Training local technicians in borehole drilling

Dotun Adekile and Peter Ball

How much formal education do you need to site and drill boreholes successfully? International NGOs assisting in the rehabilitation of infrastructure in Sierra Leone have found that a hands-on borehole training course for local technicians has been both popular and successful.

The eight-year conflict in Sierra Leone came to an end in July 1999 with the signing of the Lomé peace agreement. An estimated 750 000 people were displaced by the conflict. With the cessation of hostilities, the displaced persons were encouraged by the government to leave the internally displaced persons' (IDP) camps where most of them lived during the conflict, and return to their homes. Whatever infrastructure was available in the communities before the war had completely collapsed and would have to be rebuilt. Several NGOs working in Sierra Leone saw the need for assisting the communities in the provision of safe drinking water sources and sanitation facilities.

In 2000, three NGOs – Oxfam, Action Contre la Faim (ACF) and Peace Winds Japan – embarked on the construction of boreholes in some of the communities. Hard crystalline rocks of the basement complex underlie the area of operation in south-eastern Sierra Leone. The NGOs acquired geophysical and drilling equipment, and employed local staff to carry out the work. Very few of the staff had any previous experience of drilling or geophysical surveying and only two had more than secondary school education. Personnel therefore had to be trained to run the programme. The three NGOs, in mutual collaboration, employed a five-man team of consultants to carry out the training.

Organization

The training team was led by Robin Hazell and Peter Ball. Robin Hazell had previously spent 50 years in Africa as a geologist pioneering groundwater development in crystalline terrain and training a generation of hydrogeologists. Peter Ball is a drilling specialist who in the past 30 years has been involved in the development of appropriate technology rigs and training of drilling technicians in several developing countries. The other three members comprised Dotun Adekile and Yakubu Hyabo, Nigerian hydrogeologists trained by Robin Hazell, and Sunday Arafan Mangai, a Nigerian drilling technician trained by Peter Ball. Each had more than 15 years' field experience.

The first training workshop was held between October 2000 and February 2001. Since then, three other workshops were held in November 2001, November 2003 and August 2004. Table 1 shows the number of participants from each organization.

The first workshop took place in Bo, the second largest town in Sierra Leone, and it lasted for six weeks, followed a month later by a session to review the progress made by the trainees and offer advice. The training workshops comprised both interactive classroom

Table 1. Number of participants at each training workshop

Year	*NGO*	*No. of participants*
2000	Oxfam	8
	ACF	3
	Water Supply Department	5
2002	Peace Winds Japan	16
2003	Oxfam	11
	Peace Winds Japan	9
2004	TearFund	16

Geological reconnaissance includes spotting surface fissures

sessions and practical fieldwork. All the participants attended the classroom sessions and the first day of fieldwork. Thereafter they were split into two groups: a borehole site location group and a drilling group. Training resource manuals were provided for each participant.

Siting boreholes

The trainees were given an introductory lecture on the rationale for groundwater development in a rural community, safe sources of water in relation to community health, and village evaluation procedures. The need for community involvement at every stage of the project cycle was emphasized. The workshop trainers went on to discuss the principles of geology, rock classification and identification, landform development, the weathering of rocks, jointing in rocks, and the geology of Sierra Leone. The water cycle and the nature of the distribution of groundwater were explained, with emphasis on joints and the weathered zone as the target aquifers.

The theory and methodology of siting boreholes on crystalline rocks using geophysical techniques, such as the EM/VES (electromagnetic/vertical electrical resistivity sounding), was discussed. At the first workshop the trainees were taught resistivity data interpretation by field approximation and computer interpretation. In the field approximation, the curve is checked for smoothness; rapidly and constantly increasing resistivity equates to fresh rock and the lowest point on the U-shaped curve is a function of depth to fresh rock. By the time of the second workshop the resistivity software had been lost and the trainees carried on the interpretation by field approximation and later by curve-matching techniques. With these techniques they achieved a success rate of over 70 per cent, which led us to query the rationale of spending a lot of time teaching computer interpretation alone in an environment where the computer or the software may not be available. Thus, at subsequent training sessions, some emphasis was put on the trainees' proficiency in curve matching.

