A low-tech drilling method for refugee water supplies

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The Treguine refugee camp in Eastern Chad, is in a semi-arid terrain of hard, crystalline rock, where hard-rock boreholes proved inadequate. Fortunately, a significant thickness of saturated sands and gravels in a nearby *wadi* provided a sufficient quantity of water, and tube wells were constructed using a vibro-bailing technique in a few hours.

In 2003 thousands of refugees fled across the border from Darfur to settle in refugee camps in the neighbouring Chad Republic. Treguine, a camp built in 2004, was designed to take more than 15,000 refugees from overcrowded nearby camps. A low-technology method has proved to be successful in obtaining sufficient water for more than 15,000 inhabitants in the Treguine refugee camp. The work was conducted for Oxfam in 2004.

Treguine Camp

Situated some 50km to the west of the border town of Adré, annual rainfall in this area is around 400mm and falls in a three- to four-month period between June and October. The terrain is dominated by crystalline rocks, traversed by *wadis* (dry river channels, filled with sediment, flowing intermittently during and after rain).

In August 2004, dug wells were under construction to provide water for the new camp. The wells were located

The wells were unsatisfactory: they refilled very slowly and dried up in the hot season.

Wadi Hamra.

on a thin layer (<3m) of soil and regolith (weathered material) lying on top of impenetrable crystalline rock. As construction was taking place during the wet season, water and sediment were seeping slowly from the saturated soil and regolith into the base of the wells. At intervals the water and sediment slurry was pumped out, and this led ultimately to the collapse of the ground around the new well structures. These ‘wells’ would only tap muddy soil water at a very slow rate in the wet season and would dry up in the dry season, so were unsuitable as a water source. The regolith is a minor aquifer suited to limited water supplies for small rural communities. With a storage coefficient (effectively that percentage of water held in sediments that will drain from them by gravity) of at most 5 per cent there was not enough groundwater to provide an adequate water supply for the proposed camp population. As the dry season was approaching, with serious overcrowding in neighbouring camps, the need to find an alternative, adequate and reliable water source was urgent.

Some hard-rock boreholes were drilled to a depth of around 80 m, using a small mechanical drilling rig. Each borehole took around three days to complete with maximum yields below 0.5 l/s.

Wadi Hamra, a wide (>200m) sediment-filled river channel that flows only during and after rainfall in the wet season, passes adjacent to the camp site. It was noted that local people were collecting water by hand from the wadi by digging depressions of less than 0.3 m depth in the sediments. This provided the inspiration to try vibro-bailing, a technique common in Nigeria,[1] to install simple tube wells in the *wadi*.

Site location

After inspecting the morphology of the river channel, suitable sites were chosen, and within these sites a hand auger was used at a number of positions selected by random sampling.

A hand-dug depression in the wadi suggested this might be a good site for a tube well.

The bailer and stem are withdrawn while the casing is pushed further into the ground.

Once a likely site was selected, a hand auger and bailer were used to establish the nature and thickness of the sediments beneath that site and the depth to the water table.

Required equipment

The equipment comprised an auger, interchangeable with a bailer tube with a flap valve, attached to a jointed metal stem; a working casing (stiff hollow tube) of 90mm internal diameter, through which the auger and bailer were operated; and extension segments of around 1m length for both the casing and the auger stem handle to allow progressive introduction into the ground. Clamps with handles were used to support the working casing and to push it into the ground (or to withdraw it) and tools were required to add or remove sections of the stem. A dip meter was used to measure the water level during and after construction.

Tubewell construction

The hole was started by augering into the sediments and inserting the first casing length. Once the water table was reached, or if the sediments were unstable, the bailer tube and stem was inserted and vibrated gently up and down to enable it to sink into the sediments. When the bailer tube was full it was withdrawn and emptied. At the same time as the bailer was withdrawn the casing was rotated and pushed into the ground with the clamps. Sections of stem and casing were added as needed with increasing depth of the hole.

The sediments encountered were clays, sands and gravels and the variety of sediment profiles, along and across the wadi, indicated that the different sediment layers were interlaced and, in some places, mixed.

