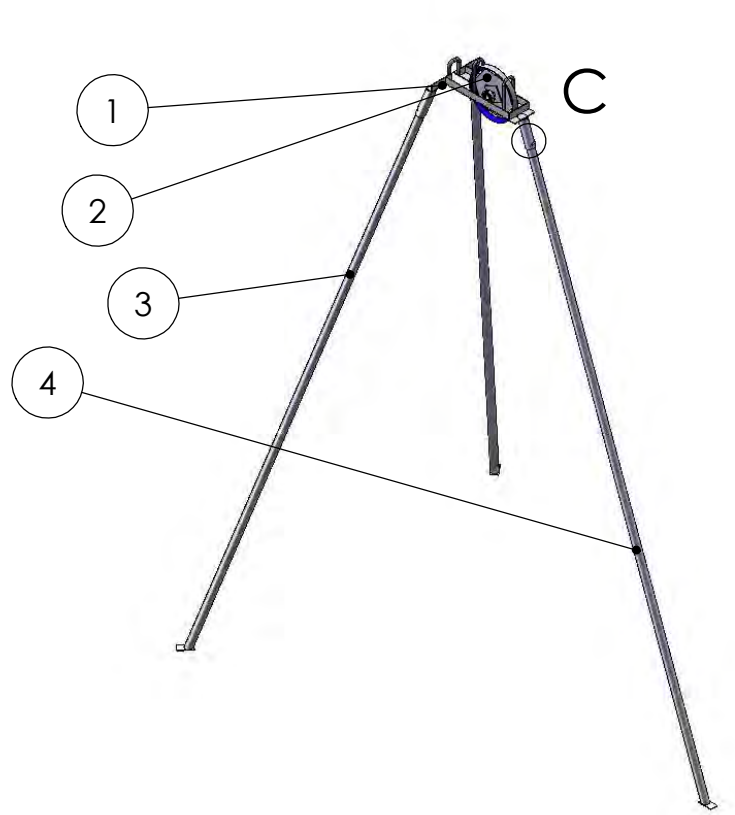
Bailer
Drawing 005



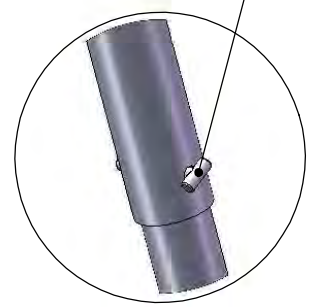
Safety pin
Drawing 001



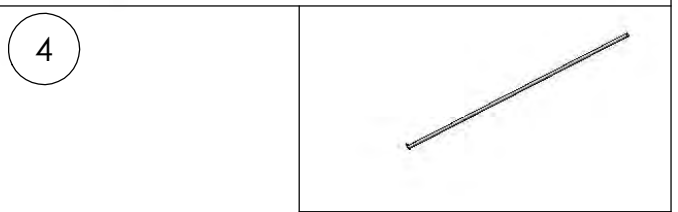
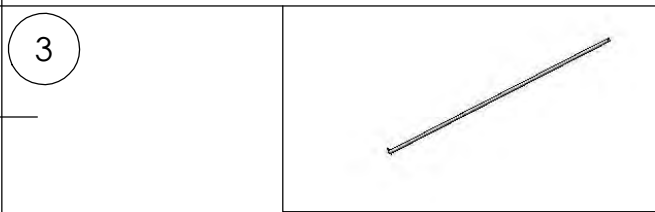
A
B
C



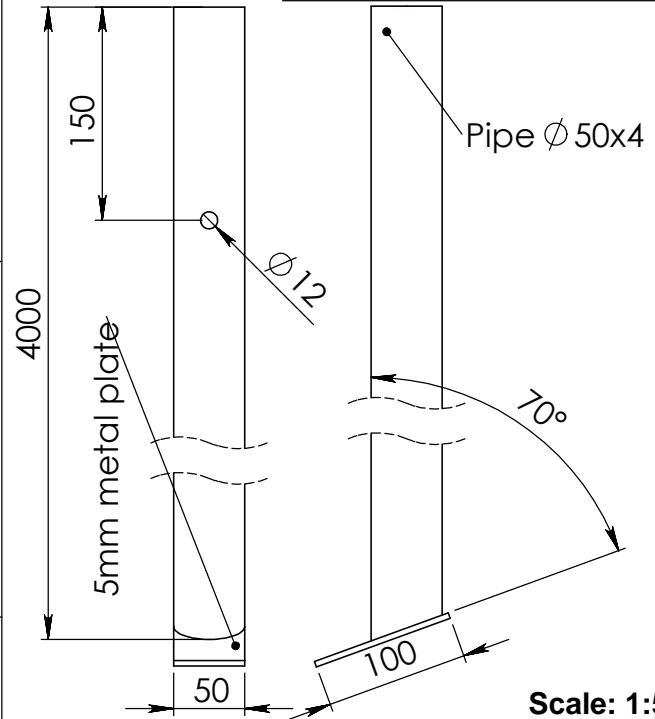
10mm Pin to secure the pole in the tripod



