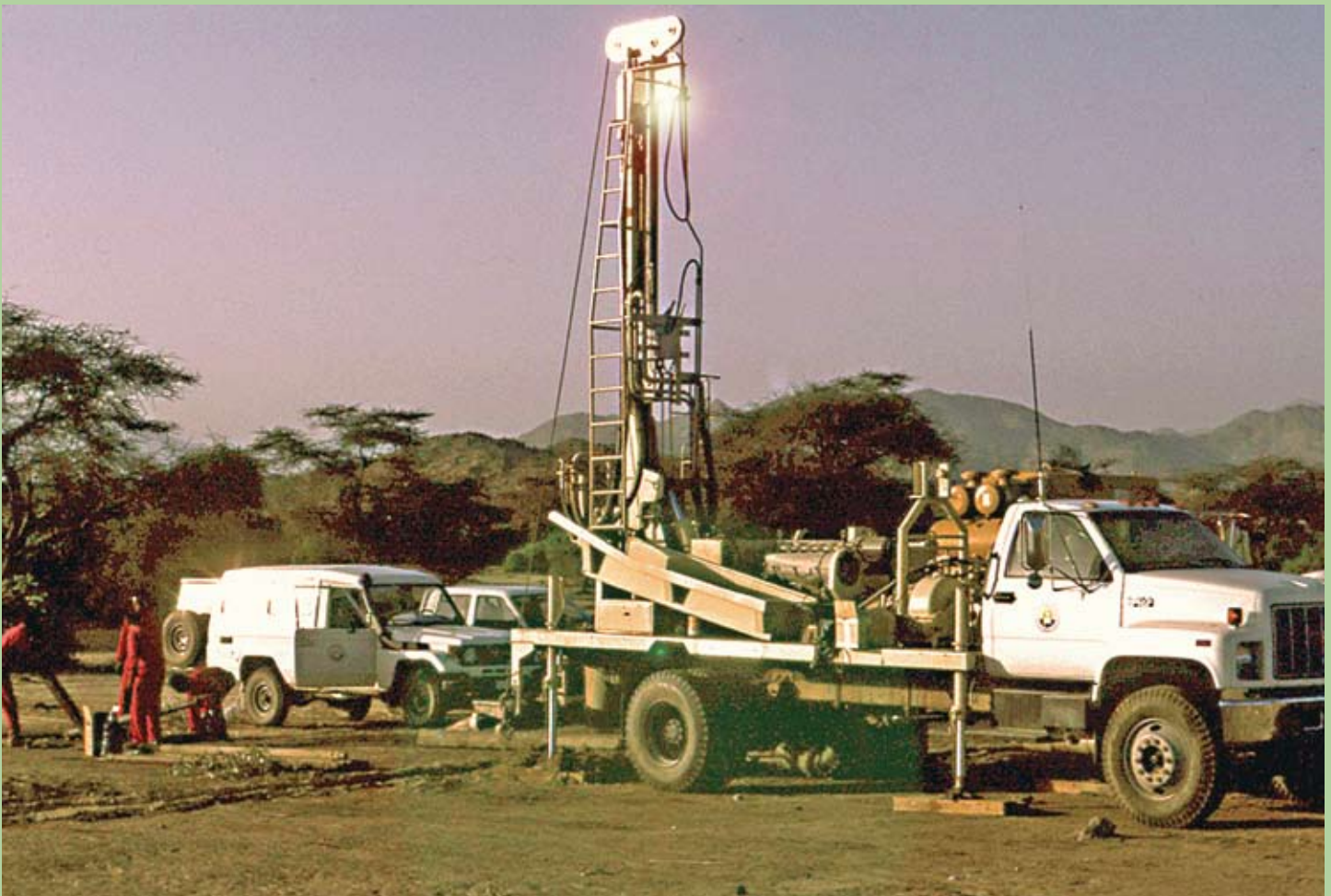


# Ten-step Guide Towards Cost-effective Boreholes

## Case study of drilling costs in Ethiopia

Increasing access to groundwater is a high priority for sub-Saharan Africa. One key to this is to reduce the costs of conventional drilling and borehole construction. This field note, describing a recent study in Ethiopia, sets out some of the ways in which this may be done.



## Executive Summary

Reducing borehole<sup>1</sup> drilling costs in sub-Saharan Africa must be a high priority, if the Millennium Development Goals (MDGs) or national water supply coverage targets are to be met. Even small savings could extend services to many millions of people across the continent. Drilling costs in India are typically less than one tenth those in sub-Saharan Africa, but there are good reasons for those differences. Simplistic comparisons are dangerous.

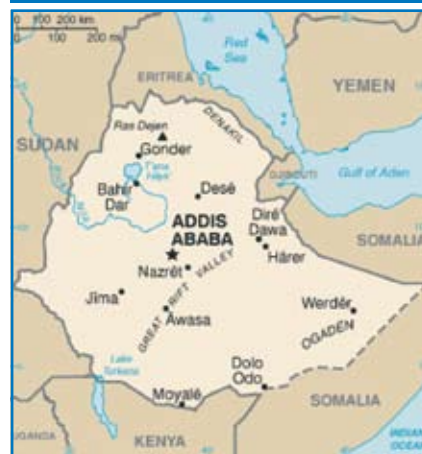
In 2005-06 an investigation of the borehole drilling sector was undertaken in Ethiopia by the Rural Water Supply Network (RWSN). The aim of the study was to develop an in-depth, integrated understanding of the sector. This included systematic and consistent costings and cost-comparisons, and detailed analysis of those costs. New approaches to the modeling of the qualitative and quantitative issues involved were also covered.

The Ethiopian case study of RWSN's Cost-Effective Boreholes Flagship (Carter et al, 2006), when taken together with other country and continent-wide studies, provides a 10-step guideline to reducing drilling costs.

Bringing about the required changes however is not so straightforward, as they require the committed involvement and participation of multiple stakeholders. These are public, private and civil society correspondence who must all share ownership.

<sup>1</sup> Borehole means a well which is constructed by a drilling machine regardless of depth, diameter or drilling technique.

