Professional Water Well Drilling

A UNICEF Guidance Note

Professionalism is the skill, good judgment, and behaviour expected from a person or organisation who can undertake a job well.

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Foreword

It is sometimes argued that rural water supply boreholes are simple and don't require much technical input. This is an erroneous view – boreholes which are poorly designed, sited and constructed may have yields that are inadequate, marginal or unsustainable, and short lifetimes. They may also supply water of poor quality for drinking and domestic use. A lot of programme funds may be wasted. Even where the designs are appropriate to the local groundwater conditions, lack of supervision of construction often compromises the quality of the final product. In a large programme, the resulting cumulative loss of investment may be the same as the investment for a few properly specified, high-yielding urban boreholes. Nobody would question the need for proper technical inputs for both design and supervision in the urban context.

John Chilton, Executive Manager,
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Acknowledgements

The Rural Water Supply Network (RWSN) has published guidelines on cost-effective boreholes since 2004 thanks to the collaboration of UNICEF, the Water and Sanitation Programme (WSP) of the World Bank, Skat Foundation, USAID, the UK Department for International Development (DFID), WaterAid and the Swiss Agency for Development and Cooperation (SDC). Thanks to all of the individuals and agencies involved over the past twelve years for not giving up with the complex task of improving the professionalism of borehole drilling.

Thanks to the members of RWSN's online discussion group on sustainable groundwater development for regularly sharing experiences and providing advice to one another. Much has been learnt as a result of these exchanges which has enriched this publication. It is encouraging to see the small but growing movement of individuals that are striving to raise professionalism in their respective organisations and countries.

A huge thanks to Alan MacDonald, Brighid O Dochartaigh, and Helen Bonsor (British Geological Survey), Cecilia Scharp, Chris Cormency and Franck Abeille (UNICEF), Richard Carter, Vincent Casey (WaterAid), Kalim Hanna (USAID), Karen Villholth (IMWI), Hannah Neumeyer (WASH United) and Dotun Adekile (Water Surveys Nigeria) for your thorough reviews of various drafts of this guidance note.

A special thanks to John Chilton (IAH) for sharing your ideas several years ago and continuing to encourage and guide us subsequently and review this document.

Preface

UNICEF's comparative advantage in supporting governments at all levels to improve drinking water supplies places the organisation in a unique position. This is recognised by international donor agencies and partners, and is a weighty responsibility. The timeframe for the Sustainable Development Goals (2015-2030) coincides with the new UNICEF Water, Sanitation and Hygiene (WASH) Strategy. This provides the opportunity to re-define the role of UNICEF as a leader for improving drinking water supplies.

UNICEF supports the provision of drinking water services, and in 2014 and 2015 alone, it is estimated that 32 million people in over 80 countries benefited from UNICEF's direct support in water development. This includes significant borehole or water well drilling (in this document, the terms 'borehole' and 'well' or 'water well' are used interchangeably).

In programmes where UNICEF is providing direct support, the organisation bears the responsibility of leading by example. In cases when UNICEF provides indirect support and transfers funds to governments, it has an important role to advocate for and support good practices.

Drilled water wells, or boreholes, are vital for Africa, and if the continent is to have universal, safe and affordable drinking water that can last, they need to be professionally sited and constructed in the first place, with proper consideration of the groundwater resource. This forms the necessary basis for subsequent operation and maintenance.

Given UNICEF's focus on Africa, this guidance note is published for the UNICEF West and Central Africa Region (WCAR) and East and Southern Africa Region (ESARO) offices. Its aim is that UNICEF staff and partners who manage or support water well drilling programmes understand what professional groundwater development means and incorporate good practices into programmes and advocacy.

The scope of the guidance note covers both mechanised and manual borehole drilling and rehabilitation but does not include community development, operation and maintenance or supply chains. Part I explains the background to UNICEF's role in borehole drilling and rehabilitation, setting out the concerns about professionalism and groundwater resources. Part II provides guidance for UNICEF country offices to raise the professionalism of mechanised and manual drilling and borehole rehabilitation in Africa in the form of practical and more strategic actions for UNICEF and its partners. The guidance note includes practical examples of what has been done already and links to relevant resource materials.

