
Professionalising Groundwater Development in Zambia

Short Course on Drilling Supervision



'The supervision checklists have allowed me to understand what needs to be checked on a drill site. Previously I would go to site meetings and would not know what to do or look for. Now I have been empowered with some guidelines and standards'. Training course participant

Final Report

September 2018

Acknowledgement

The course facilitators, Dotun Adekile, and Max Karen gratefully acknowledge the support of Douglas Abuuru and Humble Sibooli of UNICEF Zambia for their support in preparing for the short course. We are also grateful to all the participants for their cooperation.

Background

This document reports on the Short Course on Drilling Supervision that took place in Zambia in July 2018 as part of the Project Collaboration Agreement (PCA) 2017-2019 between UNICEF and Skat Foundation. Developing and running the course was made possible with financial support from UNICEF Programme Division, Skat Foundation and UNICEF Zambia. The course was carried out on behalf of the Ministry of Water Development, Sanitation and Environmental Protection Zambia.

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Frontispiece

Group photograph of the training course participants on 11nd July, 2018

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Abbreviations

MWDSEP	Ministry of Water Development, Sanitation and Environmental Protection
NGO	Non Governmental Organisation
RWSN	Rural Water Supply Network
WARMA	Water Resources Management Authority

Summary

As part of the cooperation agreement between the Government of Zambia, UNICEF and SKAT Foundation on Professionalising of Groundwater Development in Zambia, a five day training course on Borehole Drilling Supervision was conducted by Skat Foundation on behalf of the Ministry of Water Development, Sanitation and Environmental Protection between the 9th and 13th July, 2018. The training course was delivered at the Mika Convention Centre, Mean Wood, Lusaka and the Centre for Child Development, Chongwe, Lusaka, Zambia by Dotun Adekile and Max Karen with remote support from Kerstin Danert, all of Skat Foundation. Douglas Abuuru and Humble Sibooli of UNICEF Zambia provided logistical support during the course. Twenty five participants took part in the course, of which four (16%) were women, 18 (72%) were young professionals (i.e. aged 35 or under) and two were young professional women. The following report gives an account of the proceedings and outcomes of the training course.

The learning objectives of the training course were that by the end of the course, the participants would:

- Understand the importance of effective supervision in borehole construction for sustainability
- Understand the steps and detailed actions required in full time supervision
- Understand the steps and detailed actions required in part time supervision
- Be able to quality assure and certify drilling records
- Be in a position to undertake borehole construction supervision

The course was delivered in four units as follows:

- Unit 1: Principles of Borehole Supervision
- Unit 2: Understanding groundwater without jargon
- Unit 3: Principles of Cost Effective Boreholes – what does it mean for Zambia
- Unit 4: Field work, on-site borehole supervision

The course was delivered by a mixture of training and teaching methods and hands on field measurement. The course comprised a first day of classroom sessions to introduce the different aspects of drilling supervision followed by three days of practical field work and a final day in the classroom for rounding up and reflection on lessons learnt. The classroom sessions were delivered by lectures using PowerPoint presentations, interactive discussion and film shows. Participants were encouraged to ask questions for clarification regularly during each presentation. The classroom sessions were conducted at the Mika Convention Centre where the participants were accommodated. On subsequent days, participants were taken by bus to the drilling site at the Child Development Centre.

Printed slides of the power point presentations were availed to the participants as well as the prints of the supervision checklists from the annex of the RWSN *Supervising Water Well Drilling, A Guide to Supervisors*. The participants were also presented with flash drives containing the following RWSN Publications and films:

- Code of Practice for Cost Effective Boreholes¹
- Costing and Pricing - A guide for Water Well Drilling Enterprises²
- Procurement and Contract Management of Drilled Well Construction³
- Supervising Water Well Drilling, A Guide for Supervisors⁴

¹ Available on: <http://www.rural-water-supply.net/en/resources/details/128>

² Available on: <http://www.rural-water-supply.net/en/resources/details/146>

³ Available on: <http://www.rural-water-supply.net/en/resources/details/431>

⁴ Available on: <http://www.rural-water-supply.net/en/resources/details/392>

- Short animated films on borehole quality, siting, supervision and contract management⁵ and other relevant publications specific to Zambia.

Six inter-related challenges were encountered in the delivery of the course as follows:

1. Reliance on separate funding for borehole drilling led to challenges in preparing the practical components of the course.
2. Delays in finalising the location and site of the practical aspect (drilling) of the course.
3. Land ownership was not clarified adequately. The owners of the land of the site chosen for the practical session refused access to the land on the day drilling was to begin and an alternative site had to be found.
4. The alternative chosen location had first to be surveyed by geophysical measurement for a suitable drilling site. Only a marginally suitable site was found which turned out to be low yielding, and on development the borehole had to be declared abortive.
5. The pumping test crew were late to arrive on the site, delaying the practical work.
6. There was time overrun on the training because of the facilitators having to attend to issues beyond their remit (i.e. finding an alternative site).

Some of the challenges could have been avoided. Despite the months of preparation for the course and setting of milestones, the location (and site) selection took place too late. As a result, the issue of land ownership and permission for the borehole from the landowners was not obtained in time. However the challenges were faced and also used to demonstrate to the participants the realities of drilling project management; that drillers are often confronted by unforeseen circumstances; the challenges that can occur despite early planning; and getting the written consent of all parties to the ownership of any land proposed for community boreholes. Unfortunately the problems meant that there was less time available for the practical training than planned.

Throughout the training, participants were encouraged to discuss the current situation of the drilling sector in Zambia using the RWSN generic Principles of Cost Effective Boreholes as a guide. The outcome of the discussion is as follows:

- Drilling companies and groundwater consultants are registered. Licensing of drilling companies began in 2018.
- There are no national guidelines for borehole siting, though basic siting procedures are provided in the standard bidding documents for National Rural Water Supply and Sanitation Programme (NRWSSP) Water divining is still widely practised.
- The drilling market is dominated by Indian drilling companies using second-hand rigs from India. Manual drilling is practiced on a small scale where feasible.
- The borehole procurement process can be lengthy and cumbersome. Supervising groundwater consultants often perform poorly.
- There is tendency towards short term cost-cutting so that the coverage rate can be seen to improve at the expense of long-term cost effectiveness.
- Although there is supervision of drilling on some of the government projects, the tendency by the implementing agencies (i.e. government and NGO) is not to budget for supervision and none carried out. The poor performance of some consultants exacerbates the negative attitude towards supervision.