Map of Ethiopia



## Introduction

The study summarised in this field note has its roots in the widespread perceptions that drilling costs in much of the African continent are unnecessarily high, and that better understanding of the factors contributing to these costs could lead to significant cost reductions.

The idea of carrying out a country case study of drilling costs in Ethiopia was mooted through the Water and Sanitation Program (WSP) Ethiopia country office and the (then) Handpump Technology Network (HTN) at the Durban conference in 2003. HTN has subsequently evolved into the Rural Water Supply Network (RWSN), consisting of three focus thematic areas or flagships covering self supply, cost effective boreholes (CEB) and sustainable handpumps.

The investigation was led by a study coordinator in consultation with the

Figure 1. Ethiopia drilling study components

### The Sector Players

- Regional Governments
- Private Contractors
- Major Donors
- Public Sector Drilling (State Enterprises)
- NGOs

### The Key Issues

- Training
- Groundwater Data & Investigation
- Licensing & Regulation
- Design and Technology
- Sustainability
- Importation

### Sector Experiences

- Starting Out and Operating in the Private Sector
- Sub-contracting
- Costing and Pricing

Source: Carter, et al (2006)

CEB Flagship Coordinator and WSP's Senior Water and Sanitation Adviser in Addis Ababa. Due to the wide scope of the work, and to enable participation by the targeted multiple stakeholders, a team of five experienced water sector professionals undertook the study. These were two economists, two hydrogeologists, and one water engineer who also owns his own drilling company. The study was divided into a total of 14 sub-topics (Figure 1).

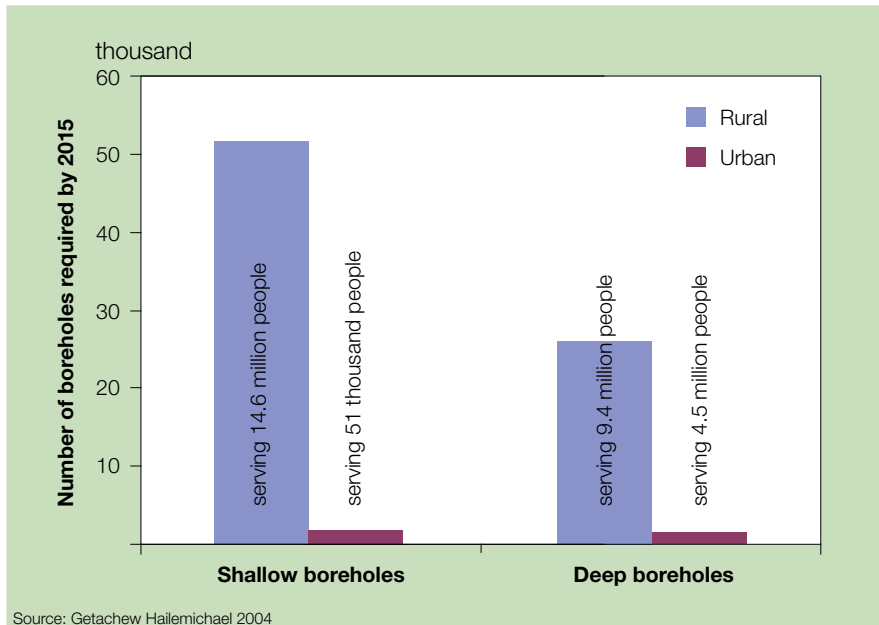
### Well Drilling in sub-Saharan Africa: Too Expensive?

In Ethiopia, great distances, poor infrastructure, a rudimentary manufacturing sector, challenging drilling conditions, and difficulties of 'doing business' contribute to the high costs of groundwater drilling. Nevertheless, the private sector is expanding as a result of demand and increasing investment. In turn, this will introduce greater competition within the sector and inevitably lead to improving the cost-effectiveness of borehole water supplies.

It has been estimated that sub-Saharan Africa needs about 1 million new boreholes to reach full coverage. If a 10 percent reduction could be achieved on the average US\$10-15,000 cost of a borehole in much of Africa, this would result in savings of more than US\$1 billion. This potentially adds another 30 million people with access to safe water.

In Ethiopia alone, Getachew (2004) estimated that more than 80,000 new boreholes will be needed by 2015 to serve an additional 28 million people (MDG target). A cost saving per borehole

Figure 2. Numbers of boreholes and people to be served by 2015



Shallow and medium depth boreholes supply rural water handpumps

## Box 1. Success factors of a water program

**Political will** – long-term Government commitment, expressed in investment in the sector.

**Continuous investment by external support agencies** – not necessarily the major financial contribution, but key investments at critical moments.

**A strong industrial base** – India's industrial base was able to support the drilling program.\*

**Skilled human resources** – India already had strong technical and management skills prior to take-off of the groundwater-based drinking water program.

**Involvement of the private sector** – private sector manufacturers, suppliers and contractors were ready and eager to participate in the drinking water program.\*

**An extensive work program** – leading to major economies of scale.

**Informed technical choice** – the program had access to the best technical know-how, logistics management and equipment.

**Logistical control** – the program was highly effective, once control over logistics (purchasing and deployment of materials and equipment) was in the hands of private contractors rather than Government.

**Standardisation** – simplifying logistical and management issues.

**Communication and infrastructure** – via excellent road, rail and air connections.\*

**Monitoring and evaluation** – systematic and comprehensive monitoring and reporting.

\* Key issues of contrast with sub-Saharan Africa

Adapted from 'Key ingredients leading to the success of the Indian Groundwater-based Drinking Water Program (Talbot, 2004).

of 10 percent could lead to an additional 2 million people in Ethiopia having access to safe water for the same investment which would be a significant achievement. (See Figure 2.)

Studies of drilling costs need to take three important issues into account:

- Care needs to be taken over inter-country comparisons. There are

specific contextual factors which determine the costs of drilling, and vary from country to country. Natural and physical factors such as geology, climate, distance from base of operations, road access, and communications all affect cost. For example, much of the previous work on reduction of drilling costs in sub-Saharan Africa has assumed that the majority of boreholes are drilled in

the Basement Complex to relatively shallow depths (50-60 meters).