Summary

Groundwater provides about 45% of global domestic water demands and 75% of Africa's. In places where groundwater is readily available and of good quality, it can be a reliable resource. Groundwater storage in Africa is extensive, and acts as a natural buffer against climate variability. However, the quantities that can be abstracted are unevenly distributed, and yields vary. The lack of understanding of groundwater resources in much of Africa undermines its potential to contribute to poverty reduction and economic development, and threatens its environmental sustainability.

Over the past two decades, Africa has witnessed a significant increase in drilled water wells, or boreholes. These are financed by development programmes as well as investments by water users and local businesses. Not only do boreholes supply handpump water, but they also play a substantial role in small as well as larger piped water supplies. Use of groundwater by smallholder farmers in sub-Saharan Africa is on the rise; use of groundwater for irrigation in Africa is expected to grow significantly.

Sustainable Development Goal (SDG) Target 6.1 is to "achieve universal and equitable access to safe and affordable drinking water for all by 2030". Serving everyone is a momentous shift from the Millennium Development Goal target, particularly for rural and peri-urban Africa, where access to safe and affordable drinking water is particularly low. Without doubt, groundwater supplies, and boreholes in particular, have a tremendous role to play in reaching the SDG target for drinking water. Groundwater is also likely to be increasingly used for food production. More use of groundwater for agriculture will raise abstraction while the application of fertilisers and pesticides is likely to affect its quality. Effective groundwater monitoring and management are thus essential to ensure that long term domestic and agricultural demands can be met without depleting or damaging the resource.

In many African countries, UNICEF supports borehole drilling and efforts to strengthen the enabling environment. Developing sustainable groundwater supplies and managing the resource is a highly skilled endeavour. The way that UNICEF-supported initiatives are designed and implemented within the wider socio-economic, institutional and political environment affects the sustainability of the supply, and ultimately the resource. If boreholes are not properly sited, designed and constructed in the first place, supplies cannot be maintained, and investments are wasted. And in the longer term, if groundwater resources are not properly managed, there is risk of over-abstraction and pollution and massive failure of drinking water supplies. This cannot be allowed to happen.

There is growing evidence of major weaknesses in how borehole drilling initiatives are undertaken in a number of African countries. If there is to be any chance of meeting the SDG target for drinking water, this needs to change. As the main UN agency supporting the SDG drinking water target in rural and peri-urban areas, UNICEF programmes need to demonstrate professional groundwater development and support effective groundwater management.

This guidance note provides practical guidance for UNICEF Country Offices. It builds on the Toolkit to Professionalise Manual Drilling (UNICEF et al, 2010), the Code of Practice for Cost Effective Boreholes (RWSN, 2010) and associated guidelines, as well as other key publications and experiences of numerous organisations and individuals that are trying to raise the professionalism of groundwater development in Africa. The guidance note is mainly concerned with rural and small towns' water supplies but is mindful of the huge challenges faced by supplies in many growing African cities dealing with problems of groundwater quantity and quality.

The guidance note is structured around six broad areas of engagement for UNICEF country offices, as illustrated in the figure below.

The engagement proposed for each area is summarised as follows:

- The **institutional framework** matters – promote initiatives to improve national (or state) policies, regulation, standards and procedures of borehole drilling, including the clarification of roles and responsibilities.
- **Groundwater information** is essential – value groundwater data and ensure that drilling records are collected, quality assured and collated. This data, together with information generated from it, should be made readily available to help inform future borehole siting and design, as well as groundwater resources management.
- **Capacity** is fundamental – raise the skills and knowledge of groundwater development and encourage the availability of suitable equipment in the country.
- **Project design, implementation and monitoring** needs to be thorough – improve the design, implementation and monitoring of specific borehole drilling or rehabilitation projects, and ensure that documentation of the process and results is readily available.
- **Dialogue & awareness** is crucial – foster dialogue between government agencies (including regulators), drilling contractors and consultants, NGOs, development partners and civil society. Encourage and support efforts that raise awareness of decision-makers and the public about groundwater potential, management and its exploitation.
- **Investment** is indispensable – invest adequate financial resources to improve and sustain professional groundwater development.