⁵ Available on: <https://vimeo.com/channels/drilling>

- Water Resources Management Authority (WARMA) has standardized the format for data collection and is in the process of collecting the data on all existing boreholes in the country.
- WARMA is the depository of all groundwater data in the country.
- There is generally no post construction monitoring except on some of the projects funded by external support agencies.

A documentary film of the proceedings of the course was made and is available online⁶. The film will be used for the promotion of drilling supervision and other courses aimed at the professionalising of groundwater development in Zambia and beyond.

There was a varied rating in the evaluation of the course by the participants. A great number indicated they were very satisfied with the course but a few others indicated that it was just okay. However in their reflection on the course all the participants indicated they benefited from the training and are taking with them some useful knowledge and skill. In the quiz that was conducted as an evaluation of their understanding of the course content, the average score was 84%. Three participants scored 100% and only two scored below 70%.

The course has created an awareness of the need for effective borehole drilling supervision for sustainable water supply sources. The participants were taken through the steps required in borehole supervision and provided with adequate resource materials for future reference. It is hoped that they will have the opportunity to put into practice what has been learnt, transfer it to others and form the nucleus of the critical mass required for professionalising groundwater development in Zambia.

A short course such as this provides a good starting point in creating capacity for local drilling supervision but it needs to be followed by further training at the drill site, ideally, with the supervisors mentored. Other support such as logistics and camping equipment is also required.

A participant suggested that a similar training course should be organised for the directors and decision makers involved in borehole procurement. This has often been mentioned in other countries. Having understood the processes of sustainable groundwater development from this type of course, the technicians are handicapped by the lack of buy-in or knowledge of their superiors. This impedes the deployment of the new knowledge acquired and the overall performance of the technicians. The suggestion is to enlighten decision makers, managers and directors so that they have an understanding of the critical issues in borehole procurement and drilling and the need for supervision. Skat Foundation once proposed a groundwater course targeted at executives. As this issue continues to resurface there may be need to revisit the idea and make it a reality.

The Government, through WARMA is making progress in the regulation of groundwater development but there are still several issues of the sector that need attention:

- The borehole procurement process needs to follow the procurement act.
- Guidelines have to be developed for borehole siting to reduce the number of dry boreholes and increase the national water supply coverage.
- A mechanism for systematic post construction monitoring of boreholes and support to communities in operation and maintenance has to be developed.

⁶ <https://vimeo.com/290225478>

Introduction

The Government of Zambia through the Ministry of Water Development, Sanitation and Environmental Protection (MWDSEP), in collaboration with UNICEF Programme Division, UNICEF Zambia and SKAT Foundation, Switzerland is striving to raise the professionalism of groundwater development in the country. The use of groundwater as the main source of drinking water in Zambia is growing considerably. An estimated 3.4 million people rely on boreholes today compared to 1.2 million in 2002.

Despite 365 registered drilling companies in the country, until recently there was no regulation of the industry. There is inadequate supervision of drilling and insufficient capacity to supervise as well as a limited understanding of how to effectively procure and manage drilling contracts. The Government of Zambia through the Water Resources Management Authority (WARMA), charged with the responsibility to regulate groundwater development in the country, is taking actions to correct the situation.

In 2016, a collaboration between WARMA, the former Ministry of Local Government and Housing, UNICEF Zambia, UNICEF Programme Division and Skat Foundation in 2016 carried out the training of 35 government, NGO and private sector groundwater personnel in *Procurement, Contract Management and the Costing and Pricing of Boreholes* to build capacity in borehole procurement in the country. It also provided support to WARMA in the development of groundwater regulations.

In continuation of the collaboration, UNICEF Zambia and SKAT Foundation conducted a five day training course on drilling supervision in Lusaka, Zambia between the 9th and 13th July, 2018. The training course comprised classroom sessions and practical field work at a drill site. The classroom sessions were held at the Mika Convention Centre, Mean Wood, Lusaka and the field work at the Centre for Child Development, Chongwe, Lusaka. This report gives an account of the activities during the training.

Preparation for the training course

The concept and content of the training course had been agreed between UNICEF Zambia and Skat Foundation. The course content was adapted from a previous course delivered in Sierra Leone by Skat Foundation in 2014. Preparations, including agreeing roles and responsibilities and setting milestones was undertaken between UNICEF, Skat Foundation and the Government of Zambia over several months in the build-up to the course itself.

UNICEF Zambia sent out letters of invitation to the participants in the public, private and NGO sectors. There was some delay in getting the letters signed by MWDSEP but the participants had been informed by email and they all turned up in time for the training. As it was to be a hands-on training course, UNICEF Zambia contracted a drilling company, Zambezi Drilling & Exploration Company, to drill a borehole to be used for the training.

It was also intended that the proceedings of the training course be professionally photographed, video recorded and a documentary film produced from the training. The film is to be used to raise awareness, for promotion of other courses for professionalising groundwater development and to support efforts to fundraise to strengthen Zambia drilling capacity. UNICEF therefore engaged a media firm, Outset Pictures, based in Lusaka to produce the documentary film.

The lead facilitator arrived in Zambia a week before the training to participate in the final preparations for the course. He met with the drilling contractor who assured him of their readiness for the project. He checked the siting of the proposed borehole drilling, although this site was later changed. He also met with

the media firm and showed them samples of previous documentary videos made by Skat Foundation for them to have an idea of the quality of documentation required.

Participants and trainers

A total of twenty five participants, two facilitators and two UNICEF Zambia personnel took part in the training course. The participants comprised five private sector practitioners, one from an NGO and the rest were from the public service at national level and local government level. Four of the participants were women. Twenty five participants took part in the course, of which four (16%) were women, 18 (72%) were young professionals (i.e. aged 35 or under) and two were young professional women. The list of participants is provided in Annex 1.

The short course was facilitated by two trainers. The lead facilitator, Dotun Adekile, a hydrogeologist, based in Nigeria, had been involved in the development of the Cost Effective Borehole theme of the Rural Water Supply Network (RWSN) and had delivered the course in two countries (Nigeria and Sierra Leone). Max Karen, a British hydrogeologist based in Lusaka with over 20 years' experience in Africa, who is involved in training and mentoring drilling supervisors in Zambia was the second facilitator. The two facilitators, in preparation, spent time going through the entire course material so that there was common understanding about the delivery of the course. Douglas Abuuru and Humble Sibooli of UNICEF Zambia provided logistical support for the training course.