The conditions in Ethiopia are more challenging as the Basement Complex represents less than 10 percent of the geology. Many of the wells drilled for handpump supplies (about 66 percent according to Getachew) can be shallow, but even some of these need to be drilled to more than 100 meters depth. However unlike other countries in sub-Saharan Africa, a number of boreholes need to be much deeper (150 to over 450 metres) and motorized to give access to the more densely populated towns and cities. (See Figure 2.)

- The idea of a 'typical' borehole or an 'average' unit cost (whether calculated on a per borehole or per metre basis) is misleading. Borehole costs vary according to a long list of factors. Quoting a 'typical' borehole cost is a little like referring to the typical cost of a building. Purpose, location, dimensions, and completion details determine the actual costs in both cases. Averages are useful as a general indicator but they hide as much as they reveal. One of the purposes of the study was to attempt to unpack the variations and detail the differences. Furthermore, it is vital to understand the 'cost of doing business' where quoted costs (price) will always be higher than actual costs (see Box 2).
- Previous studies of drilling costs have tended to focus on technical aspects and contractual issues. In the Ethiopia case study RWSN investigated a wider set of issues which together

diagnose the 'health' of the groundwater drilling development sector in Ethiopia.

## India's Experience

The success of India's groundwater-based drinking water program extending from the 1960s to the present day is well known and well documented (Talbot, 2004; Black and Talbot, 2005). Rupert Talbot suggests that there were 11 key ingredients of that success. They are summarised in Box 1.

Key features of India's experience, which are at variance with that of sub-Saharan Africa, mainly relate to the relative sophistication of India's manufacturers and contractors, the excellent infrastructure, and the sheer size of the markets involved. India's average population density is 11 times that of sub-Saharan Africa. At the height of India's drinking water supply program in the late 1970s, there were nearly twice as many people not served with a safe water supply (450 million) compared to sub-Saharan Africa today (290 million). Now, after massive investment, there are half as many unserved in India (140 million) as in sub-Saharan Africa.

## Ethiopian Context

Ethiopia's natural and physical environment varies throughout the country. Altitudes range from 125 meters below sea level in the Danakil depression (Afar Region) to over 4,600 meters in the Simien Mountains of Amhara Region. Mean annual rainfall varies from less than 100 millimeters in the Ogaden (Somali Region) to over 2,500 millimeters

### Box 2. Drilling costs - some basic considerations

#### Costs and prices

The difference between the costs of drilling (to the contractor) and the price quoted to and paid by the client (Government or large donors) is sometimes not fully grasped. Assuming that the contractor can accurately estimate the direct costs of a particular contract – and this is not always a fair assumption – he then adds a number of items to arrive at a tendered price (the cost of business). These items include administrative overheads, taxes (such as VAT), profit margin, and different risk ratings and their associated costs. For example if he expects a dry hole, he may increase the profit element on the drilling component and reduce that on the supply and installation of casing. Desire to win a tender and degree of competition are other considerations in pricing.

#### Drilling cost components

Borehole construction costs (drilling costs) are generally made up of four components, each of which can be further sub-divided. These components are:

- **Mobilization and demobilization** – the costs of getting the rig and supporting equipment to site and ready to drill. Major elements of this component are the depreciation costs of equipment, direct costs of moving equipment to site, and the costs of manpower.
- **Drilling** – the actual cost of progressing a hole to the required depth, at the required diameter. Here the main costs again include rig and equipment depreciation and manpower.
- **Supply and Installation of casing** – the costs of completing the borehole construction, using well screen, casing, gravel pack, sanitary seal and concrete headworks.
- **Development and test pumping** – the costs of removal of drill fluids and drilling damage to the aquifer, and test pumping of the borehole and aquifer.

The absolute and relative magnitude of these components varies widely, but each contributes significantly to the total cost of an individual borehole.

#### Costing of components

The costing of each of the four individual components should follow a rational procedure, in which the real unit costs of each element (for example rig and equipment depreciation, manpower, vehicle running costs, consumables costs) are fully accounted for, on an hourly, daily, per km, per m or other appropriate basis. A spreadsheet is a useful tool for this. The Ethiopia study report (Carter et al, 2006) sets these procedures out in detail.

in Bench-Maji and Illubabor zones of Southern Region and Oromia. Around 70 percent of the population live in the 1,500-2,400 meter altitude range. The geology is difficult, and includes intrusive and extrusive volcanic rocks, extensive sedimentary formations, and alluvial deposits.

The majority of Ethiopia's population (more than 86 percent) inhabit the predominantly highland regions of Amhara, Oromia, Southern Nations Nationalities and Peoples Regional State (SNNPRS) and Tigray Regions, and around 84 percent of the total 73 million population is rural. Infrastructure, especially all-weather road access, is poor. Out of a total road network of about 36,500 kilometers, only 4,635 are asphalt. Distances are great making access for drilling equipment challenging and costly. The rainy season and scarcity of asphalt roads restrict the drilling season to between six and nine months of the year.

## Ethiopian Players

Ethiopia's drilling sector is characterised by a mix of state, private sector and civil society organisations, significantly increased financial commitments in the run-up to 2015, and rapid expansion in private sector activity from home and abroad.

The Ethiopian drilling sector comprises the following players:

- Federal Government (Ministry of Water Resources, MoWR)
- Regional Governments (Water

Resources Bureaux)

- Major donors
- State enterprises
- Private sector (subdivided into local and foreign, drilling, manufacture and supply)
- NGOs
- Water users.

As in other African countries, Federal Government's role has evolved from that of service provider to setting sector policy and strategies. It channels its own and donor funding, and provides guidance to the Regions. In addition, it also regulates the private sector and other providers of goods and services. The Regional Water Resources Bureaux (RWBs) in turn are the major purchasers of contracted out services, such as borehole drilling, using donor and nationally generated funds. Ethiopia differs from many other African countries in the supply side.