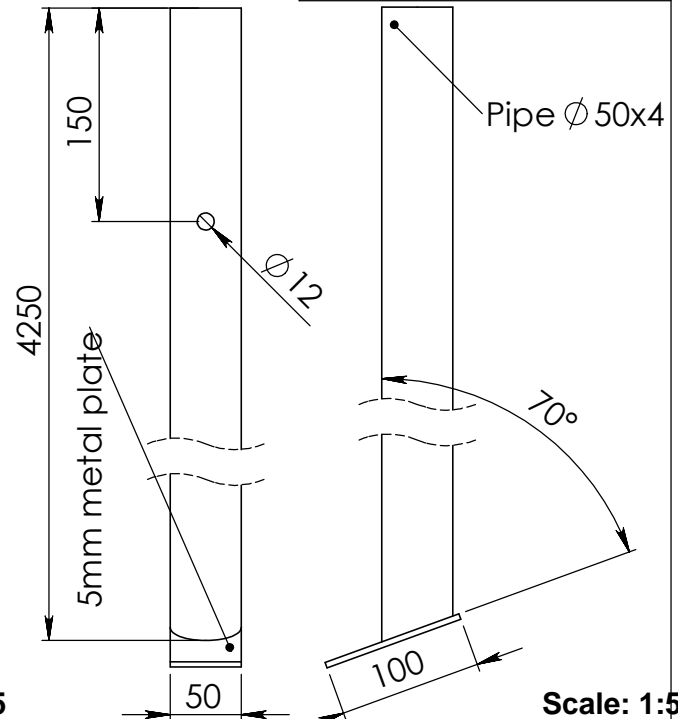
DETAIL C
SCALE 1 : 5



D
E



Scale: 1:5



Scale: 1:5

F	01	Tripod structure
	02	Pulley assembly
	03	Back poles of tripod
	04	Front pole of tripod



TITLE:
Percussion tripod (1)