Picture 1 Dotun Adekile(lead trainer) making a presentation



Picture 2 Max Karen (trainer) explaining a point to a participant

Learning objectives, course structure and approach

The learning objectives of the training course were that by the end of the course, the participants would:

- Understand the importance of effective supervision in borehole construction for sustainability
- Understand the steps and detailed actions required in full time supervision
- Understand the steps and detailed actions required in part time supervision
- Be able to quality assure and certify drilling records
- Be in a position to undertake borehole construction supervision

The course was delivered in four units as follows:

- Unit 1: Principles of borehole supervision
- Unit 2: Understanding groundwater without jargon
- Unit 3: Principles of Cost Effective Boreholes – what does it mean for Zambia
- Unit 4: Field work - on-site borehole supervision

The approach was a mixture of training and teaching methods and hands on field measurement. The course comprised a first day of classroom sessions to introduce the different aspects of drilling supervision followed by three days of practical field work and a final day in the classroom for rounding up and reflection on lessons learnt. The classroom sessions were delivered by lectures using PowerPoint presentations, interactive discussion and film shows. Participants were encouraged to ask questions for clarification regularly during each presentation. The classroom sessions were conducted at the Mika Convention Centre where the participants were accommodated. On subsequent days participants were taken by bus to the drilling site at the Child Development Centre. The programme of activities of each day of the training course is presented in Annex 2. The highlights of each day's activities are summarised below.

Outset Pictures, the media concern, took several film clips and interviewed the participants.

Day 1 - Welcome and Orientation

Opening

The training course was declared open by Abel Manangi, Principal Engineer, representing the Director, Ministry of Water Development, Sanitation and Environmental Protection. He stated government's efforts in increasing water supply coverage in the country through groundwater development and the mechanisms that are being set up to regulate groundwater development to ensure standards are maintained and public interest is protected. He enjoined the participants to fully avail themselves of the opportunity provided by the course as some of them would soon be going out to supervise the borehole projects that are being planned by the government.



Picture 3 Abel Manangi declaring the training course open

Background to the course

Following the opening and introduction of participants, Dotun Adekile, provided the background to the course. He mentioned that the use of groundwater in Zambia as the main source of drinking water supply is growing considerably. As a result of the demand, there are now 365 registered drilling companies in Zambia.

As government is making efforts to regulate the drilling sectors, it is perceived that there is a lack of trained personnel to supervise the drilling of boreholes and limited understanding of how to procure and manage borehole projects. The collaboration of MWDSEP, UNICEF and SKAT foundation aims to develop capacity in this respect.

He spoke about the RWSN and its activities in promoting cost effective boreholes and sustainable groundwater development and invited the participants to join the group. He presented the learning objectives of the course, the course outlines and the daily activities of the training course.

Unit 1 Principles of drilling supervision

Dotun Adekile gave a power point presentation on the Principles of Drilling Supervision. He explained the aims of drilling supervision and why supervision is required to ensure boreholes that last the designed lifespan. He outlined the different steps in borehole construction workflow and the responsibilities of the driller, supervisor and the community at every stage of the workflow. He then went on to discuss in detail the supervision requirement at every stage of the drilling workflow from the pre-contract inspection, to siting, mobilisation, drilling, onsite design modification and pumping test to demobilisation, documentation and handing over. He emphasised the need to ensure that the approval of the owners of the land of a proposed drilling site is obtained in writing. He gave an example of an embarrassing experience of a site in Sierra Leone where the owners refused access to a site that had been previously agreed to be used for a demonstration drilling on a similar training course in 2014. Some of the participants contributed their own experience. Dotun also emphasised the importance of safety on site.

Film show

Two animation films produced by RWSN on the theme of drilling supervision were shown: *A borehole that lasts a lifetime* and *Drilling the importance of good siting*. Both films provided a visual summary of the morning's discussions. The lessons of the film were discussed by the participants.



Picture 4 Screenshot of RWSN film 'A borehole that lasts a lifetime'

The printed slides of the power point presentation were presented to the participants as well as the prints of the supervision checklists from the annex of RWSN *Supervising Water Well Drilling, A Guide to Supervisors*. They were also presented with flash drives containing the following RWSN Publications:

- Code of Practice for Cost Effective Boreholes⁷
- Costing and Pricing - A guide for Water Well Drilling Enterprises⁸

⁷ Available on: <http://www.rural-water-supply.net/en/resources/details/128>

⁸ Available on; <http://www.rural-water-supply.net/en/resources/details/146>

- Procurement and Contract Management of Drilled Well Construction⁹
- Supervising Water Well Drilling, A Guide for Supervisors¹⁰
- Short animated films on borehole quality, siting, supervision and contract management¹¹ and other relevant publications specific to Zambia.

Unit 2 Understanding groundwater without jargon

Max Karen gave a power point presentation on groundwater occurrence using non-technical language. He discussed groundwater in different rock types and the importance of permeability and porosity of rocks in groundwater flow; groundwater in the water cycle and baseflow; why some wells and boreholes run dry as a result of water table fluctuation and underlined the principle that groundwater is flowing. He discussed the different aquifer types in relation to borehole siting and drilling, the main techniques used in borehole siting and the different techniques of borehole drilling technology.

Close of the day

At the close of the day participants were asked to form four groups for the field drilling supervision. Each group was assigned their first activity for the following day as follows:

- Group 1 Depth monitoring
- Group 2 Penetration rate monitoring
- Group 3 Drilling sample collection and description
- Group 4 Community liaison

Each group would perform the assigned activity for one hour and hand over to another group. They were reminded to bring the printed supervision checklists on the clip boards to the field the following day.

The bill of quantities for the contract for the borehole drilling was distributed amongst the participants and they were asked to study it.



