Rural Water Supply Network

Cost Effective Boreholes

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Hand Drilling Directory

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Introduction

Throughout the world, hundreds of thousands of hand, or manually drilled wells provide rural dwellers with water for agriculture and domestic use. Hand (or manual) drilling of water wells for domestic and productive use is very comment throughout most of Bangladesh and along the Ganges plain of India. In parts of Latin America and Africa, hand drilling technologies have been introduced more recently. In some cases, such as Niger and Nigeria, hand drilling has become fairly well used.

There are four distinct types of manual drilling: augering, jetting, percussion and sludging, as well as several variations on each. Increasingly, more than one or two techniques are used together. Hand drilling techniques are suitable for niche hydrogeological environments and, although a more affordable solution, do not provide a panacea for rural water supplies. There a number of cases where hand drilling techniques have been mechanised to drill deeper and faster. As this develops further, it will be interesting to observe if these techniques can drill cheaper than existing conventional drilling equipment, and if construction quality is satisfactory for the consumers.

Manual (or hand) drilled wells cost anything from US$ 20 to US$ 3,000, depending on the location, technology used, geology and hydrogeology. Given that conventionally drilled wells in sub-Saharan Africa can cost from US$ 2,000 to US$20,000, manual drilling, where feasible, could provide considerable savings for the provision of rural water supplies. Hand drilling is also attractive as it can be undertaken by small, local enterprises. In many cases the wells can be paid for by users themselves rather than external funding organisations.

Despite the tremendous potential of hand drilling technologies to provide water at low cost, they are not well known by many WASH sector professionals, and in some cases are not considered to be acceptable. There are relatively few organisations involved in the development, promotion and research of hand drilling technologies and, until recently, work tended to be fairly fragmented, with the same lessons being learned from scratch in different parts of the world.

This document provides a short summary of each of the hand drilling techniques being utilised today; a county-by-country overview of the extent of hand drilling taking place in select countries; an annotated list of organisations involved in promoting and supporting hand drilling and an extensive list of literature, from published articles to training materials and on-line videos.

It is envisaged that, practitioners, researchers and funding organisations will keep up the information flow so that this document can be updated. For an online version of the directory, please visit http://www.rwsn.ch

It should be borne in mind that the drilled well is not the end of rural water provision, as water still needs to be lifted out of the ground. Numerous hand and motor driven pumps are available on the market but these are not considered in this document.

Hand Drilling Explained

This chapter provides a succinct description of the hand drilling techniques that are currently in use.

Overview

Accessing groundwater can be undertaken by hand digging; human-powered drilling techniques (also known as manual, or hand drilling); drilling with small conventional drilling rigs; and drilling with large conventional drilling rigs. The three basic aspects of water well drilling are 1) breaking the formation; 2) removing the loose material and 3) supporting the hole as described in Box 1.

Box 1. Basic principles of water well drilling (Extracted from Carter, 2005)

All drilling techniques must be able to:

1. Penetrate, break or cut the formation to be drilled. Unconsolidated materials such as sands and silts require relatively little energy for this. Materials such as clays, laterite, sandstone and limestone require considerably more energy. The formation can be broken as follows:
   a. Percussion (repeated striking of the formation with a pick, chisel, end of pipe or a drill bit);
   b. Rotary action (grinding or tearing at the surface of the formation);
   c. High energy percussion with rotation (known as down the hole hammer);
   d. Loosening by a water jet directed at the bottom of the hole.
2. Remove the loose material from the hole. This can be done by:
   a. Alternate removal with breaking (ie break, clean, break again, clean and so on).
   b. Continuously remove material as the drilling proceeds by using a medium to flush the hole (eg water, drilling mud, compressed air). Mud-rotary drilling uses mud; well-jetting, wash-boring and sludging use water and down-the-hole hammer uses compressed air.
3. Support the hole to prevent collapse during, or immediately after drilling by:
   a. Lining the hole as the drilling progresses, with temporary casing, or permanent lining;
   b. Maintaining a sufficient pressure (hydraulic head) of fluid in the hole at all times.

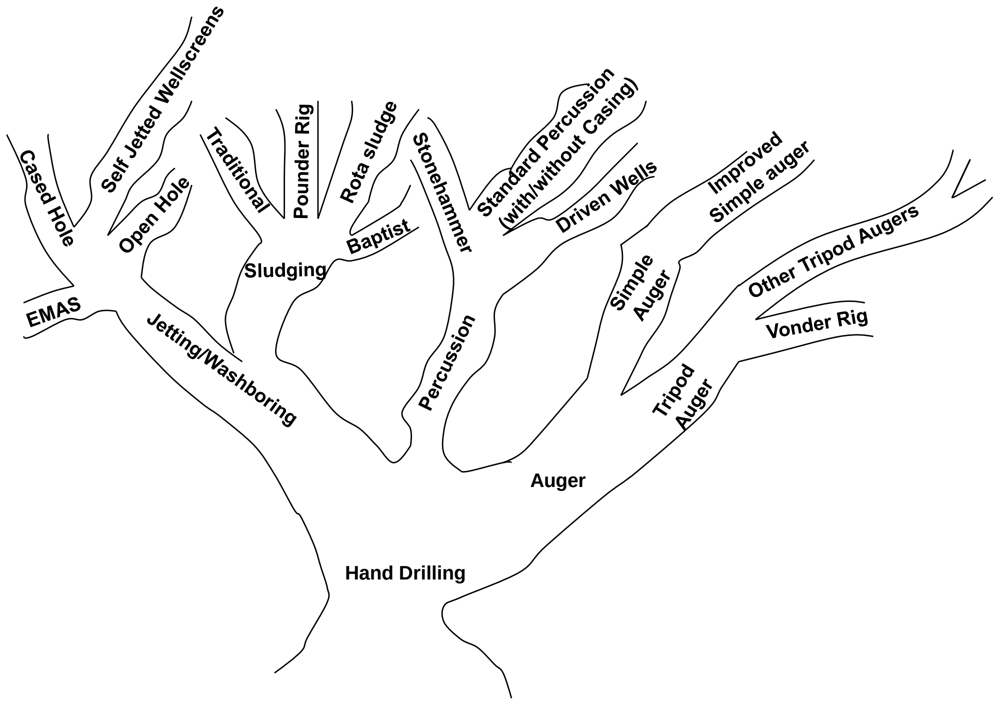
Hand or manual drilling comprises techniques that rely primarily on human energy to undertake the three aspects outlined in Box 1. As a consequence, manual drilling is constrained by the limits of human energy. Breaking the formation and removing the spoil requires considerable energy and there are thus limits as to what human-powered drilling can achieve. Minimising drilled diameters is one way to reduce energy requirements. Doubling the diameter of a drilled well increases the volume of material to be broken and removed by a factor of four.

The different techniques are only viable in certain hydrogeological formations. In cases where the formation is too hard, or the water bearing formation too deep, conventional drilling is the preferred option.

Hand Drilling Family Tree

The tree depicted in Figure 1 is an attempt to classify the various hand drilling technologies, and thus assist the newcomer in navigating his or her way through a minefield of terms. Broadly speaking, there are four distinct types of manual drilling: auger, percussion, sludging and jetting. Over time, developers of one technology have drawn lessons from another and some people use combinations of methods.

Figure 1. Hand Drilling Family Tree



The **auger** method involves penetrating the ground with a small-diameter borehole with a cylindrical or helical soil auger. This method can penetrate certain sands and silts and some clay formations.

Hand percussion and **stonehammer** drilling involve the lifting and dropping a cutting tool suspended at the end of a rope. They are dry techniques, only adding a little water in order to remove the spoil (drill cuttings).

In contrast to the above, the **jetting and sludging** methods use considerable amounts of water to wash out the spoil. Jetting (also known as **washboring**) and the **EMAS** technology inject water down and out the bottom of a drilling pipe to wash the spoil up to the surface. Self-jetted well-screens are an improvement of the original jetting technique. The use of a cutting point when jetting enables more compact materials to be drilled. A tripod (or derrick) enables the technique to penetrate deeper. The EMAS technique uses a percussion action coupled with back and forth rotation of the drill bit to break the formation, whereas jetting is designed to penetrate mainly sands and silts with the force of the jetted water.

Sludging and its more recent modifications (**Baptist**, **Rota Sludge** and **Pounder Rig**) are all continuous drilling methods that allow the drilling fluid to flow down the annulus (ie the gap between the drill pipe and the drilled hole) and carry the cuttings up through the drill pipe. The Baptist method, Pounder Rig and Rota sludge have all tried to penetrate harder formations, with varying success. The Pounder Rig places the more emphasis on drilling of a vertical hole, whereas the Baptist and Rota Sludge techniques emphasise very low cost wells. The Baptist and Rota Sludge techniques can be combined with stonehammer drilling to penetrate harder formations (eg laterite) whereas the Pounder rig is already designed for this.

Carter (2005) and Koegel (1985) provide good overviews of hand drilling technologies. Table 1 sets out the key aspects of digging and drilling techniques.