DRAWN BY:
Don de Koning

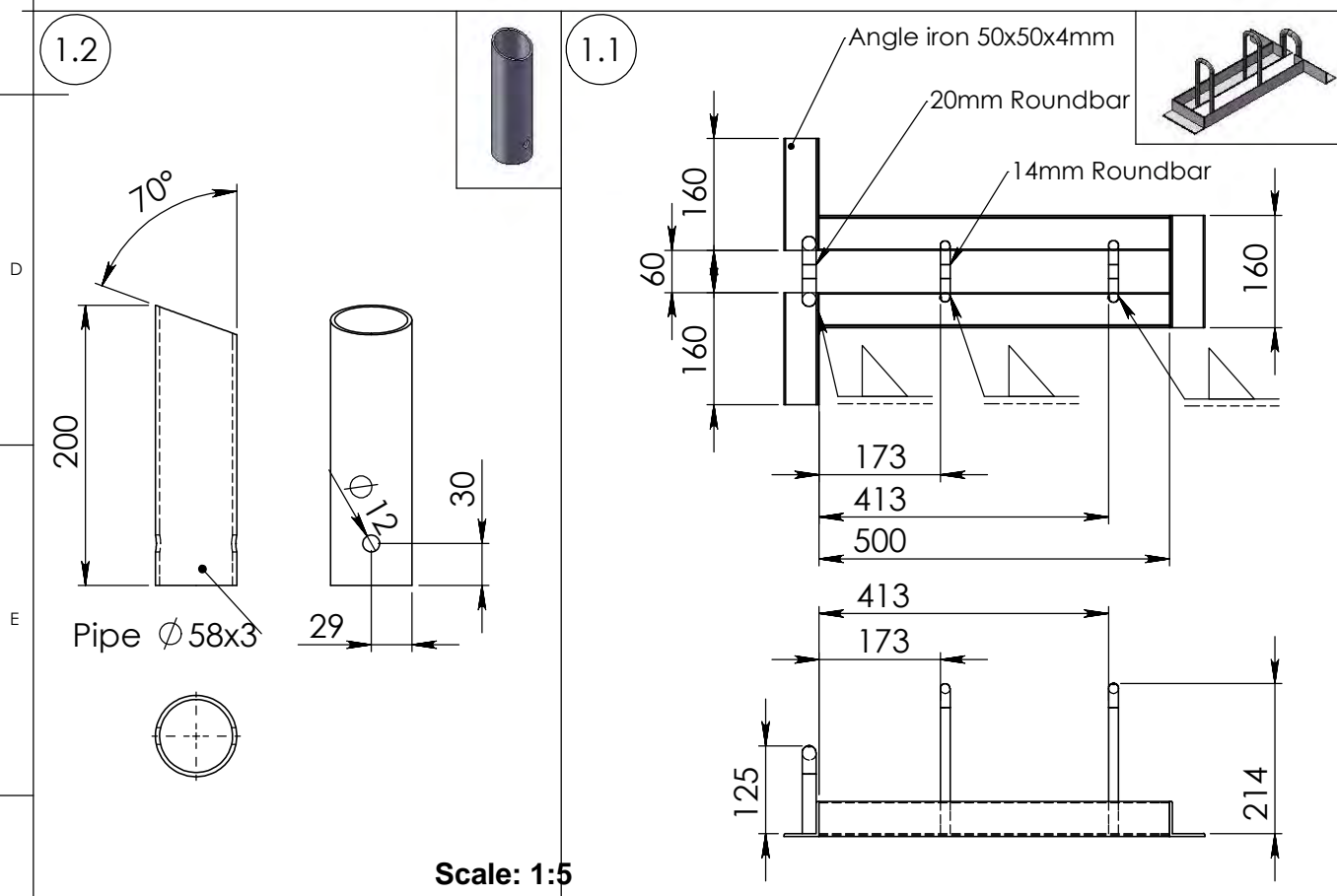