The six areas of engagement are not a sequence of ordered steps, but rather a set of entry points and options. The priorities and mix of actions required depend on the context. Due to the complex nature of the problem, there is no simple formula to raise the professionalism of borehole drilling and rehabilitation. As no single organisation can successfully raise professionalism alone, collaboration and partnerships with other organisations are necessary.

Contents

Abbreviations and Acronyms

BGS	British Geological Survey
ESAR	East and Southern Africa Region
JMP	Joint Monitoring Programme
MDG	Millennium Development Goal
NGO	Non-Governmental Organisation
NWRI	National Water Resources Institute, Nigeria
RWSN	Rural Water Supply Network
SDG	Sustainable Development Goal
WCAR	West and Central Africa Region

Glossary

Aquifer – a layer of rock that does or is capable of containing water that can be abstracted.

Bill of Quantities – a document used in the construction industry in which all materials, parts, labour and transport are itemised. It enables contractors to price the work for which they are bidding.

Borehole – water well, tube well or hole which is drilled in the ground and partially or fully lined for the abstraction of groundwater.

Borehole design – the depth, diameter and lining materials of the borehole, and the drilling technique to be used.

Borehole development – the act of cleaning a borehole after construction by flushing or other means until the water from the hole is clean and free of fine materials.

Data – all facts about a borehole collected before and during, drilling, borehole development, completion and pumping test and facts about the resource, such as aquifer properties (geological formation and groundwater level) and climate conditions (e.g. rainfall).

Drill logging – preparation of a detailed record (a well log) of the geological formations penetrated by a borehole based on visual inspection of samples brought to the surface when drilling.

Formation stabiliser – if a well can be developed naturally, or, if the annular space around the screen is limited, a permeable backfill, known as a formation stabiliser, is placed simply to fill the annular space and prevent the formation from collapsing onto the screen.

Gravel pack – an artificially placed permeable annular backfill which is placed around the screen of the drilled water well. It needs to be at least 70mm thick to be effective. If it is thinner, then it is actually a formation stabiliser (see above).

Groundwater – water which occurs in the rocks (aquifers) beneath the surface of the Earth and which can surface in springs

Groundwater drought – a condition during a prolonged meteorological drought whereby groundwater resources decline and become unavailable or inaccessible for human use.

Consultant – the professional company or individual that is responsible for borehole siting and design and/or supervision.

Monitoring – the periodic checking of the functionality of boreholes, pumps and aprons and community management of the water source as well as water levels and water quality.

Operation and maintenance – running and repairing the water well, pump and apron so that sufficient clean water can be pumped at all times throughout its designed life and the general area of the well is kept clean. It also encompasses wellhead protection, post-construction support and access to spare parts for the pump and well maintenance.

Procurement – the process of selecting a drilling contractor, hydrogeological consultant or supplier to undertake a particular service or construction.

Professionalism – the skill, good judgment, and behaviour expected from a person or organisation who can undertake a job well.

Pumping test – pumping water from a borehole at a controlled rate to test the response of the water in the aquifer.

Siting – (borehole siting) the selection of the optimal location of the boreholes by the community as well as with either hydrogeological and/or geophysical means to ensure the design yield.

Water well – a hole, borehole or tube well which is drilled in the ground and partially or fully lined for the abstraction of groundwater.

Yield – the deliverable well yield depends on the aquifer geometry and hydraulic properties, combined with the maximum permissible drawdown in that particular situation. It should be noted that this definition takes no account of renewable groundwater resources. Yield is a term which is very often misused. Drilling contractors often refer to yield when they actually mean (a) the flow measured during air-flush drilling or (b) the rate at which the water was pumped during the test pumping.

Part I Background

Part I sets out the concerns about the professionalism of borehole drilling and rehabilitation and groundwater resources management in relation to achieving the Sustainable Development Goal (SDG) target for drinking water.

TRAINING DRILLING SUPERVISORS, BO, SIERRA LEONE, 2014 (KERSTIN DANERT)

Introduction

Achieving the Sustainable Development Goal target for drinking water

Sustainable Development Goal (SDG) target 6.1 is to *"achieve universal and equitable access to safe and affordable drinking water for all by 2030"* (UN, 2015b). With its emphasis on universality, the SDG target is a momentous shift from the Millennium Development Goal (MDG) target to *"halve, by 2015, the proportion of the population without sustainable access to safe drinking water"* (UN, 2015a; JMP, 2015).