Table 1 Overview of Key Aspects of Digging and Drilling techniques

Method	Ground breaking	Hole cleaning	Hole support	Diameter (Ø) & Depth
Hand-digging	Hand-tools and/or explosives.	Bucket, shovel, rope-lift	In-situ permanent lining, or telescoped caissons; temporary support e.g. by timber/steel.	Ø = 1 to 1.5m Depth = 20m (80m in exceptional cases)
Human-powered methods				
Hand-augering	Hand-rotated cutting tool (auger) on end of solid steel rod or steel pipe.	Periodic removal of auger with drill rods/pipes.	Sometimes temporary plastic or steel casing is used.	Ø = 50 to 150mm; Depth = 20m
Hand percussion **Stonehammer**	Human-powered lifting and dropping of tools suspended at the end of a rope.	Periodic removal of the cutting tools; e.g with a bailer to gather spoil as slurry.	Temporary steel casing if required.	Ø = 50 to 200mm; Depth = 15m (20 - 30 m if no casing required.)
Sludging (S) **Pounder rig (P)** **Rota sludge (R)**	Reciprocating action of steel pipe, by lever.	Pumping action of water down annulus and up drill pipe.	Rely on drilling liquid for sufficient hydrostatic pressure for support	(S) Ø = 50 to 100mm; Depth = 30m (P) Ø = 100 mm; Depth = 30m (R) Ø = 100mm; Depth = 30m[1] (B) Ø = 32 - 150 mm; Depth = 30m[1]
Baptist drilling (B)	Reciprocating action of PVC pipe with a bottom valve. The bottom 3m pipe is iron or galvanized iron.			
Jetting (washboring)	Washing action of pumped water jet.	Flushing action of water pumped down drill pipe, flowing up annulus.	Hydrostatic pressure of water is usually sufficient. In running sand, permanent or temporary casing can be installed.	Ø = 100 - 150 mm; Depth = 6 - 10m[2]
EMAS Drilling	Reciprocating action of steel pipe, by lever.	Mainly flushing action of water pumped down drill pipe, flowing up annulus. Sometimes pumping action of water down annulus and up drill pipe.	Hydrostatic pressure of water is usually sufficient.	Ø = 50 mm; Depth = 30m
Conventional methods (small and large rigs)				
Cable percussion	Engine-powered lifting and dropping of tools suspended at end of left-hand lay steel cable.	Periodic removal of cutting tools; sometimes with use of different tool to gather spoil as slurry.	Temporary steel casing if needed; water or mud can sometimes be used in place of temporary casing.	Diameter and depth depends on the make and model of drill equipment. Diameters of up to 12 inch and depths to 800m are possible.
Mud rotary	Slow rotary action of drill bit together with washing action of pumped mud.	Flushing action of mud pumped down drill pipe, flowing up annulus.	Hydrostatic pressure of mud (with blocking/thickening agent if necessary)	
Down-the-hole hammer	Slow rotary action of rapidly percussing air-powered	Flushing action of high volume/high pressure air pumped down drill	In collapsing ground simultaneous (temporary) casing can be drawn in	

[1] There are claims by those involved in the development of these techniques that they have drilled deeper.
[2] Depths of 30m have been recorded when drilling through silt.

Hand Augering

Description: Hand augering can be undertaken with a heavy tripod and winch (such as provided by the Vonder Rig in Figure 2). Alternatively, very light equipment can also be utilised such as that common in Niger (Figure 3). Common to both of these rigs is the auger bit (Figure 4). A bailer can also be used to remove the spoil form the hole in the form of a slurry. Drilling is undertaken by rotating the auger into the ground, and adding additional drill pipe as the hole deepens.

Figure 2. Vonder Rig

Figure 3. Light Hand Auger Equipment

Figure 4. Auger Bits

Capability: Hand auger drilling can be undertaken in a limited range of unconsolidated formations i.e. non-collapsing sands and silts and some clays. Stiff clay, gravels and hard materials cannot be drilled unless the technique is combined with percussion drilling. Temporary casing can be utilised with some equipment. The depth limit for hand augering is about 20m. Diameters range from 50 to 200mm.

Locations: The Vonder rig has been used extensively in Zimbabwe and distributed widely within sub-Saharan Africa. Hand augering experiences have been made in Niger, Tchad, Senegal, The Gambia, Uganda, Zimbabwe, Tanzania and Nigeria and Niger.

Equipment Availability: Off the shelf hand auger equipment (with heavy tripod) is available from V&W Engineering (Zimbabwe), Van Reekum (Netherlands) and Eijkelkamp (Netherlands), Dormer Engineering (Australia). Lighter, but effective hand auger equipment is also manufactured in Niger by Chafagane Maiga, S/C BP: 10988 Niamey, Tel: +227 96 53 18 88.

Documentation:

Blankwaardt. 1984. *Hand Drilled Wells*. Rwegarilia Water Resources Institute, PO Box 35059, Dar Es Salaam Tanzania

DHV. 1979. *Shallow Wells*. Development Corporation Information Department, DHV Consulting Engineers DHV Consulting Engineers, PO Box 85, Amersfoort, the Netherlands, Available from: <http://www.dhv.nl>

Koegel, R. 1985. *Self Help Wells*. FAO Irrigation and Drainage Paper, FAO, Rome. Available from World Wide Web: < http://www.fao.org/docrep/x5567e/x5567e00.htm>

Naugle, J. 1996. H*and Augered Garden Wells*, Lutheran World Relief (3rd edition 1996). Available (in English and French) on World Wide Web<http://www.enterpriseworks.org/pubs/Hand%20Augered%20Wells-color.pdf>

Carter R.C 2005. *Human-Powered Drilling Technologies - an overview of human-powered drilling technologies for shallow small diameter well construction, for domestic and agricultural water supply*. First Edition, May 2005, Cranfield University, UK. Available from: World Wide Web: <http://www.rwsn.ch/documentation/skatdocumentation.2005-11-15.5533687184>

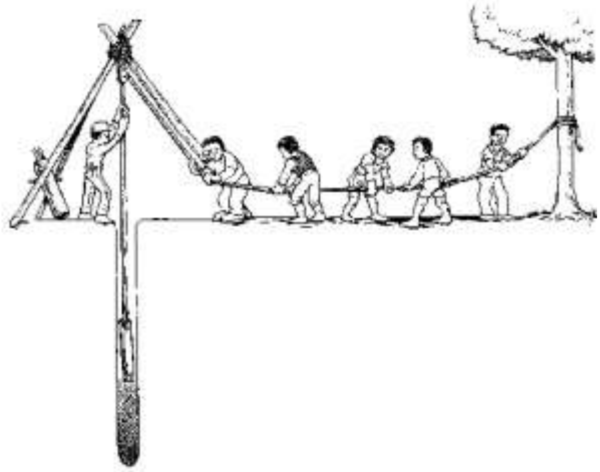
Danert, K.2006. *A brief history of Hand Drilled Wells in Niger: Only the beginning*. RWSN/WSP Field Note. Available in English and French). Available from World Wide Web: < http://www.rwsn.ch/documentation/skatdocumentation.2007-06-04.6706724248> and < http://www.rwsn.ch/documentation/skatdocumentation.2007-06-05.5454259082>

Hand Percussion

Description: Percussion (also known as cable tool) drilling refers to the alternate breaking of the formation and cleaning the hole. Percussion drilling is often undertaken with different tools – eg a chisel to break followed by a bailer to remove the spoil. There are also clay-cutting tools available that can both cut and remove the spoil. The drilling tools and weights (referred to as the tool string) is suspended from a rope or steel cable and reciprocated through a stroke of 1 to 3m (Figures 5 and 6). Small amounts of water are usually added to the hole to help loosen the formation. It is often necessary to line the hole with temporary steel casing to prevent collapse.

Figure 5. Hand percussion rig in action

Figure 6. Schematic of hand percussion rig



Capability: In principle, percussion drilling can deal with most ground conditions but progress can be very slow in hard rock. Due to the limited energy inputs of hand percussion, progress is considerably slower than for conventional (mechanised) percussion drilling. If temporary casing is used, considerable time and suitable tools are needed to drive it into the ground and remove it. Depths of 20 to 30m are possible if there is no temporary casing required, otherwise the limit is about 15m.

Locations: Zimbabwe, Tanzania, Liberia, Niger, Nigeria, Chad, Ghana, Central America.

Availability: Hand percussion is not commonly used today. However, there are some cases of mechanised percussion, and the principles of percussion are used alongside other techniques such as sludging, or have been integrated into other combination hand drilling techniques such as rota-sludge and pounder drilling.

Documentation:

Carter, RC. *Human-Powered Drilling Technologies - an overview of human-powered drilling technologies for shallow small diameter well construction, for domestic and agricultural water supply*. First Edition, May 2005, Cranfield University, UK. Available from: World Wide Web: <http://www.rwsn.ch/documentation/skatdocumentation.2005-11-15.5533687184>

Koegel, R. 1985. *Self Help Wells*. FAO Irrigation and Drainage Paper, FAO, Rome. Available from World Wide Web: < http://www.fao.org/docrep/x5567e/x5567e00.htm>

Missen C. 2007. *Wellspring Africa*. <http://www.wellspringafrica.org/>

Stonehammer drilling

Description: This technique is a variation of hand percussion drilling (Figure 8). A 60cm long cutting tool is fitted to the base of a drill pipe. A 70kg steel weight (or hammer) is lowered into the drill pipe. This hammer is raised and dropped onto the cutting tool, forcing it to penetrate the formation, before being lifted out carrying the cuttings (Figure 7).

Figure 7. Stonehammer Drill

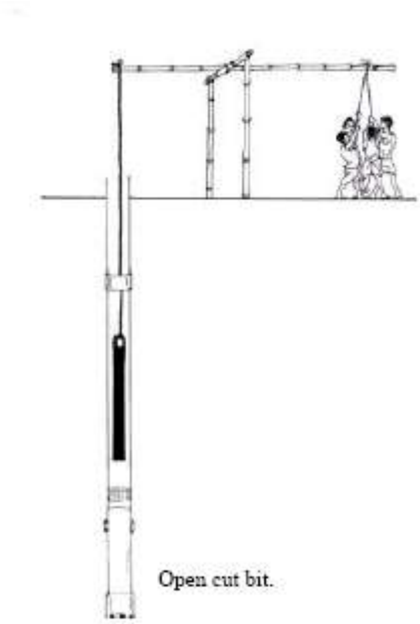


Figure 8. Stonehammer Drilling in Action

Capability: The stone hammer drilling method can penetrate reasonably hard formation, but progress is slow.