## The State enterprises

State enterprises are still the preferred service provider for the RWBs especially in emergency and resettlement programs. They have evolved over the last 30 years from the public authorities of the post-imperial/early Derg period. The oldest, Water Well Drilling Enterprise, dates back to about 1975, having been established by the International Bank for Reconstruction and Development (IBRD) and placed under Ethiopia's then Water Resources Commission. It received considerable Japanese support, and consequently much of its equipment is Japanese in origin.



Water Works Construction Enterprise was another long-established parastatal with drilling capacity. It has however recently been divesting out of drilling, and is now no longer a player in the sector.

Six of Ethiopia's Regions<sup>2</sup> (Tigray, Amhara, Oromia, SNNPRS, Somali and Afar) have State Enterprises engaged in borehole drilling. Some of these Regions, and two others (Benishangul-Gumuz, Gambella) have drilling capacity within their Water Resource Bureaux.

The State Enterprises are expected to operate in a financially viable manner, without State subsidy, and to compete with the private sector. They differ from the true private sector however in three important respects as they are:

<sup>2</sup> In total there are nine ethnically-based Regions and two self-governing urban administrations.



- Governed by Boards, often comprising mainly government personnel
- Usually the contractor of preference for Regional or Federal Government
- Subject to Civil Service rules concerning matters such as employment and procurement.

Some of the Regional Water Bureaux carry out drilling operations directly, even though there may also be a State Enterprise operating within the Region.

### Private sector

The borehole drilling private sector in Ethiopia is a relatively recent phenomenon. Hydro Construction and Engineering Co Ltd claims the longest history, having grown out of a Nigerian

parent company which was set up in 1980, and started business in Ethiopia in 1991. During that time Hydro has drilled around 450 wells. Another older company, Saba Engineering PLC, was set up in 1993 to carry out geotechnical and civil construction work. Saba entered water engineering in 1994, and drilled a small number of cable-tool wells by 1999.

With the purchase of a modern rotary/DTH machine in 2000, Saba started borehole drilling in earnest. Subsequently two more machines were acquired, and by 2003 more than 125 boreholes had been drilled. In recent years the local private sector has experienced competition from foreign firms from China and India. These seem able to operate at significantly lower costs than the local private sector. In total around 25-30 private drilling companies now operate in Ethiopia, of which 5 are from India and China.

### NGO and faith-based organisations

Some NGO and faith-based organisations carry out borehole drilling work, utilising one of three modes of operation:

- Ethiopian Orthodox Church (EOC), Kale Heywet Church (KHC), Mekhane Yesus, World Vision have their own drilling equipment. KHC, for instance, has been drilling since 1988, and with its present two rigs completes about 80 wells per year. In total KHC has drilled many hundreds of boreholes in Ethiopia over the last 17 years.

- Other NGOs such as Water Action sub-contract drilling to State Enterprises or Private Companies, but use their own in-house or consultant expertise for surveys, design and supervision.
- A third group of NGOs occasionally finance drilling, but through Regional Water Bureaux (which carry out survey, design and supervision work) and Regional Enterprises (which carry out construction). This mode of operation is not common today.

### Large donors

Large donors such as the World Bank, the African Development Bank, the European Union, Unicef and others have significant water sector investment programs. A large part of the capital investment brought in through these programs will inevitably be spent on groundwater drilling to supply rural communities with handpump boreholes, and motorized boreholes for towns and cities. Although the amounts of money and the timings involved remain uncertain at the present time, it seems likely that annual water sector expenditure may soon more than double from the US\$68 million (fiscal year 2001-02) estimated by WSP (2004).

### Operating Environment

The operating environment for any development activity in Ethiopia is characterised by strong State control. Telecommunications, including internet, email, mobile telephone and SMS messaging are under State monopoly. There is limited access to these

facilities<sup>3</sup>. Importation is subject to rules such as those requiring the use of national carriers. Registering and licensing of groundwater professionals and drilling companies is demanding in terms of personnel requirements, processes and procedures. The numbers of personnel required are aligned to public sector operations rather than the more streamlined ways of working in the private sector. Insecurity (perception of physical danger) is an issue in some parts of the country, notably northern Tigray and Afar, and Somali Region. Finally, in Ethiopia the drilling sector is also active in emergencies situations (triggered especially by regular and frequent droughts) and in the Government's ambitious resettlement program. This program involves moving more than 2 million people from vulnerable and drought-prone woredas (districts) to other less densely populated areas.

## Findings of the Investigation

### Investment

The large water sector investments by Government and by donors such as the World Bank, African Development Bank and EU should result in further competition and competitiveness among private drilling contractors, and price reductions should follow.

### Status

In Ethiopia the State remains the principal player in the drilling sector. The

<sup>3</sup> There are one tenth as many mobile phones per head in Ethiopia compared to Uganda.

### Box 3. Training needs of Ethiopia's drilling industry

Carter et al (2006) estimated that Ethiopia needs about 4,000 drillers and technicians and 2,000 trained and experienced hydrogeologists to meet its MDG obligations in the domestic water and agriculture sectors. The present numbers are not known with certainty, but both groups almost certainly number in the low hundreds. There is therefore a significant shortage of skilled and experienced personnel in the drilling sector. In-country training of groundwater personnel is or used to be provided at a number of locations.

**The Ethiopian Water Technology Centre**, supported by JICA and the Ministry of Water Resources is now the only institution that regularly offers specialist training on groundwater studies (hydrogeology) and drilling technology. The courses last a maximum of three months. The centre trains 40 people at a time, and annually trains 180 – 220 professionals. Ex-trainees and an external evaluation confirm that the courses are useful and relevant. Since its objective is to build the capacity of the Regional Water Bureaux, the Ethiopian Water Technology Centre is only open to Government employees. Private contractors have requested JICA to train their staff, but without success. Given the limited alternative training opportunities and demand from the private sector, many wish to see the Centre extend its services beyond the public sector.

perception is that private sector drillers do not wish to undertake contracts in emergency and resettlement programs, and there is still a strong preference in many parts of the country for Regional authorities to contract out to the State Enterprises.

