A few buckets more — reducing sand-invasion and siltation in Angola

Mark Osola

In very soft (sandy) aquifer formations, drilled boreholes are often susceptible to fine media ingress. This can damage submersible pumps and block handpumps, leading to downtime, expensive rehabilitation procedures or, at worst, total abandoment. Mark Osola explains why a few buckets of washed river gravel can make all the difference.

War in Angola

In the early '90s Kuito became known as the landmine capital of the world — with one mine per person (and approximately 10 million throughout the country). The city was completely cut off for a time, with both sides facing one another across the main route through the centre. Civilians could only move around in small groups at night-time, under constant threat from sniper-fire.

A long-term political solution is still proving elusive.

During 1994, the city of Kuito in central Angola, home to more than 50 000 people, was a focus for conflict in the long-running civil war (see box). The appalling suffering inflicted on the besieged population included the total loss of all piped water supplies. To this day, the rehabilitation of the municipal water supply remains a distant dream.

Emergency water supplies in Kuito were implemented as soon as conditions became safe for NGOs to move in. Oxfam carried out a technical assessment of the best option for providing emergency potable water; the result was an extensive drilling programme of shallow (20-40m) boreholes sunk into a complex, unconsolidated aquifer which, in the case of Kuito, is a non-uniform, unstable, water-bearing, underground rock formation consisting of coarse and fine sand, pebbles, and clay.

By 1997, more than 30 boreholes were complete. The work received the full backing of the Governor of Kuito and what remained of the Ministry of Public Works. When fitted with handpumps, the boreholes became crucial sources of clean drinking-water, and provided an alternative to 'unsafe' sources, such as open wells (*cassimbas*), and shallow springs and streams. A variety of handpumps and electrical submersible pumps have been used in these boreholes since 1994.

Problems began to surface only a few months later and, by 1997 — following three years of heavy pumping — nearly all the boreholes were yielding turbid (cloudy) water with varying degrees of sediment-loading. More than 50 per cent of the handpumps were out of use; the pump cylinders and rising mains had become blocked with fine- and medium-grained sand. Maintenance teams made numerous attempts to rehabilitate the boreholes by flushing and surging, but failed to solve the problem. In fact, things got worse, with some boreholes silting within hours of cleaning. Inevitably, as the boreholes gradually silted up, more and more people resorted to drinking river-water.

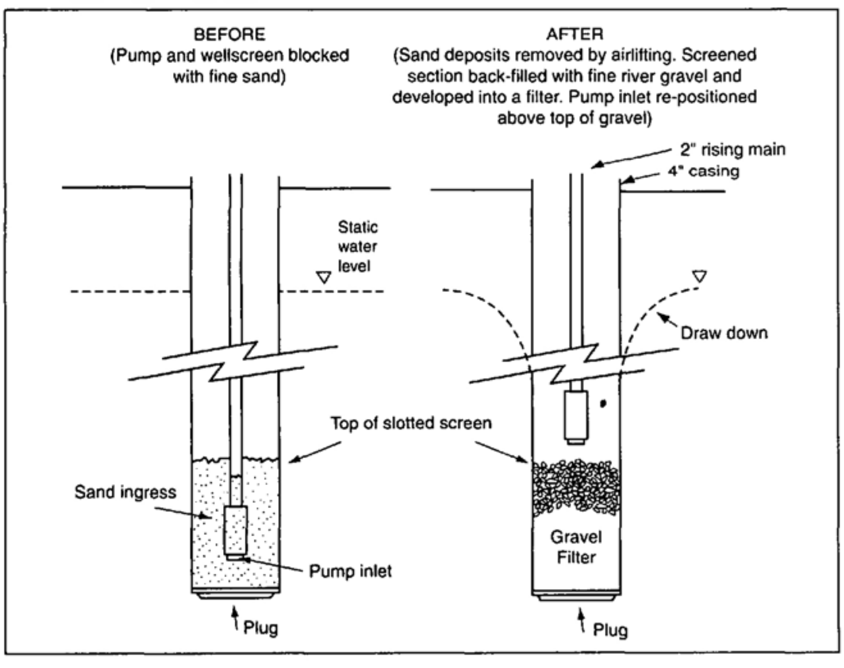

Figure 1. Borehole rehabilitation schematic.

Oxfam's (first phase) drilling programme

The short-term results were promising: the holes were relatively easy to drill with a lightweight rig using a 6 inch drag-blade and positively circulated mud-mix; drill cuttings revealed an upper layer of silty, sandy clay followed by a gradual transition to what was, in the main, coarser red sand and silt, interspersed with layers of very fine sand and silt. The water-table rested between 10 and 15m; most holes were drilled to a final depth of between 30 and 40m — the deepest reaching 45m. If the hole wall was stable, the 4 inch plastic screens and casings could usually be set to depth at the first attempt; to maximize yield, up to three 3m sections of 0.5mm (and/or 1mm) slotted screen were used per hole. Although the effective grain size was small (about 0.1mm), the estimated uniformity coefficient was greater than 4.0, so natural gravel packs were quickly formed by lifting and surging, using compressed air. Although artificial-gravel packs were available, trying to deposit fine gravel down the annular space between the 4 inch casing and the 6 inch drilled hole was ineffective — most of the gravel becoming lodged somewhere down the column. Most of the wells yielded in excess of 1000 litres of clean water per hour after a few hours' development work.