Locations: Nicaragua and India.

Equipment Availability: No off the shelf technology is available, but the rig can be assembled in a reasonable local workshop. Drawings and assembly guidelines are available in the sources set out in the reference list.

Documentation: Key references on stonehammer drilling are:

Van Herwijnen, A. 2005a. *Rota Sludge and Stone Hammer Drilling – Part 1 Drilling Manual*, PRACTICA Foundation & ETC Energy. Maerten Trompstraat 31, 2628 RC Delft, the Netherlands

Van Herwijnen, A. 2005b. *Rota Sludge and Stone Hammer Drilling – Part 2 Production Manual*, PRACTICA Foundation & ETC Energy. Practica Foundation Maerten Trompstraat 31, 2628 RC Delft, the Netherlands

Driven Wells

Description: A driven well refers to driving a well point and well screen directly into the ground using a hammering tool (Figure 9 and Figure 10). The material is forced aside rather than excavated by this technique. This technique is sometimes used in conjunction with hand augering.

Figure 9. Well driving device (guided on outside of pipe)

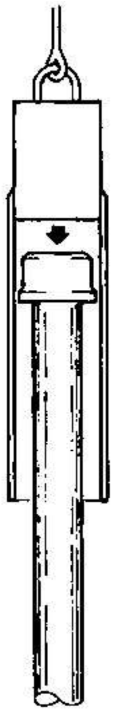
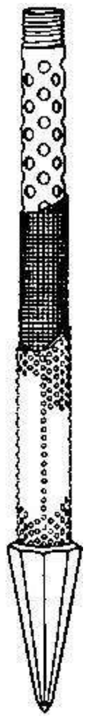


Figure 10. Drive points and screen



Capability: Koegel (1985) states that the 25 to 30 meters is probably the maximum depth for a driven well. The depth depends on the build-up of friction between the pipe and the formation drilled and the driving force available. A hand driven well can generally only penetrate about 1-2 meters into course sands due to resistance. Use of machinery can enable greater depths to be reached.

Locations: Chad, Cameroon and Madagascar

Documentation:

Koegel, R. 1985. *Self Help Wells.* FAO Irrigation and Drainage Paper, FAO, Rome. Available from World Wide Web: < http://www.fao.org/docrep/x5567e/x5567e00.htm>

Hand Sludging

Description: Hand sludging (also known as Asian, or Indian sludging) is a traditional technique used in parts of Nepal, India and Bangladesh. It involves reciprocating a steel pipe (of 25 to 40mm diameter) vertically in a shallow pit, which is kept full of water (Figure 11 and 12). The reciprocating action is achieved by a lever, which is attached to a bamboo frame. One operator operates the lever while the other uses his hand over the top like a flap valve. On the up-stroke the hand covers the pipe, while on the down stroke it lifts off. This action enables the cuttings to be carried up through the drill pipe and exit at the top.

The water in the pit flows back down the drilled hole and then up the inside of the pipe, carrying the cuttings. This provides a continuous circulation of water for the removal of the spoil as a sludge (hence the name of the technique). Thickeners or stabilisers can be added to the water in the pit to prevent collapse of the hole and reduce lost circulation. Cow dung and sawdust are commonly used thickening materials.

Figure 11. Sludging Equipment

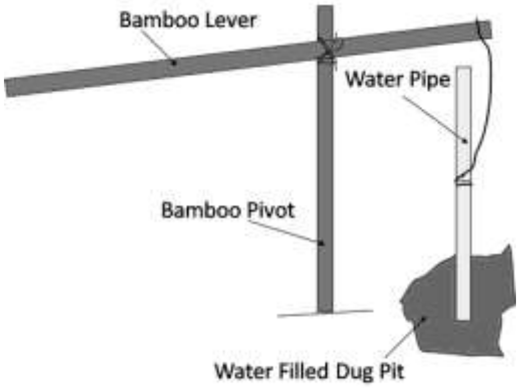


Figure 12. Sludging in West Bengal

Capability: Hand sludging is an excellent method for drilling silts, sands and certain clays. Hard layers can reduce speed of penetration or halt progress completely. Some clays can block the sludging pipe. Coarse gravels and sands can result in lost circulation and thus failure to remove spoil from the hole. Depths of up to 15m are common.

Locations: Extensively used by private artisans (mistries) India, Bangladesh, Tchad.

Availability: Hand sludging equipment is made locally in parts of India, Nepal and Bangladesh.

Documentation:

Ball P and Danert K. 1999. Hand Sludging a Report from North West Bengal, Cranfield University, UK. Available from World Wide Web: <http://www.rwsn.ch/documentation/skatdocumentation.2005-11-15.7306798097>

Carter, RC. *Human-Powered Drilling Technologies - an overview of human-powered drilling technologies for shallow small diameter well construction, for domestic and agricultural water supply*. First Edition, May 2005, Cranfield University, UK. Available from: World Wide Web: <http://www.rwsn.ch/documentation/skatdocumentation.2005-11-15.5533687184>

Knight J. 1995. Low Cost Drilling Methods: Improvements to Sludging to Penetrate Hard Layers. M.Sc Thesis, Cranfield University, UK.

Baptist Drilling

Description: Terry Waller of Water for All in Bolivia developed Baptist drilling in 1993. It is a hybrid between sludging and percussion drilling. The main difference is that while hand sludging relies on a person's hand at the top of the drill pipe as a valve, the Baptist method uses a valve, incorporated into the bit at the bottom of the drill stem.

The drill pipe and bit are normally not removed from the borehole until drilling is finished. Drill cuttings are suspended in the drilling fluid (mud) and pumped to the surface. The percussion action is performed by lifting the drill stem using a rope and pulley attached to a simple (wood or bamboo) derrick. Drilling diameter is kept small as possible with standard drill bits made from 1¼" (32 mm) internal diameter iron plumbing accessories. With reamer bits the hole diameter can be increased to 150 mm. The drill pipe is iron or galvanized iron for the bottom 3m, with PVC pipe extensions to keep the equipment light. The drill is lifted with a rope and pulley and the drill can be rotated some 90 degrees. Some drillers have motorised the lifting action. In Tanzania, the technique has been adapted for the local conditions and uses reamer bits to ream holes up to 150 mm where needed (called the SHIPO version).

Capability: This technique works best in sand, loam, small gravel and light rock. It will not penetrate hard rock or boulders. The standard drill bits work through sticky and even consolidated clays. Optimum results in varying conditions are obtained with an array of different bits, including those without a valve. In layers of pure clay or gravel, progress is slow compared to sludging, since the clay has to be pounded into suspension and stones have to be ground to small pieces to pass through the footvalve. With the Shipo version of the Baptist as used in Tanzania, stones smaller than 3 cm can be lifted in one piece because of the use of an open drill bit combined with sludging. Drilling speed is variable with different soil conditions and crews, but over 15 m per day have been obtained in favourable conditions.

Figure 13. Reaming of a Baptist drilled hole by sludging

Figure 14. Drill bit with foot valve above

Equipment and Cost: The core element of the rig can be made in almost any arc-welding workshop, using materials that can be found locally. A complete Baptist rig, all tools included and capable of drilling up to 30 m deep, can be assembled in Nicaragua for about US$ 150. In Bolivia, the wells cost around US$2 per meter (well casing and a low-cost PVC pump and small provision for rig maintenance). Prospective well owners provide all labour.

Locations: Water for All in Bolivia provides training and advice on purchase of materials to communities (Water Clubs) that want to drill their own wells. Farmer-to farmer training is used to pass the method onto other communities. To date, over 2,000 Baptist wells have been drilled in 12 countries. Most wells are in Bolivia, followed by Nicaragua, Sri Lanka and Cameroon with trials in Ethiopia, Kenya, Tanzania, Zambia, Mozambique, Malawi, Togo, Mexico, Argentina, Costa Rica, Nigeria and Mali, the Netherlands, USA and Chile.

Documentation:

Cloesen P. 2007. Baptist Drilling. Available on World Wide Web:
<http://www.rwsn.ch/documentation/skatdocumentation.2008-05-28.2809675686>

Fitzgerald, C. 2007. Low Cost Manual Well Drilling – Applicability throughout the World. Paper, Geological Society of America Abstracts with Programs, Vol. 39, No. 6, p. 522

josephstocker. 2007. www.waterforallinternational.org [online] [Accessed on 7th January 2009] Available from World Wide Web: <http://www.youtube.com/watch?v=U229vv-McNw&NR=1>

paulcloesen. 2008. Baptist Well Drilling: motorized [online]. Available from World Wide Web <http://www.youtube.com/watch?v=W6SIRaoVQZ4&NR=1>

Water for All. 2005 [online] Available from World Wide Web <http://www.geocities.com/h2oclubs/>

Waller, T. 2009 [online] Bolivian Baptist Well Drilling. Available from World Wide Web <mhtml:http://waterforallinternational.org/Documents/WFA%20Bolivian%20Baptist%20Drilling%20System.mht!WFABolivianBaptistDrillingSystem_files/frame.htm>

Baptist Well Drilling Technology. 2009. [online] Available from World Wide Web <http://www.arrakis.nl/view_more.php?page=baptist_well_drilling_technology>

Pounder Rig

Description: The Pounder Rig has been derived from sludging, but has been designed to deal with the weathered overburden, also known as regolith, which lies on top of basement formation. These conditions are common in much of Africa.