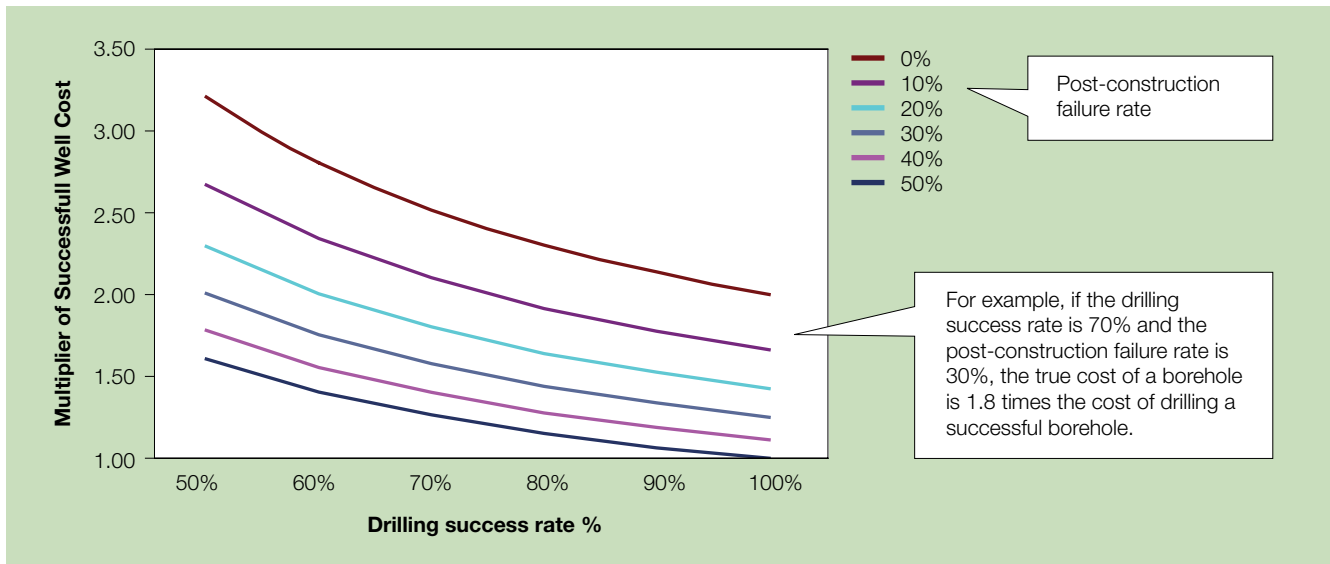
The number of drilling rigs and of contractors is increasing. Since Getachew's (2004) estimate of 103 rigs and 15 private contractors, those numbers have grown to 150 rigs and about 25-30 contractors (Carter et al,

2006). However, some 66 percent of the existing rigs are over 15 years old. Breakdowns are frequent and repairs can take a long time.

Setting up in business as a drilling contractor is straightforward in principle, but time-consuming, expensive and challenging in practice. The major challenges relate to loan financing and obtaining a Government licence to operate. Importation of spare parts and consumables requires adherence to specific rules – such as the use of



Figure 3. Effects of drilling success rate and post-construction failure rate on all-inclusive borehole costs



Ethiopian Shipping Lines for freight, and the use of letters of credit instead of less time-consuming and more cost-effective procedures for importation.

### Technical aspects

Borehole designs in Ethiopia generally consist of drilling at 10-14 inch diameter through superficial deposits, then onward drilling at 7-10 inch. Casing of 6 inch diameter is the norm for handpump boreholes, and larger for motorised boreholes. Steel is the usual material of choice for casings and screens.

Boreholes up to 60 metres depth are considered shallow in Ethiopia. Medium depth refers to the range 60-150 metres, and boreholes greater than 150 metres are classified as deep. Studies show in the recent past (WWDSE, 2003) and in the future (Getachew,

2004), shallow boreholes will make up approximately 60-75 percent of the total number required (Carter et al, 2006). For example in Oromia over the last 5 years (1998-2003), 66 percent of the 565 boreholes drilled were shallow, and these serve 26 percent of the total number of users. The other 34 percent of the boreholes were deep, but together they serve 74 percent of the borehole water users<sup>4</sup>.

The WWDSE study showed clearly that required drilling depths estimated at time of tender by officials were usually significant over-estimates compared to the depths actually completed. The implication of this is that contractors mobilize heavier equipment, and more casing and consumables than they actually need, so adding unnecessarily to costs.

### Contracting out

Packaging of contracts does occur at times, but it is not the norm. In the case of one contractor, he had to enter into 11 separate contracts to drill 24 boreholes.

Supervision of drilling tends to be carried out by young inexperienced geologists, who need to refer back to their superiors for decisions. This adds to idle time and cost.

### Information and support

Drilling records have not been collected and stored with care. Consequently an enormous amount of potentially useful information has been lost or is unavailable to new drilling programs.

<sup>4</sup> WWDSE 2005



The unit cost of a PVC well casing such as the one shown can be up to 50 percent less than a steel casing

This and scanty mapping means drilling conditions for tender purposes are often overestimated by the client. Geological mapping only extends to 20 percent of the country at 1:250,000 scale. There is a national geological map at 1:2m scale. Geophysical and other investigation equipment is available in most Regions but the amount of equipment is limited.

Training opportunities are few and restricted to employees of Government or State Enterprises. There are no formal training opportunities for private sector drillers. The need for skilled and experienced hydrogeologists and drillers

is great as there is a significant shortfall (Box 3).

### Local manufacture

The ability to locally manufacture rigs and consumables is still evolving. There have been a few attempts to assemble rigs locally, and there is some progress in local manufacture of plastic casings and screens, but both face difficulties in getting established.

### Performance and costs

Drilling success rates in Ethiopia are reported to be generally high at 70 to 85

percent. Post-construction failure rates are not known with certainty, but in other countries a figure of 30 percent is often quoted. The reality may often be higher. Dry boreholes and post-construction failures affect all-inclusive country-wide drilling costs. High failures boost the unit cost of successful wells significantly.