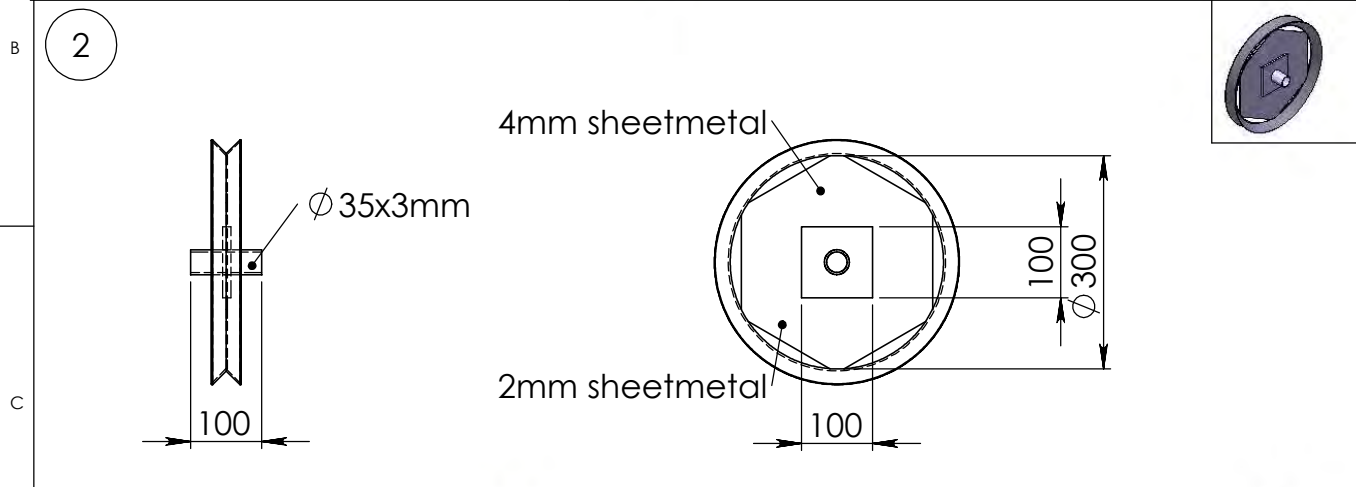
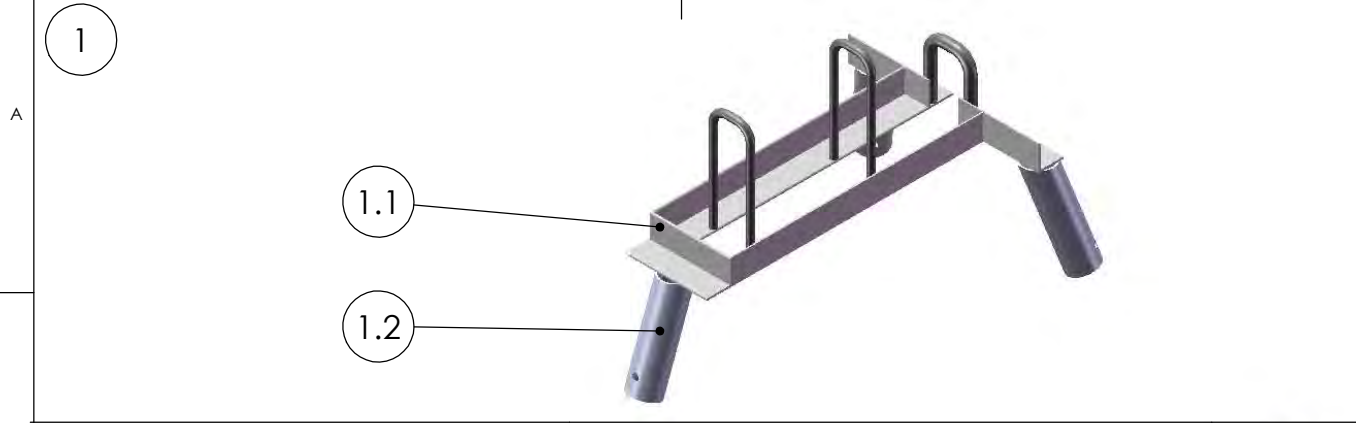
DATE:
01-06-2010