The principle of drilling is the same as for sludging. It involves reciprocating a steel pipe (of 25 to 40mm diameter) vertically in a shallow pit, which is kept full of water. However, rather than a bamboo frame, a steel frame is used (Figure 15). This ensures that the hole is drilled vertically and assists in separating the cuttings from the water and thus the recirculation of the drilling fluid. A see-saw mechanism is used to raise and lower the drilling pipe, and a steel and leather flap at the top of the pipe (inside an upturned bucket) acts as a valve. The drill pipe comprises carbon steel "wireline" drill pipe, which is considerably stronger than galvanised iron (GI) pipe and able to resist the stresses imposed by the impact on the very hard layers. Hardened steel drill bits are used to penetrate hard rock (Figure 16).

Figure 15. Pounder rig in Uganda

Figure 16. Hardened Steel Button Bit

Capability: The Pounder Rig can drill through clay, sand, silt, gravel, laterite and limited amounts of hard rock. The limitations are primarily due to the slow progress in hard formations.

Locations: Uganda.

Equipment Availability: One rig has been manufactured and is currently in Uganda.

Documentation:

Ball, P and Carter, R, C. 2000. *Specification and Drawings for the Pounder Rig*. Report of DFID KAR Project R7126 "Private Sector Participation in Low Cost Water Well Drilling", Cranfield University. First Edition, July 2000. ISBN 1861940 53X.

Carter, R, C. 2001. *Private Sector Participation in Low Cost Water Well Drilling*, DFID Infrastructure and Urban Development Division KAR PROJECT R7126 Final Report.

Rota Sludge

Description: The rota sludge technique is similar to hand sludging and the Pounder rig. It involves raising and lowering a steel pipe, which is weighted at the bottom and fixed with a drill bit on the base to drill the hole (Fig 19). A simple wooden frame and lever are used to enable the reciprocating action (Figure 17). Water mixed with cow dung is used as drilling mud – ie to carry the cuttings to the surface and prevent collapse of the drilled hole. A hand, placed at the top of the pipe acts as a valve, lifting up and releasing the cuttings on the down stroke and covering the pipe on the up stroke. A pit (Figure 18) enables the drill cuttings to settle out and thus the mud to be recycled. A handle is clamped to the drill pipe. This allows rotation of the drill pipe, which assists to scrape and break the formation.

Figure 17. Rota sludge drilling

Figure 18. Settling Pit

Figure 19. Drill Bit

The stone-hammer technique is used in conjunction with the rota sludge technique to penetrate hard formation.

Capability: Rota sludge drilling is capable of penetrating soft, sandy formations. Gravel and small stones within such formation can be lifted. The technique can be used to drill through, more cohesive sandy formations and most clay. When very stiff clay, layers of hard rock, or boulders are encountered, these are broken using the stone-hammer attachment. However, due to the limits of human energy, progress through such formations can be slow.

Locations: Nicaragua, Tanzania, Madagascar, Ghana, Senegal, Mauritania and Niger.

Equipment Availability: No off the shelf technology is available, but the rig can be assembled in a reasonable local workshop. Drawings and assembly guidelines are available in the sources from Van Herwijnen (2005a) and Van Herwijnen (2005b).

Documentation:

Van Herwijnen, A. 2005a. *Rota Sludge and Stone Hammer Drilling – Part 1 Drilling Manual*, PRACTICA Foundation & ETC Energy. Maerten Trompstraat 31, 2628 RC Delft, the Netherlands. Available on World Wide Web: <http://www.practicafoundation.nl/>

Van Herwijnen, A. 2005b. *Rota Sludge and Stone Hammer Drilling – Part 2 Production Manual*, PRACTICA Foundation & ETC Energy. Practica Foundation Maerten Trompstraat 31, 2628 RC Delft, the Netherlands. . Available on World Wide Web: <http://www.practicafoundation.nl/>

Practicafoundation. 2008. Rota sludge drilling Madagascar January 2008 [online]. [Accessed 7th January 2007] Available from World Wide Web: <http://www.youtube.com/user/practicafoundation>

Well Jetting, Washboring of Hand Turning

Description: Well jetting, also known as washboring, is considered to be a manual drilling technology, even though it utilises a small pump. The technique involves pumping water (with a hand, or motorised pump), down the drill pipe, which is held vertically in the hole. The water passes through the bottom, open end of the pipe and carries the drilling spoil up the annulus. The drill pipe is held vertically and slightly rotated and/or reciprocated. It is the washing action of the water, which forms the hole. The drill pipe is usually up to 50mm in diameter, while the hole is 100 to 150mm. The equipment comprises a centrifugal pump, suction hose, flexible delivery hose, elbow and swivel and jetting pipes. Temporary casing can be used, but a technique which enables the self jetting of wellscreens has also been developed (Figure 20). In cases where the ground is very compact, a special jetting point is used (Figure 21).

Figure 20. Well Jetting in Action

Figure 21. Jetting Point

Capability: Well jetting can be undertaken in weakly cohesive sands and silts but cannot be used in hard formations. Clay can only be penetrated very slowly; and gravels and other highly permeable formations will result in lost circulation. Given the right ground conditions, jetting is a very fast drilling technique. Normal depths are 6 to 10 meters, but depths of 30m (drilling through silt) have been recorded.

Locations: Nigeria, Cameroon, Niger, Madagascar, Senegal, Darfur, Chad, Zimbabwe, Sri Lanka.

Equipment Availability: Although an off-the shelf kit for well jetting is not available, it can be readily assembled from locally available materials. Self-jetting screens are available from SWS filtration (2004).

Documentation:

Adekile D and Olabode O. 2009. *Hand Drilling in Nigeria.* UNICEF/RWSN Field Note 2009-1. Available on World Wide Web <http://www.rwsn.ch/documentation/skatdocumentation.2009-02-27.7138623246>.

Carter, R.C. 1985. *Groundwater development using jetted boreholes*. Waterlines, 3 (3) January 1985.

Jose J. 1988. *Studies and Design Improvements of Low Cost Well Jetting*. M.Sc Thesis, Cranfield University, UK

The SWS Well-Jetting Technique 2001. [online]. Available on World Wide Web <http://www.swsfilt.co.uk/tech/tech3.htm>

Sonou M. 1995. Low-cost shallow tube well construction in West Africa. [online]. Food and Agriculture Organisation. Available on World Wide Web <http://www.fao.org/docrep/W7314E/w7314e0v.htm>

EMAS Drilling

Description: EMAS Drilling, developed by Wolfgang Buchner in Bolivia combines jetting with a percussion action. Drilling mud (water mixed with clay to a suitable density) is pumped down through the drill stem using a hand operated metallic version of the EMAS flexi-pump. The mud flows back up around the drill stem, carrying up the drill cuttings. Sand and small stones are decanted, and the drilling mud is recycled through the pump. A percussion action is performed by lifting and dropping the drill using a lever, mounted on a drilling tower. In addition, the drill stem is rotated in half-turns in both directions, enhancing the grinding action of the bit. The drilled diameter is about 2 inches and wells are cased with cheap 1½" (39 mm) PVC pipe to accommodate a 1¼" PVC piston pump although they can be reamed to a larger diameter. When progress is difficult, due to particularly course sand or small pebbles, the technique is changed to a suction system. A similar technique, called Madrill, is under development in Madagascar.

Capability: EMAS drilling can penetrate loose soils, as well as consolidated materials and light rock but not hard rock or boulders. In coarse sands, progress may be slow, as sand may sink faster than it can be lifted out with the drilling fluid. In such conditions, a temporary switch is made to a sludging technique: an open-ended drill bit is installed, and a valve on top of the drill stem. The technique drills to 30m. The entire drill stem is metallic so deeper drilling becomes heavy and several operators are needed to operate the lever.

Equipment: An EMAS drilling rig, capable of drilling holes to a depth of 30m, can be built in Bolivia for about US$ 600 – 800 (including the tower, mud pump and all essential non-common tools to operate and maintain it). All non-standard components can be built locally in about any arc-welding workshop, using only materials found in ordinary hardware stores.

Figure 22. EMAS Drilling

Figure 23. EMAS Drill bit

Figure 24. Hand operated mud pump

Locations: This technology has spread out of Bolivia and has been applied in the rural area of Peru, Paraguay, Colombia, Chile, Honduras and Nicaragua.

Documentation:

Cloesen P. 2007. EMAS Drilling. Available on World Wide Web on <http://www.rwsn.ch/documentation/skatdocumentation.2008-05-28.6936214484>

Drinking Water Project (2005). Available on World Wide Web on <http://emas-international.de/english/index_e.htm>

EMAS have produced a set of DVDs which covers EMAS drilling and other low cost water supply techniques. Contact Wofgang Buchner on emas@entelnet.bo if you would like to order a copy.

FRAG. 1999. Guía Técnica, Perforación Manual de Pozos 1, Fortalecimiento en Riego Agricola (troposec@ibw.com.ni)

Country Overview

This chapter provides the reader with an overview of the scale and type of hand drilling activity being undertaken in selected countries and organisations involved.

Hand drilled wells are being constructed for water user in more than 20 countries around the world including Bangladesh, India, Sri Lanka, Vietnam, Cameroon, Chad, Ethiopia, Mali, Ghana, Mauritania, Madagascar, Senegal, Niger, Nigeria, Mozambique, Tanzania, Togo, Zambia, Zimbabwe, Bolivia, Nicaragua. Table 2 provides an overview of scale and the extent of activities in these countries.