Figure 3 shows in particular that post-construction failure (due to poor construction, lowering of the water table due to inadequate assessment of renewable groundwater resources or extended drought, or prolonged pump failure) has a significant impact on the true costs of drilling. The assumptions behind this figure are fully set out in Carter et al (2006), and they include allowance for the fact that the cost of drilling a 'dry' borehole is around 60 percent of that of an initially successful source. This is because no permanent casings will be installed, the wellhead completion will not be carried out, and no pumping tests will be undertaken.

In the example given, assume the cost of a borehole to be US\$10,000. Then if 100 boreholes are drilled, 70 will be initially successful (costing US\$700,000), 30 will be 'dry' (costing US\$180,000) and another 21 (30 percent of 70) will fail subsequent to drilling, leaving only 49 functioning sources. The total cost of drilling will be US\$880,000. Each ultimately successful and functioning borehole will have actually cost US\$18,000 (Figure 3).

It is clearly important to protect the large investments which are made in borehole drilling by investing appropriately in pre-drilling investigations

(siting and hydrogeological studies, including assessment of recharge) and establishment of operation and maintenance procedures (at both pre- and post-construction stages).

## We Know What to Do ...

The ten-step guideline to reduce costs which have been made by others (and confirmed in the Ethiopia case study)<sup>5</sup> along with the main reasons for high drilling costs in sub-Saharan are outlined below. As can be seen possible solutions are not isolated to single steps but form a common thread through the steps.

### 10 steps for cost reduction

#### **1. Fit borehole design to purpose, drill to necessary depth only and make use of small diameters, plastic or no casings.**

Higher costs are incurred through inappropriate borehole designs at the time of tender. Examples are drilling at larger diameters than are required for handpumps or modern submersibles, and using steel casings rather than plastics. Drilling deeper than necessary also adds to the costs.

If design diameters and total depth were reduced then costs would be lower. The same applies to the use of lower cost plastics rather than steel. The unit cost of plastic (uPVC) casings and screens are significantly lower (say 50 percent less) than those of steel. In the case of shallow boreholes, for which uPVC

<sup>5</sup> Modified from Wurzel, 2001; Smith, 2003; Ball, 2004; Carter et al, 2006

casing and screen is an option, savings could be made in terms of both diameter and materials selection. The savings achievable by selecting 5 inch uPVC linings instead of 6 inch steel would be approximately 65 percent of the materials cost, 47 percent of the casing and completion component cost, or 20 percent of the total borehole cost.

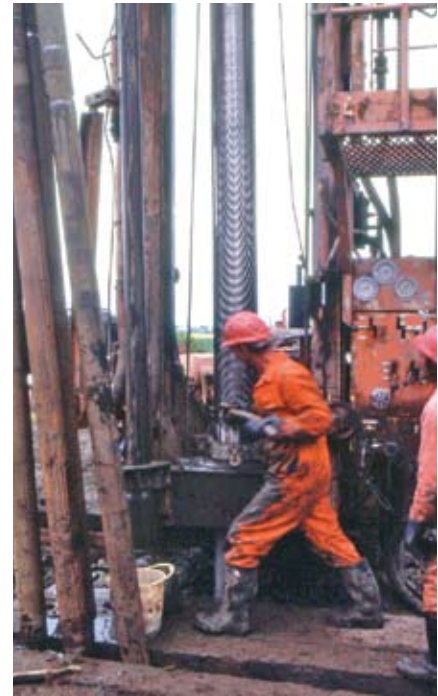
#### **2. Use smaller, less costly rigs and support equipment to match relaxed borehole designs.**

Drilling costs are raised unnecessarily when the actual drilled depth is considerably less than the estimated depth. It means that larger and more expensive rigs are deployed. This then increases the amount of drilling equipment and consumables that are mobilized to site such as steel casing which is only recommended for boreholes deeper than 100-120 meters.

Lightweight rigs and equipment for shallower depths and smaller diameter holes can reduce drill string and tool costs as well as those incurred for depreciation, energy and fuel. In addition the size and number of support vehicles are reduced.

#### **3. Allow packaged contracts for multiple boreholes in close proximity and similar geology.**

There are high mobilization costs associated with long travel distances from the contractor's base. Since nothing can be done to reduce distances involved, the only strategies can be to aim for economy of scale. Private enterprises have found that



Installation of a steel wellscreen

in most cases, drilling works are announced with very few boreholes in one lot and involve distant sites. If tenders were prepared in packages of 10-20 boreholes in a cluster area, contractors could submit lower prices as several boreholes secures them work for a longer period. Cost and time of mobilisation would also be less.

#### **4. Improve knowledge of hydrogeology, and use modern borehole siting practices.**

Many hydrogeologists and other sector professionals complain of the limited understanding of the national hydrogeology. An often-forgotten function of borehole construction, apart from the obvious goal of producing water, is to gather hydrogeological data.

If borehole logs, completion reports and test pumping data are compiled and then subsequently lost, this important aspect of the borehole construction process is wasted.

An improvement in the knowledge of hydrogeology and site survey expertise can increase the drilling success rate by reducing the number of dry holes. It will also reduce the disparity between anticipated and actual drilling depths during the tender process giving significant cost reductions.

This can be achieved through training and access to modern drilling technology for both the public and private sectors. Rules for gathering data should be enforced. Databases also need to be setup using the collected information.

### **5. Match test pumping requirements to borehole purpose.**

High costs are incurred through unnecessarily rigorous and lengthy test pumping regimes. This can be done through shorter test pumping periods for low yielding boreholes. Short-cuts should not be taken with development, since these would adversely affect long-term performance. There is an argument for carrying out less demanding yield/drawdown tests for handpump boreholes, but these should not be omitted altogether. Since the cost of test pumping is most sensitive to the location of the site (and the corresponding mobilization and demobilization costs) and the duration of aquifer testing, any appropriate savings in test pumping duration would reduce the costs.