VERSION:
Final v1.0

DWG NO.
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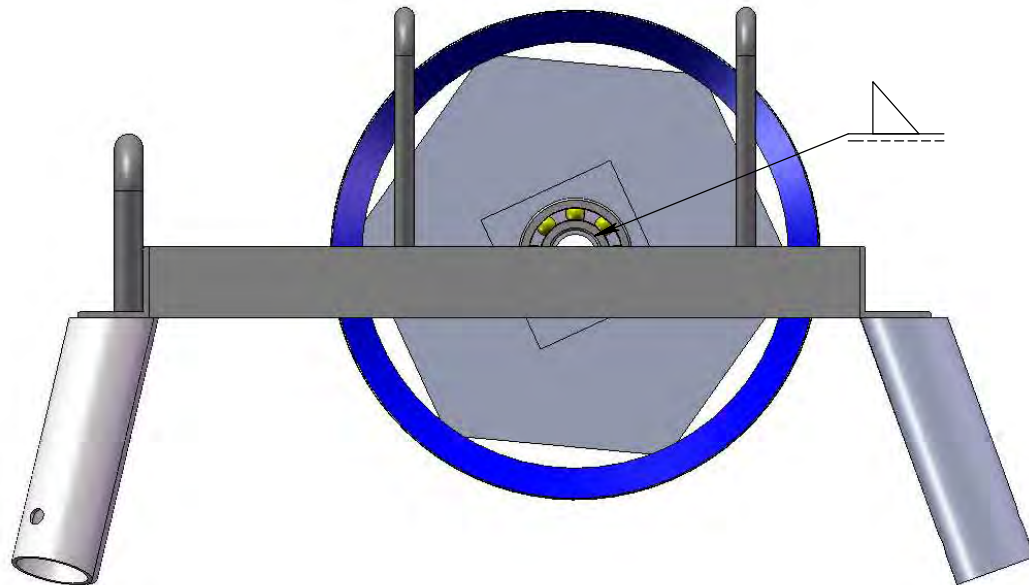
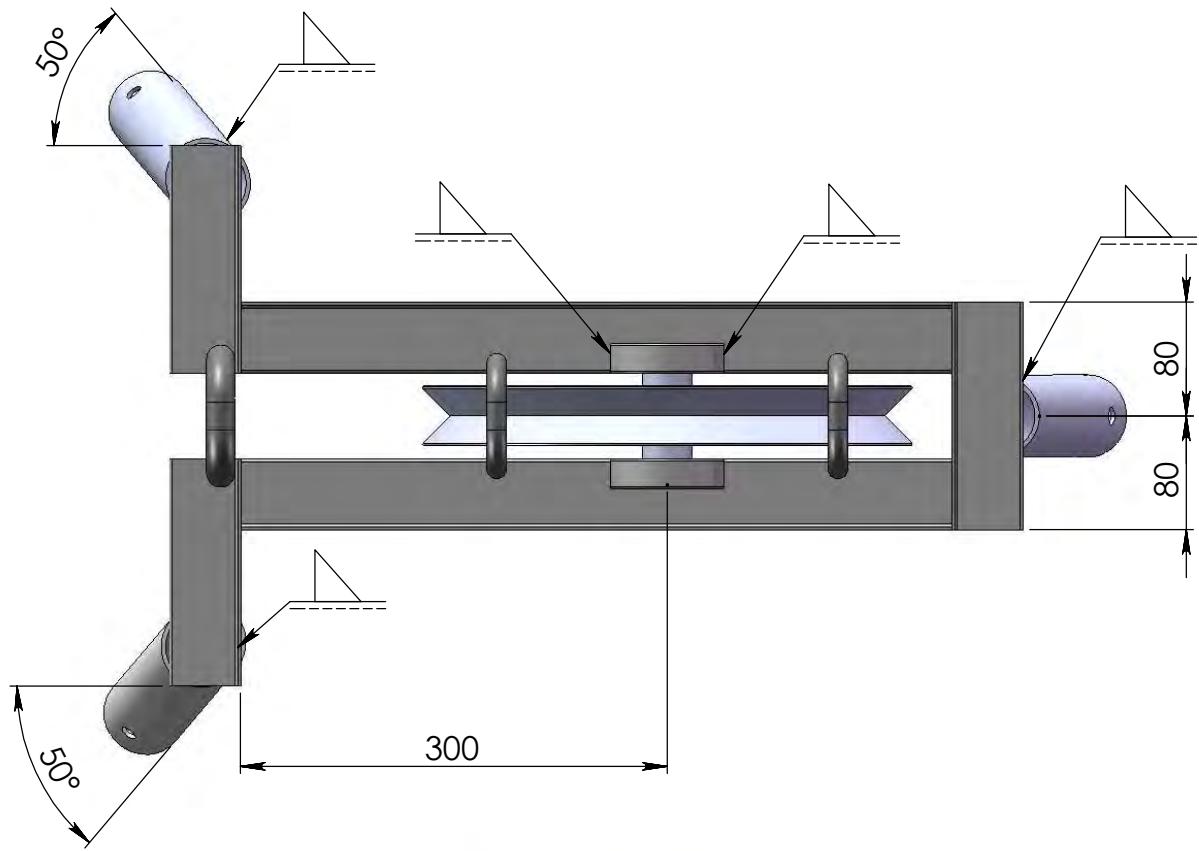
A4