However, on the whole, relatively little has been systematically documented. This chapter presents a concise overview of hand drilling experiences from the eight countries of Bangladesh, Bolivia, Chad, Madagascar, Mali, Nicaragua, Niger and Nigeria.

Table 2 Summary of extent of hand drilling in selected countries (Source: Danert, 2009)

Country	History	Techniques	Scale (number of wells) X =10's; XX= 100's; XXX= 1000's; XXXX = 10,000's	References
SOUTH ASIA				
Bangladesh	Sludging is an ancient tradition.	Sludging	Millions	WSP (2000)
India	Sludging is an ancient tradition.	Sludging	Millions	Ball and Danert (1998)
Sri Lanka	Various trials	Sludging, unnamed, Baptist	X	
Vietnam	Sludging introduced in the 1980s by UNICEF. In 1991 IDE introduced the treadle pump, which did not take off.	Sludging	Hundreds of thousands	Ikin & Baumann (2004)
AFRICA				
Cameroon	Well jetting spread from Nigeria to Cameroon in the mid 1980's. Baptist drilling was introduced more recently.	Well jetting, Baptist	X	
Chad	Manual drilling was undertaken by local enterprises in the 1980's. However, quality problems led to loss of confidence in the sector. Apparently hand drilling is once again on the rise and 20 – 30 manual drilling enterprises are active.	Sludging, jetting	XXX	Practica (2005)
Ethiopia	Pilot only	Rota-sludge, Baptist	X	Communication with Practica Foundation
Mali	Training of private artisans in 2008.	Various	X	
Ghana	Pilot only (for irrigation and domestic)	Hand augering, rota-sludge, percussion	X	
Mauritania	Some manual drilling techniques have been tested	Various	X	
Madagascar	Jetting technique introduced in the first few years of 2000.	Jetted Wells	XX	Communication with Bushproof
Senegal	Well jetting was introduced in 1991. Apparently private households in Casamance are paying for their own water supplies with this technique	Augering, well jetting, rota-sludge	XX	

Niger	Training of manual drillers started in the mid 1960's. Various projects have taken place, particularly in the mid to late 1990s involving private artisans. An estimated 10,000 hand drilled wells have been installed for irrigation and hundreds for drinking water.	Primarily Hand Augering	XXX	Danert (2006)
Nigeria	Well jetting was introduced in Nigeria in 1982 as part of the Kano Agricultural Development Project to provide irrigation wells in the sand rivers of Kano State and beyond. There was widespread adoption of the technique.	Jetting/washboring, augering, hand percussion, and recently Baptist drilling	X	Adekile and Olabode (2009)
Mozambique	Pilot stage only.	Rota-Sludge	X	
Tanzania	Hand augering introduced during the Shinyanga Project in the 1970s. Rota-sludge was introduced in 2008	Hand augering, rota-sludge	XX (estimate)	DHV (1979)
Togo	Pilot only 2008	Baptist	X	
Zambia	Pilot only 2008	Hand augering, Baptist	X	
Zimbabwe	Vonder rig development and extensive use.	Hand augering	XXX (estimate)	
LATIN AMERICA				
Bolivia	Techniques introduced in 1993 through water clubs.	EMAS and Baptist	XXXX	Personal communication with Water for All
Nicaragua		Baptist, EMAS	XXX	NWP (2006)

Bangladesh

Scale: Over 8 million hand drilled wells have been constructed to provide drinking water for Bangladesh's population of 140 million.

Expertise: In Bangladesh, hand drilled wells are primarily constructed by small scale private enterprises. Hand pumps are sold by local traders.

Techniques: Hand sludging

Pumps installed:

Mainly the Bangladesh No 6 pump.

Figure 25. Hand Sludging in Bangladesh

History: Tube wells have been drilled for at least 100 years in Bangladesh. UNICEF worked with the Department of Public Health Engineering to install tube wells in the 1970s. The 1980s saw this technology be taken up on a wide scale by the private sector, who installed millions of tube wells. By 2000, an estimated 80% of Bangladeshi's were using these tube wells for drinking water (Smith et al, 2000). By 2008, 97% of the total population relied on tube wells for drinking water.

Standards: None.

Average Costs: In UNICEF Bangladesh Programmes, the cost of a hand drilled well with pump is about $150.

Suitable Areas: Most of the country excluding some of the Chittagong Hill tracts. However, wide spread arsenic contamination of the shallow aquifer has led to questions regarding the suitability of this option. UNICEF recommends testing of arsenic is for each potential well.

Estimated potential target population: By 2008, an estimated 97% of the total population (140 million) relied on tube wells for drinking water.

Water Quality: Unfortunately, 1993 witnessed the confirmation that there was arsenic in the groundwater in at concentrations of over the maximum level recommended by the WHO (10µg/l) and Bangladesh (50µg/l). The seriousness of this problem became increasingly apparent in the second half of the 1990s. In 1998 it was estimated that 21 million people were exposed to arsenic levels of over (50µg/l). The long term health effects if ingesting high concentrations of arsenic include skin lesions, skin cancer and internal cancer (bladder, lung, liver and kidney). However, the effects take 10 to 40 years to manifest themselves (Source: Smith et al, 2000).

Organisations involved: Numerous small scale private sector drillers.

Documentation:

Smith A., Lingas, E.O. and Rahman M. 2000. *Contamination of drinking-water by arsenic in Bangladesh: a public health emergency*. Bulletin of the World Health Organisation, 78 (9)

WSP (2000) *The Growth of Private Sector Participation and Rural Water Supply in Rural Bangladesh.* Water and Sanitation Programme (WSP), Washington DC, USA.

UNICEF (2008). *Arsenic Mitigation in Bangladesh*. UNICEF

Independent Evaluations: None found.

Last update of information: June 2009

Bolivia

Figure 26. EMAS Drilling

Scale: It is estimated that more than 20,000 hand drilled wells have been constructed in Bolivia with the EMAS method derivations (BOPS or AYNI). In addition, up to 3,000 wells have been constructed using the Baptist Drilling Technology.

Expertise: Bolivia is the home to both EMAS and Baptist Drilling methods. In the case of EMAS drilling, over a hundred of local small enterprises have been trained in the method and offer drilling services and the fabrication of manual pumps for domestic supply, cattle and other minor agricultural activities (e.g. vegetable gardens). In contrast, those promoting Baptist drilling lend the equipment to water users who have formed a "water club" and drill wells for themselves.

Techniques: Bolivia is the home to both EMAS and Baptist Drilling methods.

Pumps installed on hand drilled wells: EMAS, BOPS and AYNI pumps.

History: Wolfgang Buchner first developed **EMAS drilling** in Santa Cruz around 1985. In order to apply the technology on a wider scale, Buchner formed a school to train small-scale entrepreneurs. As a result of this initiative, private enterprises own drilling equipment and provide wells for families who pay for the drilling and materials and provide labour.

Subsequently the Pan-American Health Organisations (PAHO), the Sumaj Huasi Foundation and JICA have contributed to its improvement and diffusion in Bolivia. Currently UNICEF Bolivia promotes the technology in rural areas.

Development of the Bolivian **Baptist drilling** technique by Terry Waller of Water for All (WFA) commenced in 1993. Small enterprises drilled 940 Baptist wells between 1995 and 2000. In 2001, WFA went on to use a water club approach (WFA lends drilling equipment). Since 2001, 495 wells were drilled as a result of the Water Clubs and about 200 more wells were drilled by the private enterprises (data source: WFA). WFA estimates that each well serves 10 to 20 people plus livestock.

Standards: Not yet developed.

Costs: EMAS: US$ 500–1,000 for drilling to a depth of 25-40m and equipping with a manual pump. It costs an additional US$ 500 if a concrete platform and protection structure is built and training in operation and maintenance is provided.

Baptist: These wells are subsidized by the support organisations. Beneficiaries are expected to pay US$15 per well (as a contribution for maintenance of the drilling equipment), and provide labour and local materials.

Suitable Areas: Tertiary and quaternary soils in the Amazonian Lowlands of Santa Cruz and Beni departments; the Chaco and highlands of La Paz department.

Estimated potential target population: 40% of the rural population of the above suitable areas .

Hydrogeological Mapping: Studies were carried out with the support of JICA regarding the availability of groundwater in the Chaco and Amazonia.

Water Quality of wells drilled by government or international corporation support is monitored. Non-suitable areas for exploitation of groundwater are: Andean region (arsenic) and Amazonian lowlands (excess iron and magnesium).

Organisations involved:

- EMAS (Wolfgang Buchner - emas@ceibo.entelnet.bo)
- Water for All (WFA) (Terry Waller - terry@southlandbaptist.org)
- Fundación Sumaj Huasi (FSH) (Carlos Suntura - csuntura@sumaj.org)
- UNICEF Bolivia (aalvestegui@unicef.org)
- CRS/EPARU (Alberto Chavez, achavez@crsbo.org)
- Numerous local private enterprises.

Documentation:

Buchner E. *No trastee mas agua, perfore su propio pozo.* Programa de Agua y Saneamiento (available from author).

Fundación Sumaj Huasi (FSH). *Presentación institucional de la tecnología AYNI*. 2009. (available from csuntura@sumaj.org).

Orozco G., *Operación Mantenimiento del Pozo Perforado y Bomba Manual BOPS 2002*. 1999. PAHO. La Paz, Bolivia

Water for All. 2005. Available from World Wide Web: <www.geocities.com/h2oclubs>

Waller, T. 2009 [online] *Bolivian Baptist Well Drilling* Available from: http://tinyurl.com/mmxznk

Last update of information: July 2009

Chad

Scale: It has been estimated (by UNICEF Chad) that thousands of hand-drilled wells are used for irrigation. More than 300 have been installed specifically for drinking water supply (230 were constructed since 2006, of which 130 were for Internally Displaced Persons).