Ready to start drilling in northern Ethiopia

### **6. Improve construction supervision.**

Construction supervision is often carried out by young inexperienced (hydro)geologists. A system needs to be put in place to give these geologists more extensive training in supervision, hydrogeology and drilling. This will allow decisions to be made more quickly and better supervision of the quality of work by contractors. Cost reduction implications will be through less idle time and improved quality of work as there will be fewer post-construction failures.

### **7. Carry out rigorous evaluation of renewable groundwater resources, not simply test pumping.**

High rates of post-construction failure can often be ascribed to an inadequate assessment of groundwater resources. Boreholes can fail, some time after construction, from over-abstraction in relation to the available renewable

groundwater resources. Borehole pumping tests tell nothing about groundwater resources, and separate recharge or resource assessments need to be undertaken in addition to standard test pumping.

Groundwater investigations are required to locate a borehole site which delivers a sustained yield at minimum cost. Thorough evaluations are a vital component and standard guidelines and codes of practice for ground water investigations need to be developed for all regions. Greater access should be given to groundwater investigation instruments and equipment.

### **8. Establish sustainable O&M procedures for pumped groundwater sources.**

A specific requirement of the MDGs is sustainability. Transparent clear dialogue is required pre-construction with communities to enable an informed

choice about technology. Issues that have to be addressed both before and after construction include a developed sense of ownership, strong water committees, and involvement of women in management and operation. Sound arrangements for financing of operation and maintenance are crucial as is availability of spare parts.

**9. Support private contractors by easing importation, facilitating local manufacture of casings and well-screens, giving tax breaks, and assuring steady and sufficient work flow.**

High costs result from difficulties of ‘doing business’ in those countries most in need of boreholes. Small markets lead to dis-economies of scale and limited competition.



Assessing borehole yield by air-lift testing

**Box 4. Specific training needs**

In the study, interviews with sector professionals and drilling contractors identified the following specific areas where training was needed in the drilling sector (public and private sector):

- Operation, maintenance and repair of drilling machines and equipment
- Basic and advanced drilling technology course at diploma level for drillers
- Groundwater modeling and investigation
- Field methods (collection of data in the field)
- GIS and remote sensing
- Water resources management and borehole design techniques
- Environmental impact assessment
- Modeling flow of pollutants within groundwater

Private contractors need support on importation and local manufacturing. They also need to be assured about steady work. Ways forward to reduce costs would be to develop favourable financing arrangements, extend tax exemption incentives as well as create new ones for local manufacturers and importers. A wider range of options for efficient rapid procurement of spares such as the Franco Valuta<sup>6</sup> and the internet should be introduced. There is scope to relax current requirements in terms of licensing and registration for numbers and qualifications of drillers at the present time because of significant skills shortages. Confidence regarding sufficient workflow would be increased by packaging and clustering of drilling contracts.

<sup>6</sup> Franco Valuta is a term used in Ethiopia to refer to the purchase and import of goods outside the bank process, or without opening a Letter of Credit.

**10. Improve communications networks, enhance management skills of public and private sectors.**

High costs result from weaknesses in logistics compared to potential outputs from physical equipment. Communication networks are still being developed and improvement would go a long way to cost reduction in the groundwater drilling sector. Management skills of the public sector could be enhanced through improving the understanding of direct and indirect costs. Rig activities need to be monitored, recorded and analysed. The management of equipment, human resources and financial resources by both the public and private sectors need to be improved if significant cost reductions can be achieved.



## But How To Do it is More Challenging....

The 10 steps to reduce borehole construction costs appear straightforward. Most relate to either technical or contract management issues, and are apparently simple to change. The reality, however, is somewhat different. Underlying the issues highlighted behind the 10 steps to cost reduction are several weaknesses which are present in Ethiopia, but also more widely in sub-Saharan Africa. These include:

- Resistance from the public sector which professionals experience when they try to change design standards or practices;
- Limited expertise, and even more limited resourcing, at local government level to permit critical tender evaluation and adequate contract management, inspection and supervision;

- Difficulties of 'doing business' – obtaining loans on realistic terms, importing spare parts and consumables, competing fairly in a transparent operating environment, and having some assurance of a sufficient workload;
- Insufficiently detailed knowledge of groundwater conditions, introducing uncertainties into contract specifications;
- Unacceptably high post-construction failure rates because of the inherent weaknesses of communal ownership and management, the failure of spare parts supply chains, and inadequate external support to communities or other borehole operators.

## Lessons Learned

The Ethiopian case study showed that major changes are needed to bring construction costs down. All 10 Steps

need to be addressed. Two questions remain: how to prioritise these changes, and how to achieve them?

## Establishing priorities

Some of the proposed means of cost reduction require only simple quantitative analysis. For example, the use of plastic rather than steel casing, or the savings achievable by packaging drilling contracts can be readily calculated, using a simple spreadsheet which sets out a borehole costing in a systematic manner.

Other factors are less easily quantified. For example, to what extent would better construction supervision lead to better construction quality, and what effect would this have in turn on post-construction failure rates? And how, and at what cost, could supervision be improved?

Or to what extent would increases in investment in geological mapping and databases result in improved drilling performance, and consequently reduced overall costs?

There is clearly a mix of readily quantifiable factors and more qualitative issues which affect the performance of the drilling sector, and all need to be taken into account. The case study report itself (Carter et al, 2006) gives some indications of the potential of decision modelling tools for a context such as this.

### Processes of change

It is clear that no single authority can reform the drilling sector on its own. The changes which need to be made span issues of technology, public sector rules and procedures, contract management and supervision, knowledge management, public sector expertise and resources, and investment. All stakeholders therefore need to be involved in a process of change which is jointly owned, and to which all are committed.

### Implications for policy

The Ethiopian case study has added to an increasing body of evidence showing that there is a significant potential to reduce drilling costs. However, if drilling costs in sub-Saharan Africa are to decrease significantly, a number of policy and strategic implications need to be taken on board.

- The national private sector needs to be viable. It needs to be supported

with technical and business training, a steady and sufficient work flow, and an operating environment in which the challenges of 'doing business' are minimized. This requires a judicious combination of 'hands-off' policies to enable the private sector to flourish, with strong support from the public sector in the form of training, work flow, and effective on-site supervision.