Scale: 1:5

F	1	Tripod structure		TITLE:	
	1.1	base structure		<h1>Percussion tripod (2)</h1>	
	1.2	pole holder			
	2	Pulley assembly			
DRAWN BY:		DATE:	VERSION:	DWG NO.	SCALE:
Don de Koning		01-06-2010	Final v1.0	002	1:10
A4					

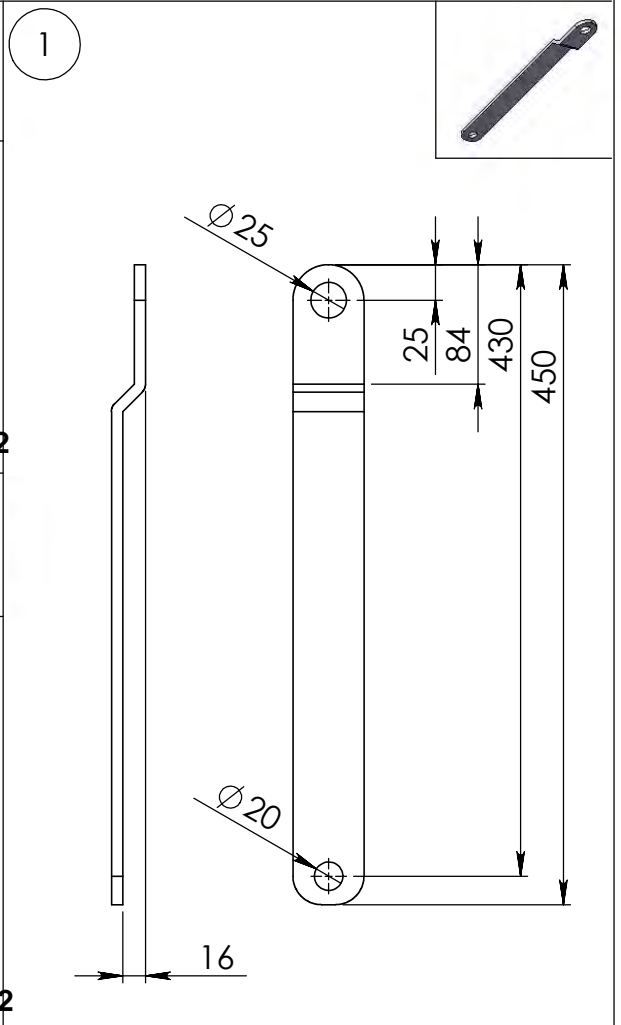
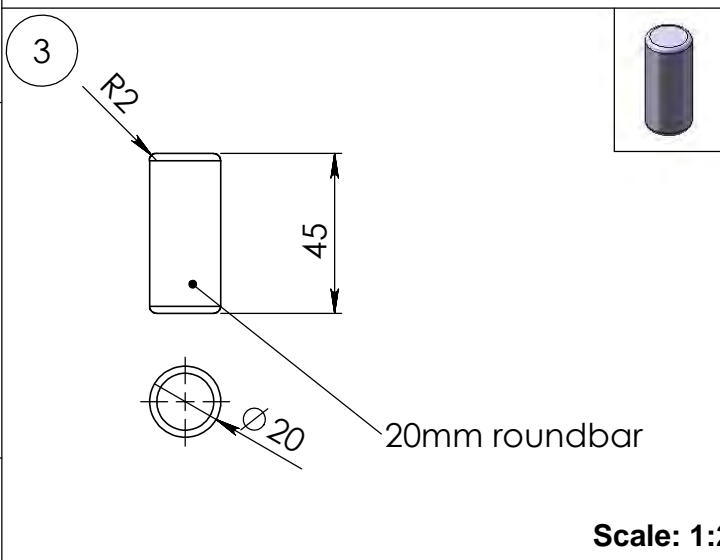
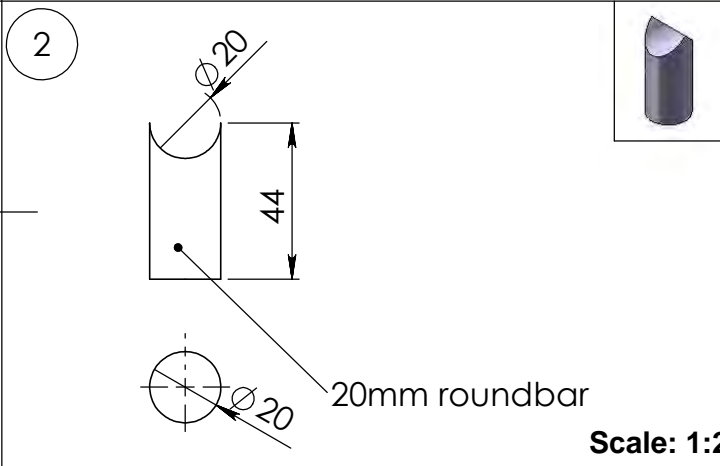
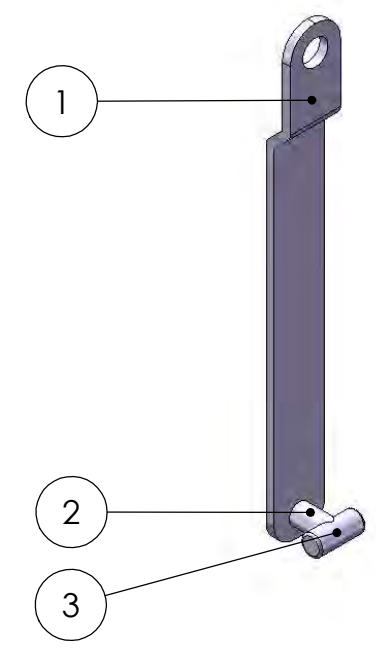
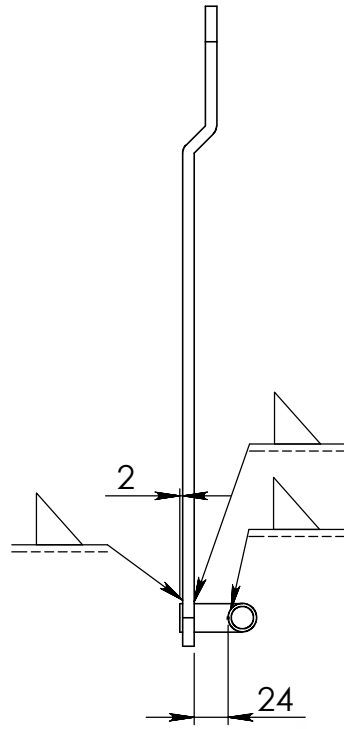
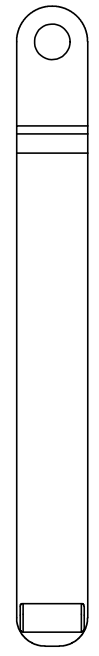
Tripod structure assembly