Picture 5 Participants listening to presentations on Day 1

⁹ Available on: <http://www.rural-water-supply.net/en/resources/details/431>

¹⁰ Available on: <http://www.rural-water-supply.net/en/resources/details/392>

¹¹ Available on: <https://vimeo.com/channels/drilling>

Day 2: Understanding groundwater and siting

Unexpected change of the drill site

The plan for the day was to commence drilling with the participants using the prepared checklists for equipment and personnel inspection, siting, drilling, borehole design. Participants were to proceed in the bus to the Wabasha Primary School in Mean Wood. Though this is public school, it sits on a private land, which UNICEF came to learn about when disputes arose. The authorities of the school had implored UNICEF to drill a borehole as there is no safe water source around the school. The children go to the stream to fetch water. However, during breakfast, it was learnt that the property owner had refused access to the site and asked the driller to remove his equipment because he was not consulted. UNICEF Zambia appealed to the property owner but he were adamant claiming there were still unresolved land disputes with school administration. This was the situation that had been discussed the previous day on being certain of the approval of the land owners to use the site for drilling. Max Karen using his local knowledge suggested a second site at the Child Development Centre in Chongwe where there had been a request for a borehole and yield testing of an existing borehole for a proposed solar installation to be funded by an NGO. The participants then proceeded to the centre. They centre allowed the use of the library for the training discussions and the garden for meals.

Whilst waiting for the rig and personnel to arrive at the centre, Max continued with his presentation on *“Understanding groundwater without jargon”*; it had not been fully concluded the previous day. He also took the participants through demand calculation, flow rate calculation and the importance of understanding the different units in groundwater estimation. A brief introduction to the geophysical siting methods was also included in the session; particularly the resistivity methods and what should be noted and observed during the survey.



Picture 6 Participant listening to a briefing on Day 2

Borehole siting – resistivity measurement

The rig eventually arrived at the centre at lunch time but no site had yet been identified for the drilling. It was the driller's responsibility to carry out the geophysical survey on the site and identify a suitable site. This had already been done on the previous site. The driller had no siting equipment or personnel on site for this

at the centre so Max volunteered his resistivity meter and got the participants to assist in locating the site using Vertical Electrical Sounding Resistivity method which had been explained in the previous session.

There was only time to carry out two resistivity depth soundings but no suitable site was found. One site was slightly more promising than the other and this was selected. The exercise gave some of the participants who were not familiar with resistivity sounding an opportunity to see a demonstration of its operation. The participants then took turns taking readings and plotted the data on log-log graph paper and the process of interpretation and site selection was explained to them.

By the time the siting was completed it was time to return to the lodge. The participants were issued with hard hats and reflective jackets for the following days' activities.

Day 3 – Practical Drilling Supervision

Equipment and personnel inspection using checklists

The participants in their groups took turns to inspect the equipment, material and personnel using the checklists; Checklist 1: Equipment and personnel, Checklist 2: Siting, Checklist 3: Mobilisation, Checklist 4: Health and safety before the commencement of drilling. They inspected the rig, compressor, casings and screens, the gravel pack material and interviewed the driller's personnel to find out if they were qualified for the job. They checked that the drilling team had protective clothing and first aid equipment on site.



Picture 7 Participants checking the driller's equipment



Picture 8 Participants interviewing the drilling contractor's personnel

Drilling depth and penetration monitoring

As drilling commenced and progressed the groups took turns monitoring the drilling depth, penetration rate, collecting drill samples, checking for water strikes and explaining the drilling process to the community members i.e. the teachers and students.

Drill samples and logging

The drill samples were collected every metre interval and laid out in rows of tens and then described with particular attention to the water strikes. The importance of the weathered, fractured zones, and water strikes were explained in relation to aquifer identification. A group described the samples as in Table 1.



Picture 9 Participants checking the drill samples

Table 1 Sample description

Depth m bgl	Sample description
0 -3	red surface CLAY
3- 4	brown CLAY
4 -11	light brown mica SCHIST
11 -12	grey mica SCHIST
12 - 24	fractured grey mica SCHIST
24 – 48	light grey GRANITE GNEISS
48 – 64	fractured GRANITE GNEISS
64 -80	GRANITE GNEISS

A minor water strike was encountered at 48m depth. Another water strike was encountered between 61 and 64m depth. The borehole terminated at 80m depth without any other was strike. Although the water strike was assessed as marginal, for the purpose of the training, it was decided to line it. The participants were taken through the process of a final borehole design. PVC casings and screens were measured to correspond to the borehole design. The borehole was lined with screens set between 48m and 64m depth. The gravel pack volume was calculated and installed to 6m below ground level. As the casings were being lowered a joint disconnected and 9 lengths of casing and screen dropped into the hole. However, the driller reconnected the casings and the lining was completed.



Picture 10 Participants measuring the lengths of borehole casing and screens

The RWSN Principles of Cost effective Boreholes and Implication for Zambia

Dotun took the participants through a discussion of the RWSN Principles of Cost effective Boreholes in relation to the drilling practice in Zambia. The outcome of the discussion is presented in Table 2. It shows that although WARMA is making efforts to regulate the sector there are still no technical guidelines on borehole siting and water divining is still widely practiced. It was reported that groundwater consultants often perform badly in borehole construction supervision probably as a result of lack of skill and expertise. The poor performance of the supervising consultants in turn discourages investment in borehole supervision. The borehole procurement process could be lengthy and cumbersome and payments are often delayed. There is no systematic post construction monitoring and support to communities in the management of water supply facilities.

Table 2: The RWSN Principles of Cost Effective Boreholes and the Zambia Situation

RWSN Principle	The Zambia Situation
Principle 1 - Drilling is by professional enterprises and consultants under national standards	Drilling companies and consultants are registered and there are regulations governing their performance. Licensing of drilling companies began this year. There has been an upsurge in drilling activities over the past 15 years. In 2003 there were 10 drilling companies compared to the present 365 companies. The Drillers Association of Zambia was established in 2017.
Principle 2 - Appropriate siting practices are utilised and scientifically carried out	There are no technical guidelines on borehole siting. Appropriate siting is sometimes done on large scale rural water supply project however the “ <i>wet borehole contracting</i> ” methodology used in major government projects over the past 8 years has put the onus on the driller to find water and professional siting is often not used. In many contracts divining on water is still used. For domestic water supplies geophysics is rarely used due to the cost and lack of trained people.