Once the desired depth had been reached, a continuous length of pipe (63 mm outer diameter UPVC water distribution pipe was used in Treguine) was prepared for use as the rising main, the length allowed being equal to the depth of the hole plus 2m. The base of the pipe was sealed by melting it in a small straw fire and 1mm width slots were cut with a hacksaw into the bottom 0.5–1m to allow the inflow of water. The rising main was then introduced inside the temporary casing and pushed below the water level until it reached the required depth.

Once the slotted section was at the desired depth, with a good length sticking out at the surface, the temporary casing was slowly withdrawn, segment by segment, ensuring that the turning of the casing to release it did not cause the segments to detach at depth, and taking care not to allow the rising main to be withdrawn with the casing. As the casing was withdrawn, the sediments at depth collapsed around the rising main. Once all the casing had been removed, the rising main was left sticking out of the surface of the sediments.

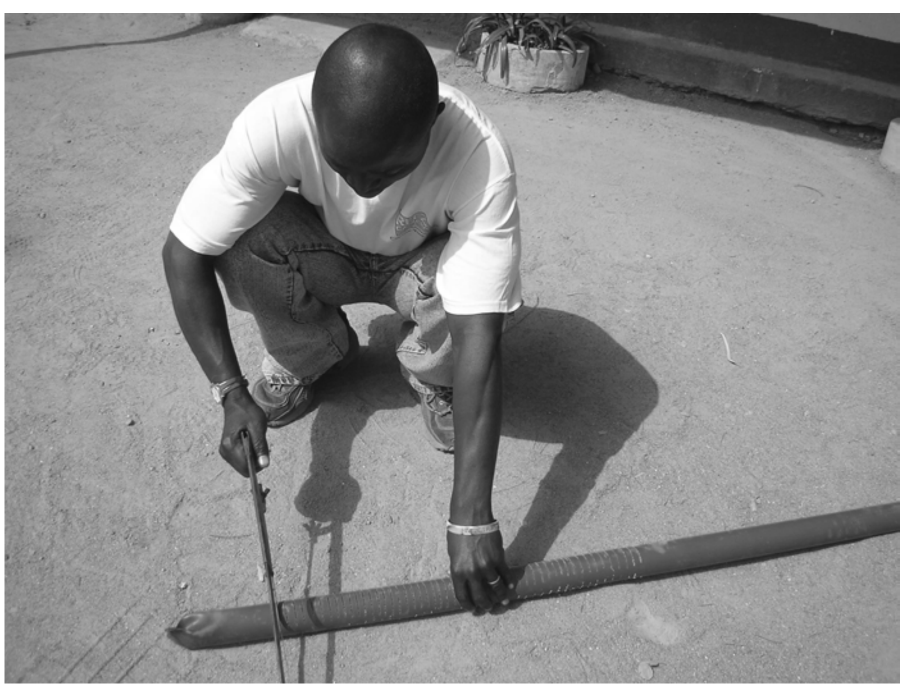
Clearance pumping and yield

The tubewell was developed by attaching the suction line of a centrifugal pump directly to the end of the rising main. Initially the water abstracted was cloudy, as it contained fine sediment particles mixed with the gravels, but it cleared within a couple of hours as a natural gravel pack formed around the screened section at depth during pumping.

The maximum yield obtained per tubewell in Treguine was 6 l/s with a mechanical pump, limited only by the dimensions of the installation. Thus a single tubewell could provide 15 litres/person/day (using the Sphere minimum standard) for the entire camp population of 15,000 if it were pumped for 10.5 hours a day. In fact tubewells were installed in several locations in order to facilitate water distribution to different parts of the camp.

Discussion

The maximum depth achievable by vibro-bailing depends on the sediments encountered, but it is around 7m in loose formations (sand and gravel). Washboring, a parallel technique, can go deeper but cannot penetrate clay bands, so could not be used. It is important to keep a log of the nature of the sediments (grain size, shape and sorting) as the hole progresses, as well



Preparation of rising main showing hand-cut slots and sealed end.