Expertise: 83 local hand-drilling enterprises have been identified in Chad. Of these, 43 have been registered in a database (maintained by UNICEF Chad) and have been given further training in hydrogeology, well drilling, management and business skills. A total of 20 controllers have also been trained.

Techniques: Hand augering, sludging and jetting are the three methods deployed in Chad. The jetting method is the most commonly used method.

Figure 27. Rota Sludge Drilling

Pumps installed on hand drilled wells: India and Vergnet.

History: Wells have been drilled manually in Chad since 1965. The Peace Corps were using the techniques in 1980 and Care International between 1987 and 1990 for safe drinking water supply and irrigation. With the support of these organisations, numerous drillers were trained.

As demand increased, more enterprises began to drill but they lacked the necessary technical skills. Poor construction quality led to a loss of confidence in manual drilling and a belief that the wells collapse easily and cause pollution of shallow groundwater.

In 2005, UNICEF Chad took the lead in a re-emerging manual drilling sector. PRACTICA and Oxfam undertook a feasibility study in September 2005. A strategy was adopted by the Ministry of Hydraulics to professionalize and scale-up up manual drilling.

Standards: Technical standards have been developed for manually drilled wells (30 to 50 m in depth) and adopted by Government (Ministry of Fisheries, Pastoral and Rural Hydraulics, no date).

Average Costs: Irrigation wells – US$ 300, Drinking water wells – US$ 2,500 to 4,000 (higher costs include pump and training).

Suitable Areas: 55% of the southern part of the Chadian territory: Kanem, Hadjer-Lamis, Logone, Tandjillé,Mayo-Kebbi East, Guera, and the South-East.

Estimated potential target population: 70% (this is a qualitative estimate made by UNICEF and the Ministry of Hydraulics. In Chad, manual drilling is very suitable in the most populated areas

Hydrogeological Mapping has been undertaken to identify suitable areas for manual drilling. Maps are available (Practica Foundation, 2005).

Water Quality: No documents published. No specific issues have been raised.

Organisations involved: Ministry of Fisheries, Pastoral and Rural Hydraulics, UNICEF, PRACTICA, World Bank, Chadian Chamber of Trade and Private Sector, African Development Bank (AfDB).

Documentation:

Practica Foundation 2005. *Assessment of the Feasibility of Manual Drilling in Chad*. Practica Foundation/UNICEF (download report from <http://www.rwsn.ch/documentation/skatdocumentation.2009-02-16.0323391999>)

Le Ministère de la Pêche, de l'Hydraulique Pastorale et Villageoise, 2009. *Normes et Standards de Forage Manuels au Tchad.* (Available on World Wide Web: <http://www.rwsn.ch/documentation/skatdocumentation.2009-07-16.4957306091>

Last update of information: June 2009

Mali

Scale: Less than 100.

Use: Domestic Water Supplies

Expertise: Two local enterprises in Gao were trained in the hand auger technique but only one enterprise is still active.

Techniques: Hand augering, manual percussion drilling

Pumps installed on hand drilled wells: Rope Pumps.

Figure 28. Hand Driling a Tubewell

History: Oxfam GB introduced hand drilling in Gao in July 2007 (ECHO funding). Following initial trials (based on information from documents of the technique), hand drillers from Niger went to Mali to provide training in 2008. By mid 2009, 66 hand-drilled tubewells mostly using the hand-augering methods had been constructed, with more planned. Currently ECHO continues to fund this work as part of a response to malnutrition in Bourem.

Standards: There are currently no documented national standards for hand drilled wells in Mali.

Costs: According to Oxfam, it currently costs 2,049,600 FCFA (~US$ 4,300) for a 13m deep hand drilled well equipped with a rope pump.

Suitable Areas: Areas of high groundwater table along the length of the Niger River.

Estimated potential target population: No estimates have yet been made.

Hydrogeological Mapping: Hydrogeological Studies have been undertaken for specific sites selected for hand drilled wells.

Water Quality: Water points have been tested by Oxfam and Winrock but reports have not been published.

Organisations involved:

- Oxfam GB (Abdoul Hamid, AAHamid@oxfam.org.uk and Trish Morrow, TMorrow@Oxfam.org.uk)
- Winrock International (Patrice Beaujault, beaujault@winrock-mali.org).

Documentation: No.

Last update of information: April 2009

Madagascar

Scale: Up to 1,000 hand-drilled wells have been constructed in Madagascar. Jetted wells are currently the most common.

Use: The wells are mainly installed to provide domestic water, as communal sources.

Expertise: There are about 20 drilling teams in the country, with expertise in one or more hand drilling technique.

Techniques: Jetting and the local variant known as Madrill, augering, rota sludge.

Pumps installed on hand drilled wells: Canzee pump, India Mark (III), rope pump (family & community), Tany Pump (local surface pump) and other deep well pumps.

Figure 29. Jetting a well in Madagascar

History: Several organisations have introduced manual drilling into Madagascar. They all appear to have started in early to mid 2000:

- Enterprise Works/VITA introduced well jetting techniques to Madagascar from Senegal.
- Richard Cansdale taught well jetting techniques to MEDAIR and Bushproof.
- 2005 saw the Food and Agricultural Organisation (FAO) introducing hand augering (with consultancy inputs from Niger).
- In 2006 Practica (supported by FAO & UNICEF) introduced the rota sludge technique.

Hand drilled wells continue to be constructed under projects in Madagascar. The local private sector is drilling wells for private and community use to a lesser extent.

Standards: Not for hand drilled wells.

Costs: Bushproof jetted wells cost € 600-1200 each. Prices of 30m deep rota sludge wells drilled by private enterprises and NGOs (Medair and CRS) have been quoted as € 225-440 (excluding concrete slab and pump).

Suitable Areas: From recent mapping work, it has been estimated that 20% of the land, mostly the coastal fringe, is suitable for well jetting.

Estimated potential target population: The mapping study (Voahary Slama, USAID and Practica, 2008) of eight regions found that up to 2.9 million inhabitants (out of 7.7 million) in these regions could be served by hand drilled wells.

Hydrogeological Mapping: Mapping of suitable areas for manual drilling has been undertaken for eleven regions in Madagascar (see Practica, 2008 and Voahary Slama, USAID and Practica, 2008).

Water Quality: No specific issues have been raised. No specific documents have been published.

**Organi
sations and Individuals involved:**

- Bushproof (Luke John Paul Barrett, madatech2@bushproof.net).
- Care, CRS, FAO, Medair, UNICEF.
- Experienced drillers in jetting - Fitahiana Mamy William, Befitia Zaivelin, Randrianantenaina Perlin, Jocelyn, Randriarimanana José, Ranoelison Hajamanana Herizo & Rakotoarisoa Eric Dany.
- Practica (Stéphan Abric; (stephan.abric@practicafoundation.nl)
- VONJY private enterprise (mavonjy@yahoo.fr)
- Rota sludge trainer and national consultants (Vonjy Mavo Andriamaroandraina; mavonjy@yahoo.fr) (Haja Mavo Andriamaroandraina; andriamaro_hajaserge@yahoo.fr)
- Voahary Salama (Jonathan Annis, jonathanannis@mac.com)

Documentation:

Practica. 2007. *Capitalisation d'expériences sur l'introduction et la diffusion de technologie sd'irrigation à faible coût à Madagascar.* Report available from info@practicafoundation.nl on request.

Practica. 2008. *Elaboration d'un plan d'action de développement de technologies à faible coût d'AEPA dans les régions de Sava, Diana et Sofia* Report available from info@practicafoundation.nl on request.

Voahary Slama, USAID and Practica. 2008. *Cartographie thématique des zones favorables aux techniques de captage et d'exhaure à faible coût.* Report can be downloaded from http://www.rwsn.ch/documentation/skatdocumentation.2009-05-05.0565319511

Last update of information: May 2009

Nicaragua

Scale: It is estimated that up to 5,000 hand-drilled wells have been constructed in Nicaragua.

Use: Drinking water.

Expertise: Two companies are known to be involved in the construction of hand drilled wells.

Techniques: Baptist, EMAS, Rota-Sludge, Stonehammer.

Pumps installed on hand-drilled wells Rope pumps have been installed on RotaSludge and StomneHammer drilled wells. EMAS flexi-pumps have been installed on Baptist and EMAS wells.

Figure 30. Removing Cuttings from Settleing Pit

History: Nicaragua has a tradition of hand dug wells, with experts locally known *pozeros*.

The Stonehammer technique was tested in 2001 by PRACTICA Foundation. Modifications gave birth to what is now known as the Rota Sludge technique. By 2003, some 50 manually drilled wells had been completed by drillers from the NGO CESADE and the private enterprise AMEC. and Baptist drilling. The construction of hand drilled wells using hand auger, rota sludge,

EMAS drilling was introduced in Estelí and Malpaisillo in the early 2000's, and in 2004 in León. Apparently not many more EMAS wells have been subsequently drilled for reasons that have not been documented.

The Baptist Drilling technique was introduced in four locations in León in 2004. Subsequently dozens of people learned the technique from peers and drilled their own wells. By early 2008, a total of 100 wells had been constructed and installed with pumps. The Baptist technique was was introduced in Jinotepe in 2008.

More recently, UNICEF has been trying to introduce hand drilling technologies near rivers in the Atlantic areas.

Standards: No published national standards for hand drilled wells – only internal standards of the organisations involved.

Average Costs:

- Rota-sludge drilled well of 4" diameter and 20 meters deep well is approximately US$ 1,050 (information from Practica).
- Self-built Baptist wells (not deeper than 18m and installed with EMAS pump) - US$ 40 to US $65 (information from Water for All).