In 20 out of 44 countries in the West, Central, East and South of Africa, less than 60% of rural dwellers use an improved water supply (JMP, 2015). Achieving universal access in countries with such a low baseline is a tremendous challenge for governments and support organisations such as UNICEF. Fragility and protracted crisis in many of these places raise the level of difficulty (Danert et al, 2016). Support agencies may need to work differently than in the past and reposition themselves to improve their effectiveness.

The importance of groundwater and boreholes in Africa

Margat and Van der Gun (2013) estimate that 45% of the global population depends on groundwater for domestic use. In Africa, groundwater dependence is even higher, estimated at over 75% (ECA, 2000). Sparsely populated areas within the continent are particularly reliant on groundwater, with hand dug wells historically playing a major role in rural and peri-urban areas. There is also considerable dependence on groundwater for urban water-supplies, particularly in Nigeria (IAH, 2015).

UN-Water (2013) states that there is no doubt that groundwater supplies and boreholes in particular will play a tremendous role in achieving the SDGs in Africa. In rural areas, as countries gradually improve supply coverage, new sources are required in difficult-to-reach locations and tough hydrogeological conditions where the risks of drilling a dry borehole are high. Managing this uncertainty is one of the challenges of meeting the SDG drinking water target. Groundwater use for irrigation is also forecast to increase, placing further demands on a poorly understood resource.

Professionalism

It is estimated that about a third of handpumps are failing, including an alarming number within the first one to two years of their installation (Carter and Ross, 2016). There are growing concerns that one of the principal reasons for such premature failure is poor siting and drilling of boreholes (Bonsor et al, 2015a; Bonsor et al, 2015b, Anscombe, 2004).

A borehole that lasts for its intended 25-50-year life span is a prerequisite for the sustainability of water systems that rely on groundwater. If boreholes are not well sited, designed, constructed and installed in the first place, the water supplies will fail, and investments are wasted. High quality boreholes are essential to ensure that the water withdrawn is safe. Groundwater resources need to be properly managed to prevent pollution or over-exploitation, and complete failure of the water supply service.

If the SDG targets for drinking water are to be met, drilling practice and groundwater resources management must improve.

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Figure 1: **WHY ARE SOME BOREHOLES BETTER THAN OTHERS?**

SOURCE: RWSN 2016b

UNICEF's crucial role

Professionalism is the skill, good judgment, and behaviour expected from a person or organisation who can undertake a job well

(RWSN, 2014)

In many African countries, UNICEF supports partners to drill boreholes alongside efforts to strengthen the enabling environment[1]. UNICEF's close partnership with government at all levels, coupled with its convening power, places it in a key position to improve groundwater development. The strong link between quality boreholes and sustainability, one of UNICEF's core tenets, makes professional siting and drilling even more pertinent.

Developing sustainable water services that rely on boreholes is a highly skilled endeavour. To be effective, UNICEF needs to ensure that its partners manage contracts, site boreholes and drill in a professional manner, ideally in the context of a supportive enabling environment. In many countries, appropriate policies, regulation and capacity to oversee implementation are required, and more effort to improve accountability and tackle corruption is needed.

At a global level, UNICEF has been striving to support manual drilling and its professionalism since 2010 through its toolkit and in-country work. UNICEF has also developed manuals on borehole drilling which have been published through the Rural Water Supply Network (RWSN). Broadly speaking, these documents focus more on ***what*** to do. There has been insufficient guidance on ***how*** to raise professionalism of groundwater development within the context of UNICEF-supported programmes.

This guidance note has been developed by UNICEF and RWSN partners and sets out how to raise professionalism. It includes practical examples of what has been done already and links to relevant resource materials.

[1] In UNICEF, effort to strengthen the enabling environment is also referred to as "upstream" work.

Water well drilling professionalism

In order to meet the SDG drinking water target, every country that uses groundwater needs a professional drilling sector. All professions, including manual and machine drilling, require special education or training.