RWSN Principle	The Zambia Situation
Principle 3 – Construction method is economical and drilling technology matches borehole design	The drilling market is dominated by Indian drillers using second hand air percussion rigs imported from India. In the last ten years the supply has increased, generally medium to large duty rigs, with capacity to drill depths exceeding 100m, in diameters up to 250mm. Manual drilling is being carried out mostly in the sedimentary areas of Western and Luapula Provinces and where deep loose sands makes road access difficult.
Principle 4 – Procurement: Contracts are awarded to experienced and qualified contractors and consultants	There is a Public Procurement Act but the procurement process can be lengthy involving multiple Ministries. There is a tendency to always award the contract to the lowest bidder. In the case of consultants poor performance has had a major detrimental effect since government staff often pose the question as to why large sums were being paid to consultants who were often not even present or provided inexperienced staff.
Principle 5 – The design is cost effective, to last 20-50 years based on minimum specification	The standard designs used in most rural water supply programs are simplified designs which are based on limited trained staff being available. The main objective is short term cost reduction so that coverage rates and number of boreholes is maximised, long term cost effectiveness is not prioritised due to political pressure to increase the number of people supplied with water however over the long term this is a false economy and leads to multiple problems due to poor construction and lack of community training amongst many other reasons.
Principle 6 – Arrangements are in place for proper contract management, supervision and payment	Professional borehole supervision is sometimes employed however the poor performance of some consultants has had a major detrimental affect leading to a lack of supervision in subsequent projects. Consultants are also affected by delays in payments. Sometimes contracts are awarded by the government without budgetary allocation for supervision
Principle 7 – High quality hydrogeological data for each borehole is collected in a standard format and submitted to the relevant government authority	WARMA has standardized the format for data collection and is in the process of collecting the data on all existing boreholes in the country.
Principle 8 – Storage of hydrogeological data is undertaken by a central government institution with records updated, information made freely available and used in preparing subsequent drilling specification	The data were previously scattered but now WARMA is the repository of all borehole data. WARMA is making efforts to gather all previously existing borehole records.
Principle 9 – Monitoring: Regular visits to water users with completed boreholes are made to monitor functionality in the medium as well as long-term, with the findings published	There is some post construction monitoring done, especially by KfW and UNICEF. There is a system for borehole rehabilitation subject to the availability of funds. Systems for monitoring borehole functionality are being developed.

Day 4 – Practical Borehole completion and inspection

The morning started with Max taking the participants through a discussion of borehole development and pumping test. He explained the need for jetting of the screened interval for proper well development.

The participants then proceeded to the drill site. The static water level in the borehole was measured using the dip meter as 9.48m. Following which the jetting tool was lowered for the development of the borehole. Development proceeded for 2 hours by which time it was decided that the borehole would have to be declared abortive as the yield was below 0.1l/s.

It was then decided to use the existing borehole in the school premises for the demonstration of a borehole camera inspection and pumping test procedure. The school had previously expressed a desire to install a solar powered submersible pump in the borehole and it had been agreed that the yield of the borehole should be established to know if it could support one. This handpump on the borehole had to be removed and this took quite some time. After it was removed, Max gave a demonstration of the borehole camera inspection. The participants were able to see the casings and the joints in the borehole. There was an obstruction at 34m depth. The pumping test crew did not arrive on site in time and it was decided to postpone it to the following day.

Day 5 - Pumping Test and Review

The pumping test crew who promised to install the pump by 07.00hrs did not arrive on site until 09.00hrs. The yield of the borehole was measured using a calibrated V-notch tank and graduated bucket. Participants took turns measuring the dynamic water level. After one hour of pumping test it was concluded that the borehole could not be fitted with a submersible pump. This demonstrated the need to test the yield of the borehole in relation to the demand and in relation to planned pumping rate using submersible pumps.

WARMA Presentation



Picture 11 Levy Museteka Senior Hydrogeologist WARMA making a presentation

Levy Museteka and Peter Petulo gave a presentation on the progress WARMA was making towards the regulation of groundwater development in the country. They described how the Water Resource Management Act of 2011 was being enforced in relation to groundwater use. It is now a legal obligation for boreholes to be registered and for permits to be granted for groundwater use. Before the legislation, only commercial surface water use was licensed. The smaller scale of groundwater abstraction meant that in the past, this was not considered important for regulation. However the rapid development of commercial

agriculture and other industries has led to a massive increase in commercial use of groundwater. Groundwater abstraction for domestic use i.e. less than 10,000 litres per day is not regulated. Modalities are being developed to identify large scale groundwater users. Since the legislation came into force in 2018 two contractors have been penalised for drilling without a permit.

Course review and participants' reflection

Dotun summarised the activities on the training course from the first day to the last. He then asked each participant to state one point they were taking away from the course. The participants' response is presented in Annex 3. Three of the responses are presented below. Their reflection indicates that the participant have benefited from the training course and taking back with them some useful knowledge and skills.



Picture 12 *"I wish there will be a workshop for the directors",*
Beatrice Kanyamuna

'I have learnt a lot about the importance of supervision. In my organisation we award contracts to drillers without supervision and we have had many failed boreholes without knowing the cause. With this course I am hoping to be able to convince my superiors that supervision is cardinal. I also wish that there will be a workshop for the directors so that they will understand the importance of supervision'



Picture 13 *"I must confess what I have been doing the last five years is monitoring rather than supervision",*
Chizela Moonga

'I have to explain WARMA regulation to the community members and the councillors and the expectations from them particularly on land issues. I have realised that there is a cost implication for supervision. I must confess that what I have been doing in the last five years is monitoring rather than supervision. I have to go back to let the councillors know even before they are trained that there is need for budgeting for supervision'.



Picture 14 *“I did not know it was the supervisor’s responsibility to inspect the drillers equipment”,
Precious Mulubwas*

‘I learnt that the pre-construction inspection of the driller’s equipment and materials for the borehole are important. Previously I did not know that it was part of the supervisor’s responsibility’.

Quiz

A quiz was conducted as a revision exercise for the course and to evaluate how much the participants had learnt and retained. The quiz consisted of ten questions spanning the entire course content. The average score on the quiz was 84%. Three participants scored 100%. Only two participants scored below 70%. The questions missed by the participants were revised.

Course evaluation

Participants were asked to evaluate, using a form, the presentation, delivery and organisation of the course to improve on the design of future courses. The form and a summary of the response to the questions are shown in Table 3. From the summary and discussions, it can be inferred that most participants were satisfied with the conduct and organisation of the course with some not very satisfied. One respondent ticked neutral on all the questions asked.

It is clear that the challenges encountered in the organisation affected the delivery of the course, with less time available for practical work than envisaged in the course programme (Annex 2). Specific comments and recommendation for improvement to the course are summarised in table 4. Most of these relate to the need for better preparation and extending the duration of the course.