Suitable Areas: Large stretches of non-rocky plains in the Pacific north-east region. However it has been suggested that the Atlantic coast may be even more suitable.

Estimated potential target population: No estimate available. In the coastal plains, which cover most of the country, the water table is usually less than 20 m deep.

Hydrogeological Mapping: Not published.

Water Quality: In specific places there are issues with Arsenic and other heavy metals (in the mining areas) and cyanides (of volcanic origin)

Organisations involved:

- PERFOR (Aris van Herwijnen http://www.perfor.org/index2.html)
- AMEC, Save The Children, Practica, Interchurch Organization for Development Co-operation (ICCO), UNICEF Nicaragua
- Asociación Desarrollo Comunitario Abangasca (ADCA), Abangasca, Sutiaba, León - Sr. Agustin Ruiz (via: Maria Yanirée Alvarez Olivas, myalvaarez@yahoo.com)
- AUCS, Tuscany Italy - Stefano Dell'Anna s.dellanna@gmail.com;

Documentation:

- Baptist drilling: http://www.geocities.com/leonvida/Leonvida/ProyectosAgua.htm
- Water for All website (www.waterforallinternational.org)

Last update of information: May 2009

Niger

Scale: It is estimated that more than 18,000 hand drilled wells have been constructed in Niger.

Use: Initially, wells were for small-scale irrigation but people also used them for domestic use. Some wells have been drilled specifically for drinking water (household and community).

Expertise: Over 40 small enterprises undertake hand augering.

Techniques: Mainly hand augering. A couple of enterprises are using jetting techniques.

Pumps installed on hand-drilled wells: On irrigation wells treadle pumps are mainly used, and, to a lesser extent piston pumps. Thousands of small motorised pumps have been installed in the Tarka Valley, Goulbi, Maradi and dallols. For drinking water wells, a simple piston pump and, more recently the rope pump and Canzee pumps have been utilised.

History: In much of Niger, hand dug wells have been used as traditional water sources for generations. In addition to these countless wells, in 2003 it was estimated that 13,000 cement lined wells and 7,000 machine drilled boreholes had been constructed. Hand augering has a 30-year history in Niger. It was initiated by Richard Koegel in the 1960s and by an American Peace Corps volunteer in the 1970s. In the late 1980s a Lutheran World Relief (LWR) initiative introduced hand auger drilling, in eastern Niger, and then in the south. As a result of this work, which was championed by Jon Naugle, it was estimated that 3,500 wells had been drilled by hand by 1996.

The Projet Basse Vallée de la Tarka (Tarka Valley Project), the Projet Pilot de l'Irrigation Privée (PPIP I) and the Projet de l'Irrigation Privée (PIP II) were the three main projects that drove the uptake of hand drilled wells (mainly for irrigation) from the early 1990s through to 2005. Currently, in many areas where hand drilling is feasible, the drilling enterprises are paid directly by end users to construct wells for them. In addition to the numerous treadle pump manufacturers in Niger, rope pumps are being fabricated in Niamey, Maradi and Zinder.

Enterpise Works/VITA (EWV) became involved in hand drilling in Niger in 1997 and Winrock in 2007. In addition to promoting hand drilled wells for irrigation, these organisations have been promoting community wells and introducing hand percussion and rota-sludge drilling technologies. Some of this work has been supported by UNICEF.

Standards: There are currently no documented national standards for hand drilled wells.

Costs: EWV figures: Irrigation wells – US$ 50, drinking water wells – US$ 1,800 to US$ 3,000 (higher costs include training and pump); Winrock figures: Around $2,000 to $3,000, depending on soil conditions (includes pump & installation, follow up & training of stakeholders).

Figure 31. Hand Augering in Madaoua

Suitable Areas: Dallo Bosso, Dallo Maouri, Tarka Valley, the Korama (small valleys and basins) south of Zinder, Goulbi N'Kaba, Dosso; some areas along the Komadougou River and other smaller alluvial valleys in Maradi and Matamey.

Estimated potential target population: Around 20% of the total population of these areas. This is a rough estimation based on the rural population living near the river basins.

Hydrogeological Mapping: A mapping exercise of hand drilling potential in of the four regions of Zinder, Maradi, Tahoua and Dosso) is available (PRACTICA, UNICEF and Ministère Hydraulique, 2009).

Water Quality: Tests carried out. Data not published.

Organisations involved:

- Association des Foreurs et Fabricants de Pompes A2F
- Enterprise Works/VITA (Ibrahim Mamadou, babaye_i@yahoo.com);
- Winrock International (Patrice Beaujault, pbeaujault@winrock.org, Maman Yacouba, myacouba@winrock.org)
- UNICEF (Moustapha Niang, mniang@unicef.org and Chris Cormency ccormency@unicef.org)
- Agence Musulemane d.Afrique, Quatar Charity and Islamic Help.

Documentation:

Beaujault P., Abdou O. 2009. *Niger Low Cost Technologies for potable water and irrigation.* Winrock International (available from author: pbeaujault@winrock.org).

Danert K. 2006. *A brief history of hand drilled wells in Niger: Only the beginning.* RWSN/WSP Field Note. (Available from RWSN website: http://www.rwsn.ch)

PRACTICA, UNICEF and Ministère Hydraulique. 2009. *Etude des possibilités d'intégrer les Forages à faible coût au dispositif d'Alimentation en Eau des communautés rurales au Niger*.

Last update of information: May 2009.

Nigeria

Scale: An estimated 10,000 hand drilled wells have been installed for irrigation and an estimated 20,000 for drinking water supplies, primarily in major cities.

Expertise: Hundreds of small scale drillers are involved in hand drilling throughout many parts of Nigeria (see Adekile and Olabode, 2009).

Techniques: Mainly jetting (known locally as *hand turning*). Also augering, hand percussion, and (on a very small scale) Baptist drilling.

Figure 32. Hand Turners at work at a private home in Nigeria

Pumps installed on hand drilled wells: Hand pumps (Indian Mark II and India Mark III) are installed in rural areas. Submersible pumps are used in semi-urban communities, private houses and industries. Petrol pumps are apparently used on most irrigation wells although farmers in the northwest (Gusau and Sokoto) also use the treadle pump.

History: Richard Cansdale introduced well jetting (which later became known as washboring, and is now known in Nigeria as hand turning) in northern Nigeria over a two-month period as part of the Kano Agriculture and Rural Development Project (ADP) in 1982. The technique was introduced for the drilling of irrigation wells in the sand rivers and fadamas of Kano State.

There was massive adoption of the technique in Kano State and beyond, and within a few years thousands of wells being were "washed in". More than 15,000 wells were drilled with jetting (or washboring) technology between 1983 and 1990 in Bauchi, Kano and Sokoto states, providing water sources for small scale irrigation of more than 16,000 hectares. Well jetting has also been undertaken extensively in the 11 northern and middle zone states. From irrigation the jetting technique has spread to domestic water supply.

In the south of Nigeria the of hand drilling history is really not known but there are reports of hand drilled wells going back to the 1960s in Warri and Port Harcourt. Boreholes were also being drilled by hand percussion in Lagos in the 1970s for domestic water supply. This was probably an adaptation of ground investigation work to water supply.

Standards: No documented standards specifically for hand drilled wells but standard designs are available for drilled wells installed with handpumps.

Average Costs: About US$ 50 for the irrigation wells (50 mm diameter uPVC lined 6 to 18 m deep).

About US$2,000 dollars for household water supply (35 m deep with 150 mm uPVC casing).

Suitable Areas: Parts of northern and central Nigeria; loose sediments of Southern Nigeria; the southern coastal plains from the west to the east and alluvial floodplains. Groundwater is present at depths of less than 20m in most fadamas throughout the dry season.

Estimated potential target population: Very rough estimate of 30 million.

Hydrogeological Mapping: Since 1998, the Federal Ministry of Agriculture and Water Resources (FMAWR) has been compiling hydrological data to produce a map of the country. The maps are not yet available.

Water Quality: Usually good, but needs to be monitored for coliform.

Organisations involved: Hundreds of local enterprises undertake manual drilling in Nigeria (Adelike and Olabode, 2008).

Documentation:

Adekile and Olabode (2008). *Hand drilling in Nigeria. Why kill an ant with a sledgehammer?* RWSN/UNICEF Field Note.

Adelike and Olabode. 2009. *Study of Public and Private Borehole Drilling in Nigeria.* Unpublished Report by UNICEF Nigeria

Last update of information: May 2009.

Organisations

This chapter lists the organisations which develop and promote hand-drilling and provides a short profile of their activities.

Introduction

Hand drilled water wells are being undertaken by farmers, artisans and through NGOs. In some cases knowledge of the techniques has diffused from one driller to another, or has been well promoted as part of a particular project. Globally, we know of about 20 organisations which are actively involved in promoting one or more type of manual drilling.

ADPP (Mozambique)

ADPP is an NGO which has been active in Mozambique, for more than 20 years. It is supported by Humana People to People, Arrakis and Connect International among others. ADPP runs a Teacher Training Colleges programme (Escolas Para Futuro, EPFs).

Hand drilling technologies used are rota sludge and Baptist drilling (SHIPO version). By July 2008 some 15 hand drilled wells had been drilled and installed with rope pumps.

Contact details: adpp.mz@tdm.co.mz

Website: http://www.adpp-mozambique.org/

Arrakis (The Netherlands)

Arrakis is a network organization that focuses on human resources and institutional development, as well as the development and transfer of affordable technologies (renewable energy and safe water supply). Arrakis concentrates on rural areas of countries that are ranked at the lower end of the Human Development Index (HDI list of UNDP). Activities have been undertaken in Asia, Africa and Latin America 1990 through its Team of Associates, based in the Netherlands, Botswana, India and Egypt. Manuals and reports are downloadable from Arrakis website.