- The public sector must be strong, technically competent, experienced and scrupulously fair in putting work out to tender and in evaluating tenders. Furthermore it must be competent in managing drilling contracts, including providing decisive supervision, either directly or through consultants. It must administer drilling contracts fairly, quickly, and efficiently to keep the private sector working effectively.
- Sustainable operation and maintenance of boreholes is fundamental. Even if 100 percent of boreholes drilled are initially successful, if 30 percent fail within a short period of completion, for whatever reason, then the real costs of construction become more than 40 percent higher.
- Multi-stakeholder national as well as regional working groups and associations must be established to tackle problems in the drilling sector as changes require the committed participation and ownership of all stakeholders. These need to include, and benefit from, the various experiences and viewpoints of multiple public authorities, contractors, donors,

manufacturers and suppliers, and NGOs.

In conclusion, the policy implications highlighted here focus broadly on two aspects: competence and ethos. Competence is built through a combination of formal training and learning-by-doing. Competence must be multi-disciplinary, giving hydrogeologists a good awareness of contractual issues, and contract administrators and policy-makers some understanding of the challenges and risks inherent in borehole drilling. Since competence is built through practice, the natural fear of making mistakes must be resisted.

Ethos is about attitudes, motives, mutual understanding and respect. It underlies both what is done, and how it is done. The ethos required of both public and private sector organisations involved in drilling consists of professionalism, honesty, fairness, and a focus on the greater good of meeting the MDGs and reducing poverty. These attitudes can be taught to some extent, but fundamentally they need to be conveyed through example (from the top) and through appropriate incentives.

Given the massive scale of the needs for water supply in Africa, and the inevitably high costs of developing groundwater supplies, sector investments should include a strong focus on the technical and managerial competence and ethos required to deliver returns on these investments. To do otherwise would be false economy.

## References

- Ball, Peter. 2004. *Solutions for Reducing Borehole Costs in Africa*. WSP Field Note. WSP/RWSN/SKAT
- Black, Maggie with Rupert Talbot. 2005. *Water – a Matter of Life and Health*. Oxford University Press/Unicef.
- Carter, Richard, Desta Horecha, Etsegenet Berhe, Eyob Belete, Eyob Defere, Yetnayet Negussie, Belete Muluneh and Kerstin Danert. 2006. *Drilling for Water in Ethiopia: a Country Case Study by the Cost-Effective Boreholes Flagship of the Rural Water Supply Network*. Federal Democratic Republic of Ethiopia/WSP/RWSN.
- Getachew Hailemichael. 2004. *UNICEF Study on Groundwater and Requirements for Drilling and Other Systems Tapping Groundwater in Ethiopia*. Paper for International Groundwater Conference, Addis Ababa, 25-27 May 2004.
- Rowles, Ray. 1995. *Drilling for Water, a Practical Manual*. Avebury Press, Aldershot, UK
- Smith, Craig. 2003. *Rural Boreholes and Wells in Africa – Economics of Construction in Hard Rock Terrain*. American Water Works Association Journal, August 2003, Vol 95, No 8, pp100-111.
- Talbot, Rupert. 2004. *India's Water Well Revolution – Achievement and Challenge*. Paper for International Groundwater Conference, Addis Ababa, 25-27 May 2004.
- Wurzel, Peter. 2001. *Drilling Boreholes for Handpumps*. SKAT Working Papers on Water Supply and Sanitation, No 2, SKAT, St Gallen, Switzerland.
- WSP. 2004. *Ethiopia Water Supply Sector Resources Flows Assessment*, WSP July 2004.
- WWDSE. 2005. *Comparative Analysis of Water Well Drilling Costs and Technology in Ethiopia*, Water Works Design and Supervision Enterprise for Unicef, Addis Ababa.

## About the study

The study was commissioned by the Cost-Effective Boreholes Flagship of the Rural Water Supply Network (RWSN) and the Water and Sanitation Program(WSP). It was supported by the Federal Ministry of Water Resources and Regional Water Bureaux in Ethiopia, and carried out in close collaboration with UNICEF and Water Works Design and Construction Enterprise.

## About the author

The author, Prof. Richard Carter, is a community water supply and groundwater specialist with more than 30 years experience in private sector consultancy and academic environments. He has a special interest in low-cost water well drilling which he has developed through R&D and training activities in UK and sub-Saharan Africa. He is widely published and has worked in the water sector in over 20 developing countries, for a range of international agencies, consultants, and NGOs.



The Water and Sanitation Program is an international partnership for improving water and sanitation sector policies, practices, and capacities to serve poor people



The Rural Water Supply Network RWSN is a global knowledge network for promoting sound practices in rural water supply.

### October 2006

Water and Sanitation Program - Africa  
World Bank  
Hill Park Building  
Upper Hill Road  
PO Box 30577  
Nairobi  
Kenya

Phone: +254 20 322-6306  
Fax: +254 20 322-6386  
E-mail: [wspaf@worldbank.org](mailto:wspaf@worldbank.org)  
Website: [www.wsp.org](http://www.wsp.org)

RWSN Secretariat  
SKAT Foundation, Vadianstrasse 42  
CH-9000 St. Gallen  
Switzerland

Phone: +41 71 288 5454  
Fax: +41 71 288 5455  
Email: [rwsn@skat.ch](mailto:rwsn@skat.ch)  
Website: [www.rwsn.ch](http://www.rwsn.ch)

Author: Richard Carter

Peer reviewers: Erich Baumann, Kerstin Danert, Belete Muluneh, Joseph Narkevic

Prepared under the guidance of Joseph Narkevic and Piers Cross (WSP-Africa)

Editor: Melanie Low

Photo Credits: Richard Carter

Contacts: Richard Carter [[r.c.carter@cranfield.ac.uk](mailto:r.c.carter@cranfield.ac.uk)]  
Kerstin Danert [[kerstin@danert.com](mailto:kerstin@danert.com)] Erich Baumann [[erich.baumann@skat.ch](mailto:erich.baumann@skat.ch)]