The programme progressed rapidly — each borehole and handpump taking between 7 and 10 days from start to completion.

Nemesis

The saying 'Necessity is the mother of invention' was never truer than in Kuito in 1997. By the beginning of the year, the only potable water in the city came from a handful of overworked tubewells not yet silted up. Throughout the city, abandoned handpumps provided a stark reminder of the scourge of siltation and sand-invasion in boreholes. So what happened next?

A silted-up borehole was randomly selected. The pump and rising main were removed and cleaned; all the sand was flushed out of the borehole with compressed air — some holes contained up to 6m of sand. Instead of replacing the pump at this point, several buckets of washed river-gravel (with particles measuring between 1 and 5mm) were dropped into the borehole, to a level of at least 0.5m above the top of the slotted screen. Compressed air was used again, this time to develop a filter inside the borehole — a kind of internal gravel-pack. It worked! After less than two hours of airlifting, a filter had developed, and turbidity was negligible. The pump was replaced with a short rising main, with the inlet positioned 0.5 to 1m above the top of the gravel.

After a few days of monitoring, the team rehabilitated another borehole using the same technique. Three months later, all the abandoned boreholes were again in service. Not only did the pumped water remain silt-free, the boreholes were also free of clogging — and the yields remained stable.

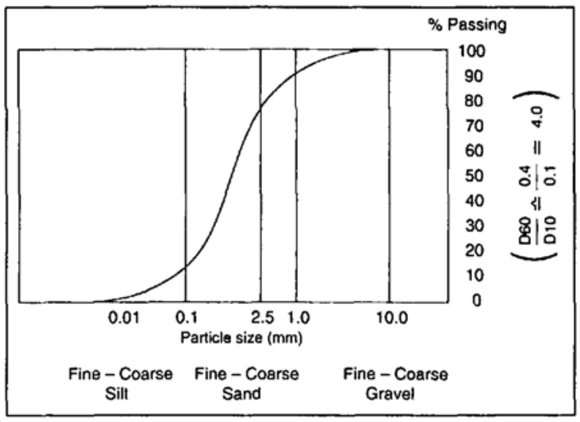

Figure 2. Sketch of particle size distribution.

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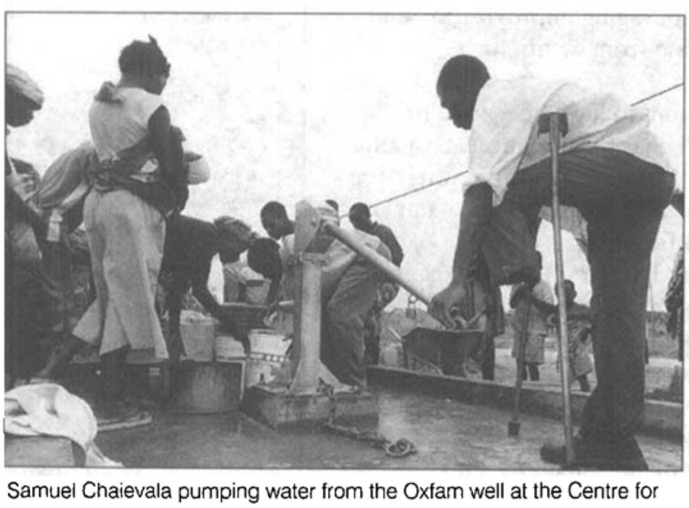
Lessons learned?

The experience has shown that, where sand invasion has been a determining factor in governing the operational lifetime of a tubewell, there is a simple and effective remedy that may avoid an unnecessary abandonment. At the very least, it is worth a try! ■

Glossary

Media ingress: very fine sand and silt particles which seep through the borehole well-screen from the aquifer into the tubewell.
Flushing: removing sand and silt deposits by pumping compressed air into the base of the borehole — the air expands up the hole, carrying particles with it.
Surging: technique whereby the air flow is turned on and off repeatedly to move the water up and down inside the borehole. This creates a surging action at the perforated well-screen section, which helps to develop a natural gravel/sand filter outside the well-screen.



Giovanni Diffidenti/Oxfam

Samuel Chaievala pumping water from the Oxfam well at the Centre for Amputee and Wounded Soldiers.

Note:
There was no community involvement (during and immediately following hostilities) due in part to the extreme conditions, and the need for a rapid response to an emergency situation. Oxfam continues to maintain an operational presence in Kuito, but one now restructured along the lines of a community-orientated peri-urban development programme which includes hand-dug well construction.

about the author
Mark Osola was working in Kuito for Oxfam as an emergency water engineer. He is currently working for Oxfam in Sierra Leone.

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