With respect to hand drilled wells, Arrakis members Jan de Jongh, and Krishna Raghavan have have given training in Baptist drilling in India and Mozambique.

Contact details: Jan de Jongh, De Olieslager 7,
5506ER Veldhoven, The Netherlands.
Tel: 0031 (0)40 2819454, Email: info@arrakis.nl

Website: http://www.arrakis.nl

BushProof (Madagascar)

BushProof is a private enterprise active in Madagascar and beyond. Over the last 3 years they have jetted in more than 500 wells in Madagascar (using jetting techniques, and their own version of EMAS drilling technique called Madrill). In 2007 Bushproof provided a tailor-made, 4-week on-site manual drilling courses to PPSSP and Oxfam in Beni (East Congo).

Contact details: Mathieu Monteleone , Technical Manager, BushProof Madagascar, Lot 21 A, Maibahoaka Antanetibe, BP 182 Ivato aéroport Antananarivo, Madagascar
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Email:adriaanmol@bushproof.com

Website: http://www.bushproof.com

Connect International (The Netherlands)

Connect International is a Netherlands-based NGO which supports the NGOs SHIPO (Tanzania), DAPP (Zambia) and ADPP (Mozambique) with knowledge transfer on more than ten low cost water and sanitation technologies, so called Smart Tecs. With the local partners Connect International is creating Smart Tec centres where these technologies are demonstrated and hands on trainings are given in production, installation, use and marketing aspects.

In the case of manual drilling Connect International transfers knowledge on step auger, Soil punch, rota sludge and Baptist (Shipo version).

Website: http://www.connectinternational.nl

DAPP (Zambia)

The NGO DAPP has been active in Zambia for 15 years. It is supported by Humana People to People, Connect International, UNICEF, WaterAid, CARE and IDE. In water supply, DAPP focuses on communal and self supply systems, including the rope pump. Drilling technologies used are the rota sludge and Baptist drilling (Shipo version).

By July 2008, 30 wells had been drilled by hand, with a low success rate because of lack of skills, errors in drilling tools and rocky areas. With more training and better site selection, the success rate of hand drilled wells is now increasing.

Website: http://www.dappzambia.org

EMAS Water and Basic Drainage Mobile School (Bolivia)

EMAS Escuela Móvil de Agua y Saneamiento (Mobile School for Water and Sanitation) is located wherever its director, Wolfgang Buchner goes, but has a workshop in Puerto Perez, Bolivia. The organisation provides training and practical solutions in low cost water supply and sanitation options.

The school has trained over 200 enterprises and 20 trainers in the EMAS well drilling technique, mainly Bolivia but also Peru, Ecuador, Honduras, Brazil, Mexico, Nicaragua, Sri Lanka and several African countries). As a result, EMAS estimates that as a result, over 20,000 wells have been drilled in the region since 1993.

Contacts Details: Wolfgang Buchner, Escuela Móvil Aguas y Saneamiento Básico EMAS, Urbanizanción Amor de Dios, Florida, Calle 1 No 8, La Paz, Bolivia Tel/Fax: +591 2 27 40 286, Email: emas@entelnet.bo

Aktionsgemeinschaft EMAS, Munich, Germany
Tel: +49 89 69 35 99 48
Website: www.emas-international.de

Enterprise Works/VITA (EWV), USA

EnterpriseWorks/VITA (EWV)[3] has worked for more than 40 years in 100 countries, to combat poverty by helping small producers and other entrepreneurs build businesses that create jobs and increase productivity, market opportunities and incomes. EWV expands access to appropriate technologies, technical assistance, knowledge and finance.

With respect to hand drilled wells, EWV has undertaken training and enterprise development primarily in Niger, Nigeria and Senegal.

Contacts Details: Jon Naugle, 1825 Connecticut Avenue NW, Suite 630, Washington, DC 20009 USA, Tel: +1 202.293.4600, Fax: +1 202.293.4598
Email: info@enterpriseworks.org

Website: http://www.enterpriseworks.org

[3] Formally Appropriate Technology International (ATI)

Independent Experts and Trainers

Richard Cansdale (UK)

Richard Cansdale, of SWS Filtration, UK has extensive expertise in well jetting, having introduced the technique into Nigeria in 1982, and improved on it to develop self-jetting well screens in 1998. Cansdale has subsequently taught well jetting techniques to the Western Savannah Corp in Nyala, Western Darfur (1998 and 1990), and to Appropriate Technology International (ATI), now (EVW) in Senegal (1991 and 1992). In mid 2004 he taught well jetting to MEDAIR/BushProof in Madagascar. He has also developed the Rower and Canzee pumps, but that is another story. Richard Cansdale still provides support on well jetting, but from a local beach in the UK, or over the telephone and supplies self-jetting well screens.

Contacts Details: rcansdale@gmail.com

Henk Holtslag (The Netherlands)

Henk Holtslag is a freelance advisor with 23 years of work experience in Africa, Asia and Latin America on development and implementation of low cost water technologies. He advises organisations in some 12 developing countries and gives hands on training in Rota sludge and Baptist drilling as well as other Smart Tecs

Contacts Details: holtslag.dapper@planet.nl

Paul Cloesen (Nicaragua)

Since 2003 Paul Cloesen has facilitated the drilling of over 100 wells using the Baptist drilling method in Nicaragua. He is also familiar with EMAS drilling.

Contacts Details: paulcloesen@yahoo.com

PRACTICA Foundation, The Netherlands

PRACTICA Foundation is an NGO that facilitates the research, development and commercial application of water and energy technologies for developing countries. Established in 2001, its mains to reduce poverty through "appropriate" low-cost technology.

In 1999, PRACTICA's founders had already started to undertake considerable research and development of the stone hammer and rota sludge hand drilling technologies in India. These were further tested and improved in Nicaragua in 2001. Since then, PRACTICA has been providing technical training to drilling teams in Nicaragua, Tanzania, Chad, Madagascar and Ethiopia.

Contact Details: Arjen van der Wal, Maerten Trompstraat 31, 2625 RC Delft, Netherlands, Tel: +31 (0)15 257 53 59, E-mail: info@PRACTICAfoundation.nl

Website: http://www.PRACTICAfoundation.nl/

SHIPO, Tanzania

Southern Highlands Participatory Organisation (SHIPO) is a small NGO, which was established in 1997. The organisation is supported by Connect International and dedicated to implement water and sanitation programs in close consultation with the beneficiaries to assure long term effectiveness.

Up to July 2008 they have realised some 230 Boreholes combined with Rope pumps. The cost of rural water points with this combination is 350- 500 Euro which is some 2000 Euro cheaper than conventional water points in the same area made with machine drilling and imported piston pumps. SHIPO has trained local workshops in the production of rope pumps and drilling groups in hand drilling SHIPO has a Smart Tec centre where Technologies are demonstrated and hands on trainings are given

Contacts: SHIPO, P.O. Box 227, Njombe, Tanzania, Tel: +255 (0)26 2782989, Email: info@shipo-tz.org

Website: http://www.shipo-tz.org/

UNICEF

UNICEF has supported manual drilling in a number of its country programmes including Niger, Chad, Madagascar, Senegal and Bolivia.

At global level, UNICEF, Practica and Enterprise Works/VITA are currently developing a toolkit for African countries wishing to professionalise manual drilling. This toolkit will include Technical Notes, Technical Manuals, Advocacy Materials, Mapping of suitable areas for manual drilling, Case Studies, and Implementation and Training Manuals.

Contacts: UNICEF, Water Sanitation and Hygiene WASH United Nations Children's Fund 3, UN Plaza New York, NY 10017.

Website: http://www.unicef.org/wash/
Email: sgaya@unicef.org

Water for All (WFA)/Aqua para Todos, Bolivia

Water for All a Christian mission organization that developed the Baptist drilling method, and now introduces low-cost well drilling, water pumping and harvesting technologies to communities in Bolivia and beyond. They disseminate the Baptist drilling method by training well drillers and supplying them with US$ 150 of drilling equipment. WFA estimate that almost 2,000 wells have been drilled in 12 countries using the Baptist method by June 2008.

Contact Details: Terry and Kathy Waller, 3214 Stanford San Angelo, TX 76904, USA (permanent residence address), Tel: +1 325 212 9182 (mobile) (+ 325) 227 8160 (landline)

Terry Waller, c/o World Concern, casilla 3681 Santa Cruz, Bolivia, Tel: Contact San Julian on: + 591 3 965 6912 (landline), + 591 7 312 4965 (mobile) Email: terry@southlandbaptist.org

Website: http://www.waterforallinternational.org

Winrock International, USA

Winrock International supports the establishment and growth of small and medium-sized enterprises and agricultural initiatives. They work on supply chain development for the development of poor people. Winrock International combines services and technologies for productive uses with access to potable water, including hand drilling activities in Niger and Mali.

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Editor

This directory was edited by Kerstin Danert, who coordinates the Cost-Effective Boreholes Flagship of the Rural Water Supply Network (RWSN).

Feedback and Further Information

If you have more information about hand drilling activities which you would like to share with others, please contact the Rural Water Supply Network (RWSN) on kerstin.danert@skat.ch or through our other contact details (see box on the right).

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UNICEF works in more than 90 countries around the world to improve water supplies and sanitation facilities in schools and communities, and to promote safe hygiene practices.

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The Water and Sanitation Programme mission is to help the poor gain sustained access to water and sanitation services.

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