F				TITLE:			
				Percussion tripod (3)			
				DWG NO.	003	SCALE:	1:5
	DRAWN BY: Don de Koning			DATE: 01-06-2010	VERSION: Final v1.0	A4	

1 2 3 4

A
B
C
D
E
F



01	Hookplate
02	hookbar 1
03	hookbar 2



TITLE: **Percussion hook**

DRAWN BY: Don de Koning

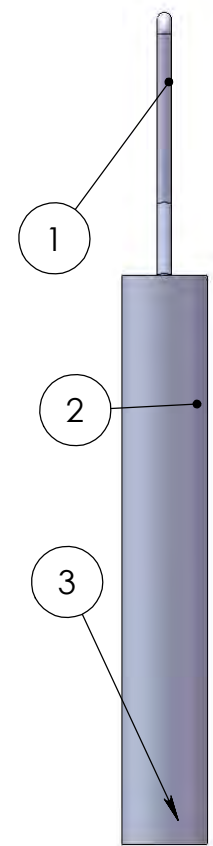
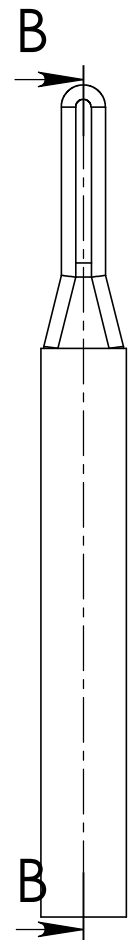
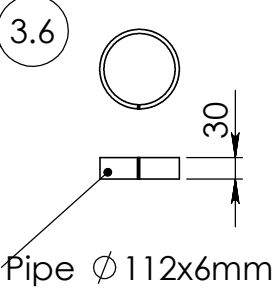
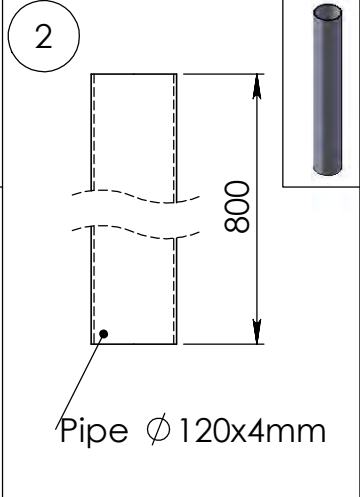
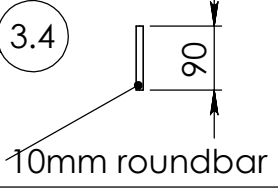
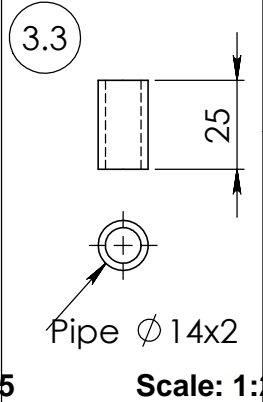
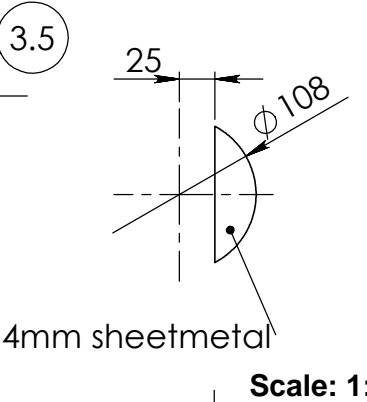
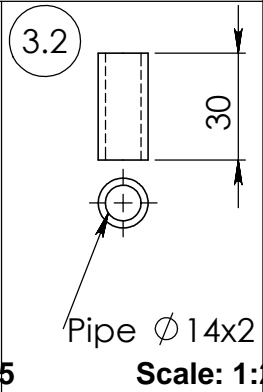
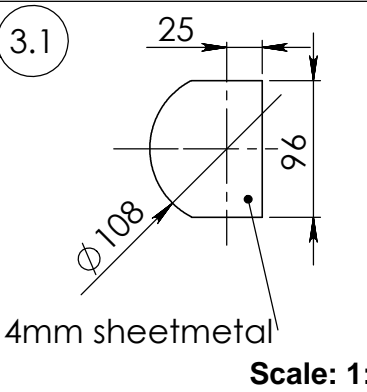
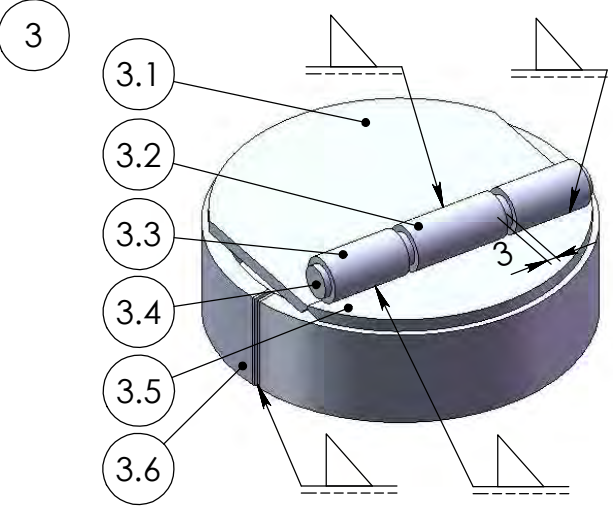
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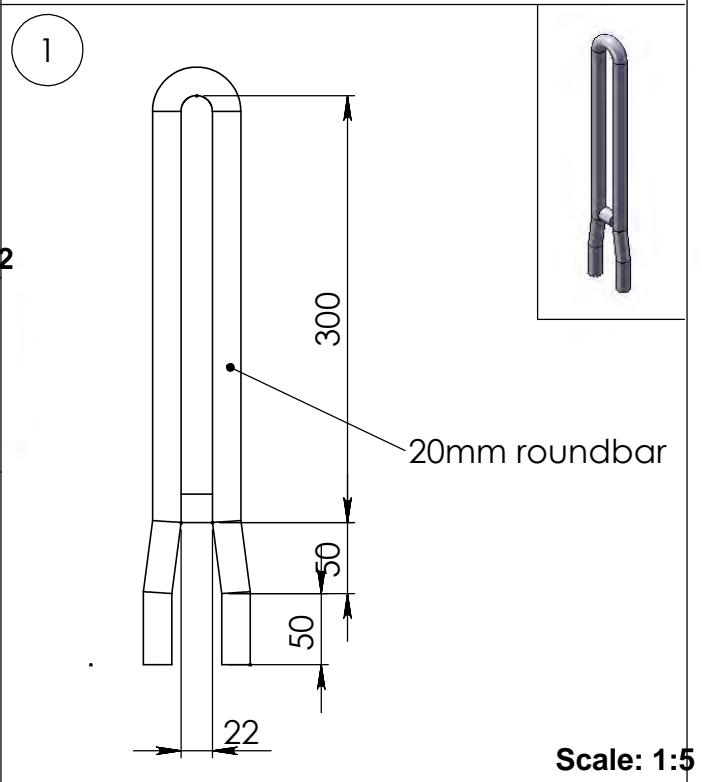
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SCALE: **1:5**