Water quality, service reliability and sustainability require proper borehole siting, design, construction (or rehabilitation) and pump installation. Arguably, the drive for numbers of users over the last 15 years has led to a fall in the quality of project implementation. Individual drillers and consultants operating in a number of countries have expressed concerns to the authors about working for government and, more widely, the lack of capacity in-country to oversee drilling programmes and follow set procedures (Danert, 2008a; Danert, 2008b; Danert, 2015c).

Several countries (including Kenya, Mozambique, Nigeria, Sierra Leone, Sudan, Uganda and Zambia) are witnessing initiatives by the private sector, governments, UNICEF and other agencies to raise the professionalism of mechanised drilling. Efforts to promote and professionalise manual drilling are also taking place in at least 20 countries in Africa (Danert, 2015b). Many of these endeavours have been supported by UNICEF.

Improving drilling professionalism is not a one-off activity, but rather a process. It takes several years to raise standards, and it requires continued vigilance to uphold them. But the rewards of a professional drilling sector are enormous for a country's economy, long-term prosperity and employment, and to meet the SDG drinking water targets.

UNICEF has a key role to play in raising the professional level of water well drilling. In the countries where it is financing major investments into groundwater development over several years, UNICEF is in a very strong position to make (or break) drilling professionalism.

Borehole supplies that can last

Functionality and failure

Functionality usually refers to whether a water point is working or not at the time of a spot check. Sustainability considers whether water services continue to function over time

(Carter and Ross, 2016).

Estimates by experts compiled by RWSN (2009) found that between 10% and 65% of handpumps in 20 African countries were non-functional at the time of spot check. Subsequent more rigorous studies indicate non-functionality rates between 14% and 26% (Foster, 2013; Tincani et al, 2015)[2]. Comparing statistics is often challenging: some surveys include abandoned sources, while others do not and the term 'non-functional' is open to interpretation.

Questions such as "Is the poor functionality a result of inadequate management by the community or was the actual borehole badly constructed in the first place" or whether supply chains are inadequate can only be answered with proper diagnosis (Carter and Ross, 2016). Studies indicate that there are several, interrelated reasons for borehole failure (Abede and Hawassa, 2008; Bonsor et al, 2015a; Bonsor et al 2015b). System age, distance from district/county capital and lack of user fee collection affect functionality (Foster, 2013) as does inadequate borehole siting and poor construction quality (Anscombe, 2004).

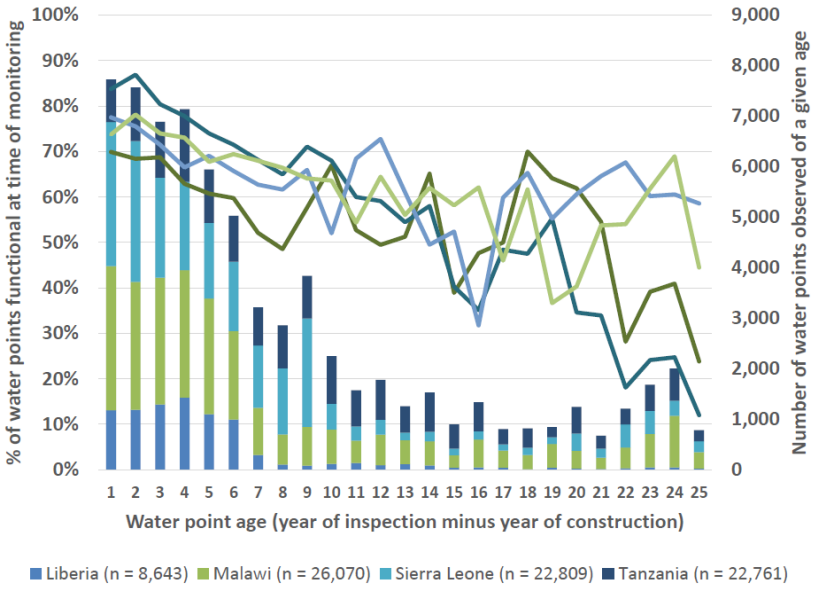
[2] Improve International (2015) catalogues 124 studies on the sustainability of water services in developing countries.