Table 3: Summary of course evaluation

		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	The training met my expectation	6	13	2		
2	I think that I will be able to apply the knowledge acquired	12	9			
3	The training objectives for each unit were identified and followed	11	6	3	1	
4	The content was organised and easy to follow	9	9	3		
5	The material distributed were pertinent and useful	15	5	1		
6	The instructors were knowledgeable	16	3	2		
7	The quality of instruction was good	9	11	1		
8	The instructors responded well to questions	10	7	4		
9	Trainees participation and interaction were encouraged	9	10	2		
10	Adequate time was provided for questions and discussion	10	7	4		
11	Format of the training course	Excellent		Good	Just Adequate	Poor
a	What do you think of the timing of the units		14	7		
b	Location, organisation, logistics	10	8	3		
c	Overall how do you rate the workshop	4	16	1		

Table 4: Comments and recommendations by Course Participants

General comments
<ul style="list-style-type: none"> • Thank you for inviting me on behalf of Water Supply and Sanitation. The training is very useful to my department. • Thank you UNICEF, I had a good time and I am sure to improve my work with the acquired knowledge. • The course was very informative. I learnt a lot of supervising skills. • I look forward to many more of such trainings and support from UNICEF to train others in different organisations.
How could the format be improved?
<ul style="list-style-type: none"> • More time should be allowed to cover all aspects of the course. The course time frame should be extended to two weeks. • By focusing on the real problems and not trying to go through everything including the obvious. • The classroom session should be given two days and two days for practical. • Preparation of the organizers should be adequate. • The issue of land ownership and permission to drill on the site should be sorted out before the course. • Have the trainees participate more in the practical • Allowing trainees to apply what they know during practical sessions • By keeping to the course outline. • Facilitators should include a woman for gender balance. • Involvement of superiors so they can appreciate the importance of supervision.

Certificates and closing

Douglas Abuuru closed the training course and presented the certificates. In closing he asked the participants to see the challenges encountered during the course as the reality of drilling. He said that the

training was timely as some of the participants will soon be taking part in the supervision of the several borehole projects planned for the future and that some of them would be asked to use their experience on the course to train others. He then distributed the certificates.

Observations and Recommendations

Planning for the course

Several challenges were encountered during the training course. Although these were overcome, they had a negative effect on the course programme. Some of the challenges could have been avoided. Despite the months of preparation for the course and setting of milestones, the location (and site) selection took place too late. As a result, the issue of land ownership and permission for the borehole from the landowners was not obtained in time. The consent of all parties to the ownership of any land proposed for community boreholes should always be obtained in writing. The change of site during the course resulted in loss of time for the practical training. This is reflected in the evaluation of the course by the participants. For future courses it is recommended to have the actual drilling funded from the same source as the training course itself, rather than rely on partners who may face their own administrative challenges of scheduling and planning drilling works.

Future courses

The course is titled Short Course on Drilling Supervision, however an alternative, and perhaps more appropriate title would be *“Understanding the Drilling and Construction Process for Project Management and Monitoring”*. Such a course would target participants that are likely to manage drilling projects and undertake periodic monitoring rather than specifically carry out on-site supervision of entire drilling and construction process.

A second course, of two week duration with considerably more scope for practical experience would target drilling supervisors, and should be linked to a mentoring programme.

The statement by a participant that she wished for a similar training course for the directors in her organisation is one that has often been mentioned in other countries. Having understood the processes of sustainable groundwater development from such a course, the technicians are handicapped by the lack of buy-in or knowledge of their superiors. This impedes the deployment of the new knowledge acquired and the overall performance of the technicians. The suggestion is to enlighten decision makers, managers and directors so that they have an understanding of the critical issues in borehole procurement and drilling and the need for supervision. Skat Foundation once proposed a groundwater course targeted at executives. As this issue continues to resurface there may be need to revisit the idea and make it a reality.

There is also the need to specifically train more trainers to deliver the various units of the courses and support the professionalization of groundwater development in Zambia and beyond. There are presently very few hands that can deliver the courses.

Making the case for drilling supervision

Full-time supervision is the ideal, by professionals with supervisors having geological training and a number of years drilling operations experience is the ideal scenario. However, the cost of having trained supervision is high, usually in the region of 10% - 20% of the drilling cost. This cost puts organisations off from investing in full time drilling supervision. Another factor is that there are very few well qualified people for

supervision. However, based on experience from all over Southern Africa and beyond it is clear that perceiving supervision as “extra” cost rather than an investment is a false economy.

Putting supervision into practice

The course has created an awareness of the need for effective borehole drilling supervision for sustainable water supply sources. The participants have been taken through the steps required in borehole supervision and provided with resource materials for future reference. It is hoped that they will have the opportunity to put into practice what has been learnt, transfer it to others and form the nucleus of the critical mass required for professionalising groundwater development in Zambia.

It is essential that capacity is created for local drilling supervision. A short course such as this provides a good starting point but needs to be followed by further training at the drill site, ideally, with supervisors mentored. Other support such as logistics and camping equipment is also required. In Zambia a method that has been explored is for certain aspects of drilling supervision to be undertaken by local pump menders, known as Area Pump Minders. This has the advantages of lower cost, building capacity in the rural areas and less likelihood of them having to leave the drill site due to other commitments. The disadvantage of using Area Pump Minders is that they need to have further field training on at least 30 boreholes, which should include all stages of the process from site selection to drilling and design, development and yield testing to construction of civil works. The other major disadvantage is that if they do not have transport and payments to them are intermittent, there is a tendency and possibility of them losing their impartiality.

The ideal will always remain that there should be full-time supervision by professionals with a background in geology and many years of experience in drilling. Given the cost of such supervision, it needs to be combined with incentives for good performance and penalties for poor work. As we have seen from this course, and experience in other countries inadequate performance by drilling supervisors tarnishes drilling supervision as a whole, discouraging the government and NGO’s to invest in it.

If the full-time supervision by area mechanics could be combined with professional oversight, this could reduce costs and increase capacity. However there will always be a need for experienced consultants especially where there are more complex requirements such as deeper boreholes, solar/electric submersible pumping larger yields.

Regulations

The Government, through WARMA is making progress in the regulation of groundwater development but there are still several issues of the sector that need attention:

- The borehole procurement process needs to follow the procurement act.
- Guidelines have to be developed for borehole siting to reduce the number of dry boreholes and increase the national water supply coverage.
- A mechanism for systematic post construction monitoring of boreholes and support to communities in operation and maintenance has to be developed.