Rising main emerging from sediments, connected directly to pump suction.

as the depth of the water-table, as these will determine where to place the open part of the rising main. Up to four persons are required to work the bailer for effective vibration while one other person does the job of turning/pushing the casing. Once full, the bailer must be quickly raised to the surface so as to prevent sediment wedging itself between the bailer and the inside of the casing, thereby jamming the bailer at depth.

Care must be taken not to operate the bailer too vigorously as this can lead to the premature wearing out of the shoe (that part of the bailer that cuts through the sediments) and failure of the flap valve hinge. In situations where a temporary casing is not available, the material intended for the rising main may be used as a working casing but needs to be sufficiently rigid and resilient to be pushed straight into the ground and of adequate internal diameter to permit the bailer to pass through it.

If the yield is low then it is worth studying the sediment log to determine if the rising main should be withdrawn somewhat, until the slotted section is opposite a more transmissive layer. Practitioners should not be tempted to increase the slotted length as this may lead to problems of air entrainment (unintentional incorporation of air which then leads to problems in the operation of the pump) and loss of yield.

Sustainability

In Treguine camp in Chad there were several sustainability issues. One of the tubewells was installed close to a grove of mango trees and the local population was concerned that the water-table would be drawn down by pumping and cause damage to the trees and/or to the crop by starving the roots of water. A concern for the viability of the camp was that, with no data available as to the depth and nature of the sediments in the *wadi* or the annual water table fluctuation, it was difficult to estimate how sustainable the water supply from tubewells would be once the dry season arrived.

Near the mango grove, a second tubewell was placed some 5m from the pumping tubewell to enable measurement of the level of the water-table during pumping. A pumping test was conducted for two hours at full output (6 l/s) and the level in the adjacent tubewell was measured with a dip meter. The results of this test showed that, just 5m from the pumping well, the water-table was depressed during pumping by less than 30mm. These results satisfied the local population that pumping would pose no immediate threat to the mango trees.

Members of the local population who used local water sources were interviewed in an attempt to find out by how much the water table in the *wadi* falls by the end of the dry season. Responses were so varied that this was considered an unreliable technique.

A team of local geophysicists was hired by Oxfam to conduct electrical surveys across the wadi to evaluate the profile (depth and type) of sediments. Electrical soundings were done along transects at intervals of several 100 metres and the electrical response in the shallow layers matched to the sediments found in the augered holes. The results of the geophysical survey indicated that a deep channel existed beneath the wadi, containing a thickness of more than 20m of sediment. Although water would not be accessible from the hand-installed tubewells once the water-table sank below a depth of 5m (due to the position of the slotted section and the suction limit of the pump), the fact that saturated coarse sediments were present at depth meant that, once the dry season started, a mechanical drilling rig could, if required, safely be moved onto the wadi and used to drill a deeper hole.

A weekly water-level monitoring programme was instigated to ensure that there would be an early warning of the dropping of the water table. Such a warning would address both the concerns of the local population regarding the threat to the mango grove and those of Oxfam regarding the sustainability of the water supply. In fact the tubewells at Treguine continued to produce a reliable water supply for the camp throughout the following 10 months of dry season, accompanied by only a modest seasonal drop in the water table. This contrasted with many other camps in eastern Chad where the water supply was either failing already or predicted to be unsustainable for the dependent population during the ensuing dry season.[2]

Conclusion

Shallow, slim wells may be installed successfully with a hand auger within the loose sediments of well-developed *wadi*s where the water-table is within 2m of the surface. The success depends on the thickness and nature of the sediments and the depth to water. For such an installation to be sustainable the sediments must be permeable and have adequate storage and there must be a source of recharge water to replenish the abstracted water. If these conditions are met, and if the population is not too large for the supply, the sustainable exploitation of such a source can be achieved.

About the authors

Lucy Lytton has worked as a hydrogeologist since 1990, working with the NSW state government in Australia and with Veolia Water in the UK as well as undertaking humanitarian placements in Venda (South Africa), Chad and Sri Lanka. Sunday Arafan is a borehole driller with Fatigen Drilling Nigeria Ltd. Robin Hazell is with Water Surveys (UK) Ltd.

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