Figure 2: DIAGNOSIS IS REQUIRED TO DETERMINE WHY A BOREHOLE FAILED

SOURCE: RWSN (2016b)

The comparison of functionality of water points[3] with their age (Figure 3) shows that functionality falls as the age rises (Tincani et al, 2015). While this is to be expected, the drop in functionality to 70-85% in the first one to two years is cause for concern. There are numerous reasons for abandonment, including lack of demand by the users, vandalism or accidental damage by users. Another reason for premature failure is that some sources cannot be fixed because the initial site selection, design of the infrastructure or construction was fundamentally flawed from the outset.

Figure 3: WATER POINT FUNCTIONALITY RATES VS AGE OF INFRASTRUCTURE[4]



SOURCE: TINCANI ET AL, 2015

[3] Data does not just include boreholes but also other sources: the Sierra Leone data contains a significant number of hand dug wells; the Tanzania data contains a significant number of tap stands associated with piped schemes.

[4] The vertical bars refer to the number of water points observed; the line refers to functionality; "n" refers to the sample size in a given country. In each particular year, the vertical bar shows the number of water points observed of that age; the line shows the percentage of these water points that are functional.

Failure of a handpump in one to two years after installation indicates vandalism or accidental damage by users, or a major problem with the selected site, borehole design or construction, or with the quality of the pump.

In the case of boreholes, recent studies and stakeholder opinions from several African countries point to poor siting, borehole design, construction and supervision as a principle cause for failure of the source and subsequent abandonment by the intended users (Anscombe, 2004, Chowns, 2015; Bonsor et al, 2015a; Bonsor et al, 2015b and Furey, 2014). There is a great need for professionalism to be raised when it comes to borehole siting, design, construction and/or rehabilitation.

Groundwater resources and climate variability

"Many countries designated as 'water scarce' have substantial groundwater reserves. These large reserves provide a large and important buffer to changes in climate, and are therefore integral to the development of adaptation strategies to current and future climatic variability"

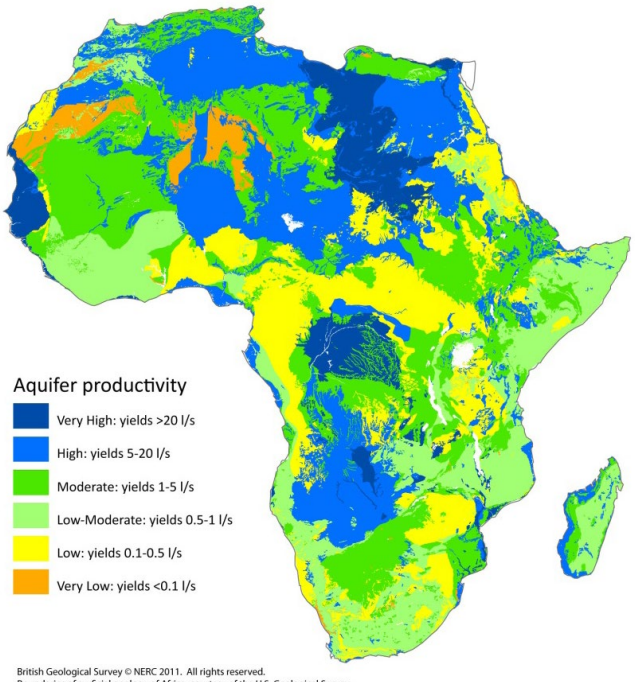
(MacDonald et al, 2012).

Groundwater can provide a natural buffer against climate variability, including drought (Calow et al 1997, Calow et al, 2010; IAH, 2015; Villholth and Stendel, 2013). MacDonald et al (2012) estimate the total groundwater in Africa to be 0.66 million km^3. To comprehend the magnitude of this vast resource, consider that the average annual rainfall on the continent is approximately 0.02 million km^3 (New et al 2000) and the freshwater storage in lakes is estimated to be 0.03 million km^3 (Shiklomanov and Rodda 2003).

Groundwater resources are unevenly distributed, and not all groundwater is available for extraction. The map in Figure 4 (MacDonald et al, 2012) indicates that it is the low and low to moderate yielding aquifers which coincide with some of the greatest densities of rural communities in Sub-Saharan Africa. Moreover, in many of these aquifers, yields actually vary greatly over very short distances, depending on the presence of local productive groundwater features such as faults and fractures and in which the greatest care is required in siting and constructing boreholes. Nevertheless, appropriately sited and constructed boreholes can support handpump abstraction which requires yields of 0.1– 0.3 l/s (MacDonald et al, 2012), and the local aquifer stores sufficient water to sustain abstraction through variations in recharge from one year to the next. Figure 4 indicates that the potential for higher yielding boreholes (>5 l/s) is much less (MacDonald et al, 2012) and is often in areas with fewer people.