The interpretation of the EM data was empirical and qualitative i.e. fresh crystalline rocks have very low conductivity while clays have high conductivity values. Porous, water-bearing, weathered rocks have moderately high conductivity values. Anomalies may be indicative of joints.

Other topics covered included:

- baseline survey methodology
- groundwater quality monitoring
- borehole logging
- data management.

Recognition logging and hardness grading of borehole samples

Drilling

The borehole-design and drilling-technology sessions also focused on weathered rocks and joints as target aquifers. The following drilling methods were taught in relation to the associated fluids and their ability to keep the borehole open by means of a hydrostatic head and the removal of cuttings by up-hole velocity.

- water/mud circulation in weathered material
- foam/compressed air drilling in harder formations.

Relevant borehole designs for the different drilling methods were introduced with a discussion of lining material, screen slot size selection and screened interval.

Other topics discussed were:

- gravel packing/ formation stabilizer
- borehole development
- pumping test
- pump installation and maintenance
- borehole rehabilitation
- site safety
- rig maintenance.

Costing of geophysical survey and drilling

As a part of capacity building, the economics and logistics of a geophysical survey and drilling were introduced at the third workshop. It was felt that the NGOs will eventually complete their programmes and disengage from the country, leaving some of the trainees as private participants in the sector. The trainees would thus benefit from some idea of costing and preparation of quotations and management of field teams. The trainees were taught how to complete a bill of quantities, bearing in mind equipment cost, amortization, staff cost, insurances, taxes and profitability.

Fieldwork

On completion of the classroom sessions, practical field training continued in some of the nominated communities and the trainees had the chance to practise at first hand the procedures which had been described in the class alongside the training consultants. They carried out baseline surveys, terrain analysis, identification of rock types, joints in rocks and degrees of weathering. Trainees were advised always to look at the grain of the

Table 2. Percentage success rate of the NGO borehole programme

NGO	*Year*	*Location*	*No. of boreholes drilled*	*No. productive*	*% success*
Oxfam	2000–2001	Barrie chiefdom	44	32	72
	2002–2003	Kailahun district	49	32	65
Peace Winds Japan	2002	Kenema	14	13	92

Taking resistivity readings

Water! The geophysics team have successfully sited and drilled a borehole at an internally dispaced people's camp near Bo, Sierra Leone

minerals of the rocks to be able to predict the weathering product and its water-bearing capacity.

Geophysical surveys were carried out and interpreted by the trainees, and borehole sites were chosen. Based on available borehole data from previous projects the range of geophysical values for successful boreholes were identified. Rigs newly acquired by the NGOs were commissioned and the chosen sites drilled.

During the first workshop there was an urgent need for water at the Kendeyela IDP camp. A drilling rig was available but there was yet no facility for a geophysical survey. The camp was on a ridge fringed by *boliland* (swampy drainage flats). The opportunity was used to demonstrate that in the absence of geophysics, a borehole could be sited on the basis of topography. The borehole was sited on low ground on the edge of the *boli*. Drilling terminated at 19 m as there was no facility for hammering and the borehole was productive.

Trainee performance

Tests administered at the end of the classroom sessions showed that, but for one or two, the trainees had a good understanding of the topics discussed. The very few that performed below average in the tests turned out to be the best in the field, an indication that the low performance at the test was a function of literacy, rather than a lack of comprehension.

After the various workshops the trainees went on to carry out the drilling programmes of their respective organizations i.e. selecting borehole sites, drilling, installation and maintenance of pumps. Feedback from two of the drilling programmes shows some degree of success, as shown in Table 2. Six abortive boreholes in Buedu village resulted in the rather modest success rate in Kailahun District. The team should probably have given up after the second borehole. With the new-found stability in Sierra Leone, NGOs are disengaging from the country. Some of the previous trainees are setting up as private service providers and some are setting up local NGOs to support the work started by the international NGOs.

Lessons learnt

The success of the NGOs' borehole programme shows that using the simplest methodology, motivated personnel with no previous specialized knowledge and modest education can be trained to site and drill boreholes in difficult terrain.

Borehole geophysical survey is best done by trained local personnel. This is preferable to foreign consultants, helicoptered in with a 'black box' and laptop, with no connection to the community.

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