A4



SECTION B-B



01	Bailer handle ϕ 14mm
02	Bailer pipe ϕ 120x4mm
03	Bailer valve assembly



TITLE: Percussion bailer

DRAWN BY: Don de Koning

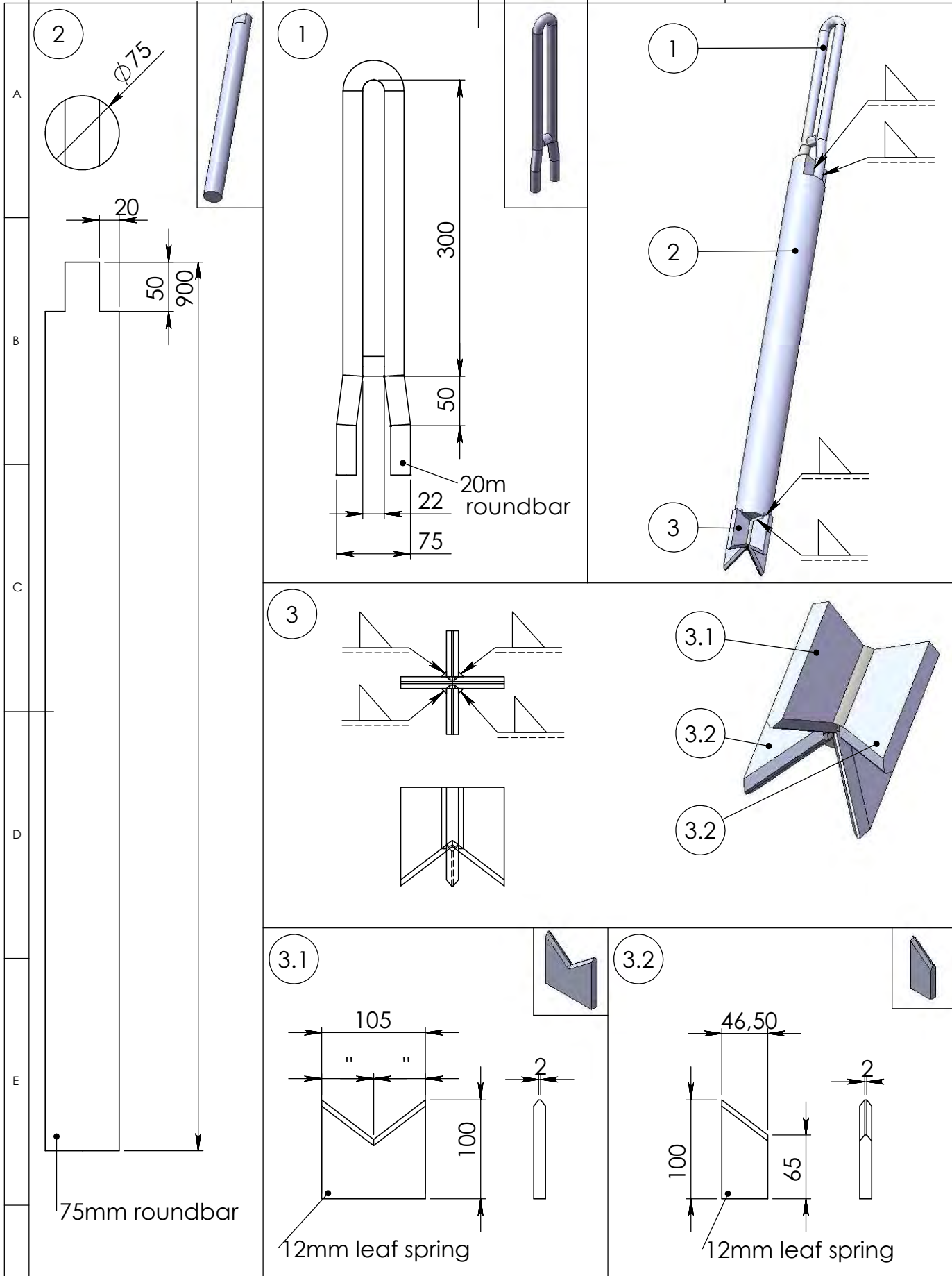
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VERSION: Final v1.0

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SCALE: 1:10

A4



F	01	handle		TITLE:	
	02	weight		<h1>Percussion bit</h1>	
	03	Teeth			
DRAWN BY: Don de Koning		DATE: 01-06-2010	VERSION: Final v1.0	DWG NO. 006	SCALE: 1:5
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