Groundwater that is recharged from the infiltration of rainfall and surface water is known as renewable. In contrast, non-renewable or fossil groundwater is built up from previous climatic conditions, but is no longer recharged. Some parts of southern Africa have been shown to be at risk of groundwater drought (Villholth and Stendel, 2013). The potential for further development of

Figure 4: GROUNDWATER INFORMATION: AQUIFER PRODUCTIVITY IN AFRICA



SOURCE: MACDONALD ET AL (2012)

irrigated agriculture fed by renewable groundwater is considerable, estimated to be between 20% and 49% of the cropland of the continent (Altchenko and Villholth, 2015). Groundwater irrigation for smallholders in sub-Saharan Africa, driven by farmers themselves, is growing considerably (Villholth, 2013). Competition for use of groundwater resources between domestic, agricultural and industrial use in Africa will increase in the future.

As demand rises, parts of the continent increasingly face risks of groundwater depletion, salinization, pollution, degradation, water logging and floods. There will also be increased pressure from mining, underground construction and the development of energy sources, all of which can affect groundwater.

If groundwater resources are to be secured for the long term, groundwater information needs to be valued and used.

Despite the importance of groundwater in Africa, understanding of groundwater resources on the continent is limited. Neglecting to build up knowledge of groundwater in the continent does not bode well for reaching the SDG drinking water target or for sustaining it.

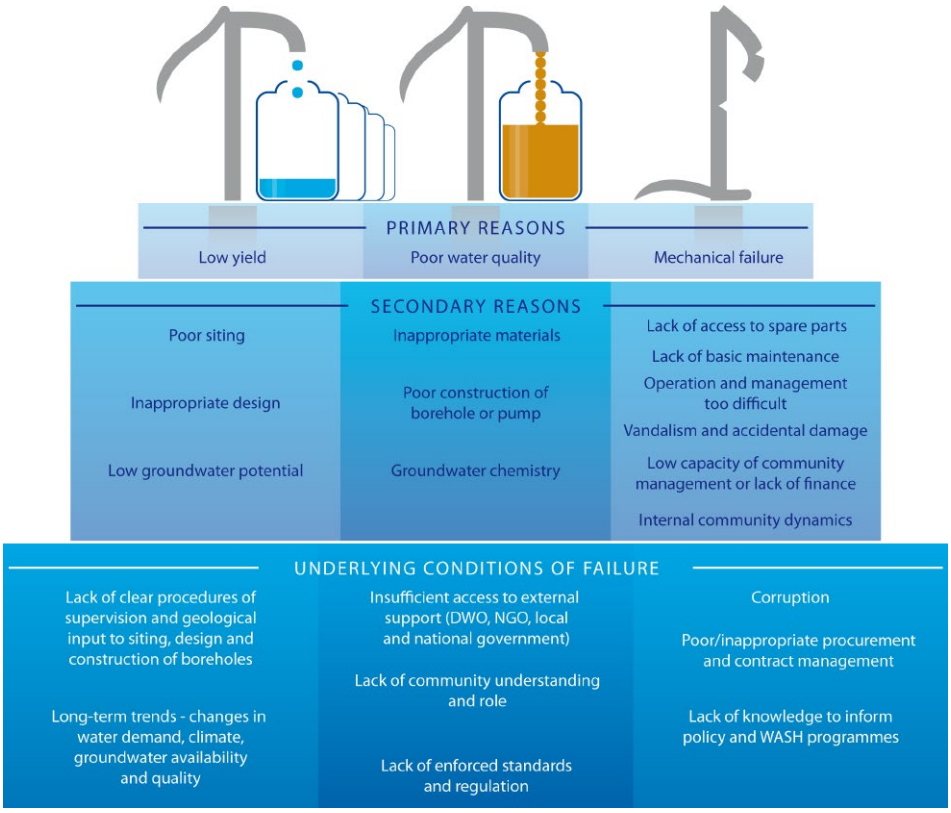
Physical problems with the borehole and pump ... and underlying causes

When boreholes fitted with pumps function poorly, and ultimately fail, the physical problems are typically:

- Low yield, i.e. inadequate quantity of water or seasonal unreliability
- Poor quality water (e.g. high turbidity, poor bacteriological/chemical quality)
- Mechanical failure of the pump

On the whole, these physical problems are caused by one or more secondary reasons, as illustrated in Figure 5[5]. In turn, these secondary reasons are a consequence of other, deeper underlying causes.