Annex 1 Participants List

Sr/no	Name	Designation	Orgaisation
1	Musansula Kasungu	Water Engineer	DRWD/MWDSEP
2	Ulanda Nyirenda	Senior Engineer	DRWD/MWDSEP
3	Katongo Mweshi	Planner M&E	MWDSEP
4	Levy Museteka	Senior Hydrogeologist	WARMA
5	Ms Beatrice Kanyamuna Pole	Senior Hydrogeologist	DRWD/MWDSEP
6	Alex Nonde	Principal Engineer	PDHID Muchinga
7	Gift Moonga	Senior Engineer	PDHID North West
8	Ms Alice Tembo	Principal WSS Officer	PDWSS Luapula
9	Charles Mwale	Principal WSS Officer	PDWSS Western
10	Robinson Mbimbi Chewe	RWSS Officer	Kanchibiya
11	Patience Sampa Kapembwa	RWSS Officer	Isoka
12	Precious Mulubwa	RWSS Officer	Chinsali
13	Kangwa Kampinda	RWSS Officer	Nakonde
14	Edward Mutale	RWSS Officer	Nchelenge
15	Daniel Chimanza	RWSS Officer	Kalumbia
16	Joshua Tuba	RWSS Officer	Kaoma
17	Chizela Moonga	RWSS Officer	Gweembe
18	Tiki Shimbiya Mozha	Driller	El Wells Water Solution
19	Mazuzyo Nvula	Senior Hydrogeologist	World Vision Zambia
20	John Miller Sakala	Technical Manager	Sustainable Water Solution
21	Happy Chilongo	RWSS Officer	Siavonga Town Council
22	Wisdom Ntenda	Hydrogeologist	Aquaquest Ltd
23	Felistus Kamkampa	Hydrogeologist	Curprite Geoservices Ltd
24	Obert banda	Drilling Supervisor	Watertech Drilling co
25	Peter Petulo	Hydrogeologist	WARMA

Annex 2 Training Programme

Note: The programme below was the programme as initially planned but it had to be altered because of the change of the drill site as explained in the text.

Day 1: Classroom: Principles of Borehole Supervision, Understanding groundwater, Principles of Cost Effective boreholes

DAY 1	TOPIC	TECHNIQUE	EQUIPMENT & MATERIALS	LEAD FACILITATOR
8:30 – 9:00	Welcome & register	Participants sign the register with the names, institutions and email		Dotun Adekile
9:00 – 9:45	Opening and introduction (Instructions to the media)	<p>Opening by MWDSEP or UNICEF Official</p> <p>Introductions – standing in a circle – name and adjective & something nobody knows</p> <p>Presentation – RWSN, Cost Effective Boreholes, Zambia & Course</p> <ul style="list-style-type: none"> • RWSN • MWDSEP, WARMA, UNICEF/Skat Collaboration on Professionalizing Groundwater Development in Zambia Course learning objectives • Course outline <p>Participants write down expectations</p> <p>Show learning objectives; Show overview of the 5 day activities</p>	Overhead projector	<p>Abel Manangi</p> <p>Dotun Adekile</p>
9:45 – 10:30	<i>Tea break</i>			
10:30 – 11:30	Principles of Borehole Supervision (part I)	<p>Lecture – PPT presentation, interspersed with questions & answers</p> <ul style="list-style-type: none"> • Show supervision film 	Overhead projector	Dotun Adekile
11:30 – 12:00	Film show	Supervision film and discussion; hand out the drillers contract and discuss if time permits	Overhead projector Film	Dotun Adekile
12:00 – 13:00	Principles of Borehole Supervision (part II)	Lecture – PPT presentation interspersed with questions and answers	Overhead projector	Dotun Adekile
13:00 - 14:00	<i>Lunch</i>			
14:00 – 15:00	Understanding groundwater without the jargon (part I)	Lecture – PPT presentation interspersed with questions and answers	Overhead projector	Max Karen

DAY 1	TOPIC	TECHNIQUE	EQUIPMENT & MATERIALS	LEAD FACILITATOR
15:00 - 15:15	<i>Health break</i>			
15:15 – 16:00	Understand groundwater without the jargon (part II)	Lecture – PPT presentation, interspersed with questions & answers	Overhead projector	Max Karen
16:00 – 16.30	Principles of Cost Effective Boreholes	Lecture – PPT presentation, interspersed with questions & answers	Overhead projector	Dotun Adekile
16:30 – 17:00	Announcements	Organisation of field work, distribution of field kits, and group formation		

DAY 2: Field Work - Drilling

DAY 2	Activity	TECHNIQUE	EQUIPMENT & MATERIALS	LEAD FACILITATOR
8:30 – 9:00	Registration and departure to the site			Dotun Adekile
9:00 -9:30	Arrival at drill site (engage with the media)	Participants gather under a tent or marque. Review of previous day's work using pass the ball technique. Instruction is given on the day's activity.	Flip chart	Dotun Adekile
9:30- 10:00	Meeting with community members	Meeting with community members, or with the institution's authority explaining the mission		Humble
10:00 – 11:30	Pre-mobilisation inspection & discussion; site supervision commences	Each group takes turn (15 minutes each) using the Supervisor's checklist in the RWSN field note, <i>Supervising Water Well Drilling</i> ; Annex B to evaluate the drillers' capacity to commence drilling. Checklist 1: Equipment and personnel Checklist 2: Siting Checklist 3: Mobilisation	Checklist/clip board	Max Karen
11:30 – 12:00	Drilling supervision	Checklist 4: Health and safety; rig position; depth monitoring, penetration rate logging, fluid viscosity monitoring, collection and logging of drill samples. Instruction of community members in the drilling process: monitoring the drilling depth; checking the samples.	Checklist, clip board, stop clock, Marsh funnel, sample box	Dotun Adekile
12:00-13:00	<i>Lunch</i>			
13:00 – 17.00	Drilling Supervision	Drilling supervision continues as in the morning. Using a flip chart each group develops a strata log of the borehole to the depth attained and presents it on the flip chart. Community members take part in the process. Documentation of drilling using Annex E of the RWSN <i>Code of Practice for Cost Effective Boreholes</i>	Checklist, clip board, stop clock, Marsh funnel, sample box	Max Karen

17:00	End of the day			
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DAY 3: Borehole design casing and lining

DAY 3	Activity	TECHNIQUE	EQUIPMENT & MATERIALS	LEAD FACILITATOR
8:30 – 9:00	Arrival on site (Engage with the media)	Review of previous day’s work using pass the ball technique		Dotun Adekile
9.00 -12.00	Borehole design	Checklist 5: Each group draws a proposed borehole design using the checklist and presents it on a flip chart and is discussed. Each group measures the casing and screen length, diameter and wall thickness; checks the tally corresponds with the design.	Checklist, flip chart, measuring tape, callipers	Dotun Adekile Max Karen
12.00 - 1300	<i>Lunch</i>			
13:00 – 14:00	Installation of casing and screen Installation of gravel pack	Participants monitor the installation of casing and screen; gravel pack and back fill. Community members participate in monitoring the installation.	Flip chart	Dotun Adekile Max Karen
14:00 – 1700	Borehole development	Checklist 6: Each group comments on the development process and checks the water sample for turbidity and sand content.	Flip chart	Dotun Adekile Max Karen
17:00	End of the day	Homework: Complete the documentation of drilling using Annex E of the RWSN <i>Code of Practice for Cost Effective Boreholes</i>		

DAY 4: Pumping test, borehole camera logging, sanitary seal and concrete pad

DAY 4	Activity	TECHNIQUE	EQUIPMENT & MATERIALS	LEAD FACILITATOR
8:30 – 8:40	Arrival, registration and review of previous day’s activity (Engage with the media)		Flip chart	Dotun Adekile

DAY 4	Activity	TECHNIQUE	EQUIPMENT & MATERIALS	LEAD FACILITATOR
09:00 – 12:00	Pumping test	<p>Checklist 6: Pump installation;</p> <p>Each group takes turn measuring the static water level; the dynamic water level; calculates the drawdown; calculates the specific capacity; proposes a safe pumping rate and pump setting; water sample collection for lab analysis</p> <p>Community members participate in the pump test</p>	Pump, dip meter, flow meter, bucket, stop clock	Max Karen
12:00-13:00	<i>Lunch break</i>			
13: 00 -17:00	Pad construction	<p>Each group takes turn checking the level of backfill in the hole.; monitors the installation of sanitary seal and pad construction according to the specification</p>		Dotun Adekile
17:00	Close for the day			

DAY 5: Review, Test and Closing

DAY 5	TOPIC	TECHNIQUE	EQUIPMENT & MATERIALS	LEAD TRAINER/FACILITATOR
8:30 – 8:45	Icebreaker (Engage with the media)	Groups on various aspects, smallest to tallest, pass the orange or wink murder or something else appropriate depending on the group		
8:45 – 9:45	Review of the course (Part I)	4 groups of participants present a summary of one module each, using a select technique, such as drama, presentation, story-telling, illustration/poster.		Dotun Adekile
9:45 – 10:15	Review of the course (Part II)	Review of the documentation of the different aspects of the supervision by the participants. Review of the objectives set by the course, and by the participants themselves.		Dotun Adekile Max Karen
10:15 – 10:45	<i>Tea break</i>			
10:45 – 11:30	Quiz	Quiz sheet handed to all participants, who fill it in, followed by a self-assessment and discussion of the results.		Dotun Adekile Max Karen
11:30 – 12:00	Course evaluation by participants	Participants fill in evaluation forms.		Dotun Adekile
12:30 – 13:30	Award of certificates and closing speeches			UNICEF Zambia
	<i>Late lunch and departure</i>			

Annex 3 Reflection on the Course by the Participants

1. My take away from the course is that before drilling commences the involvement of the community leaders is important, that is, the elected council and village heads because they are key to the operation and maintenance of the borehole.
2. I learnt that the pre-construction inspection of the driller's equipment and materials for the borehole are important. Previously I did not know that it was part of the supervisor's responsibility.
3. I have learnt the responsibilities of the supervisor. For the success of a borehole, supervision is important particularly full time supervision.
4. I have come to understand what is meant by cost effective boreholes as one that last the designed lifespan. I have also learnt that calculating the water supply demand of the community and meeting the demand are very important.
5. Siting is very important as well as full time supervision. WARMA registration is also important.
6. The issue of ownership of the land for the proposed borehole is very important going by our experience on the training course. Also it is important that the rig be tested and run before mobilisation because the rig that was used on the course was leaking and the oil could contaminate the groundwater.
7. The supervision checklists have allowed me to understand what needs to be checked on a drill site. Previously I would go to site meetings and would not know what to do or look for. Now I have been empowered with some guidelines and standards. I really appreciate the course.
8. I will be able to carry out drilling supervision in a more professional way because I have learnt the responsibilities of the supervisor.
9. The checklists will allow me to be systematic in supervision.
10. I appreciate the new technologies in water engineering particularly the borehole camera. I wish I could show it to my grandfather. I have also come to appreciate that supervision starts from the procurement stage and not when the rig has arrived on site.
11. As a driller I have come to appreciate that safety comes first and I have learnt the responsibilities of the driller.
12. I have learnt a lot about the importance of supervision. In my organisation we award contracts to drillers without supervision and we have had many failed boreholes without knowing the cause. With this course I am hoping to be able to convince my superiors that supervision is cardinal. I also wish that there will be a workshop for the directors so that they will understand the importance of supervision.
13. I am happy that the both those of us who are planners and those that are implementers are at this training. I will go back to the Ministry to ensure that for every planned project there must be substantial resources for supervision. We will also ensure that the districts and other implementers provide resources for supervision.
14. The supervisors should actually measure the dimensions of the bits, drill rods, casings and screens provided by the contractor. We often think that a length of casing or screen is 3 m or 6 m. I have now realised that they vary and the supervisor should measure them.
15. I have learnt the responsibilities of the supervisor and I will ensure when supervising that the contractors adhere with the technical specification.
16. I have to explain WARMA regulation to the community members and the councillors and the expectations from them particularly on land issues. I have realised that there is a cost implication for supervision. I must confess that what I have been doing in the last five years is monitoring rather than supervision. I have to go back to let the councillors know even before they are trained that there is need for budgeting for supervision.
17. I greatly appreciate the effort of the Ministry and UNICEF in the way they have structured the course. We have benefited greatly from the course.
18. Drilling should not be taken for granted. Cutting corners should not be allowed. Supervision should be taken seriously with the allocation of adequate resources.