Figure 5: PRIMARY REASONS, SECONDARY REASONS AND UNDERLYING CAUSES OF FAILURE OF HANDPUMPS AND BOREHOLES



SOURCE: BONSOR ET AL (2015a)

[5] Anscombe (2004) divides these underlying reasons into three categories (poor siting, poor construction and post-construction damage).

This guidance note sets out to address six of these underlying causes of failure, i.e.:

- Lack of proper siting, design and construction of boreholes, inadequate supervision and insufficient attention to pump selection and installation.
- Lack of regulation, lack of knowledge of regulations and lack of adherence. In the case of private borehole construction, lack of knowledge of construction standards (if they exist), coupled with variable skills and motivation by drilling contractors and lack of regulation cause construction quality to suffer.
- Corruption – particularly in relation to the procurement and contract management process.
- Poor or inappropriate procurement & contract management.
- Lack of knowledge to inform policy and WASH programmes. Poor understanding of groundwater by political leaders, non-groundwater specialists and society as a whole causes many problems with implementation (UNESCO-IHP et al, 2015a, Danert et al, 2015, Armstrong, 2015).

The socio-economic, institutional and political environment (often referred to as the enabling environment) affects the professionalism of individuals and organisations in the borehole siting, drilling and rehabilitation industry. If the emphasis is on large numbers of boreholes and the capacity to properly manage implementation is neglected, construction quality suffers (Anscombe, 2004). Insufficient finance (Bonsor et al, 2015a; Bonsor et al, 2015b), and unrealistic targets result in an emphasis on lowest cost rather than quality construction and supervision. Related underlying issues include:

- Difficulty in finding and recruiting staff, consultants, drilling contractors or NGOs with sufficient training, experience and expertise.
- Ad hoc or highly unpredictable work for drilling contractors and consultants (Ball, 2004, Robinson, 2006).

The nuances of these underlying causes differ with context and are often linked. Many relate to norms and incentives within projects, institutions, funding agencies including UNICEF, and the particular district, county, state or country in question.

It should be noted that the two issues of lack of community understanding and role, as well as insufficient access to external support shown in Figure 5, are beyond the scope of this guidance note.

Part II Improving the professionalism of water well drilling

Part II sets out a menu of actions to raise the professionalism of mechanised and manual drilling and borehole rehabilitation.

FATIGEN DRILLING, BO, SIERRA LEONE, 2014 (KERSTIN DANERT)

Aim and scope

Based on its experience and lessons learned, UNICEF is strategically positioning its efforts to improve the professionalism of mechanised and manual drilling in programmes that it funds directly and the wider enabling environment.

The aim of this guidance note is that UNICEF staff and partners understand what professional groundwater development means and incorporate good practices into programmes and advocacy. The target audience are those that manage or support water well drilling programmes and related activities that are meant to improve the enabling environment in Africa but may be applicable in other parts of the world.

The guidance note covers both mechanised and manual drilling. It sets out practical and strategic actions for UNICEF and its partners. The scope is limited to the technical and managerial aspects of borehole drilling and rehabilitation and does not include extensive guidance on community aspects, operation and maintenance or supply chains.

Cost-effective boreholes

Drilling cost-effectiveness is "optimum value for money invested over the long term. Boreholes are drilled to function for a lifespan of 20 to 50 years. Thus, the lowest-cost well is not always the most cost-effective, particularly if construction quality is compromised to save money"

RWSN (2010).

Drilled water wells, or boreholes, have long design lives which typically exceed 25 years (Driscoll, 1986). The lifespan of the installed lifting device (handpump or a submersible pump) tends to be shorter. A pump can be replaced entirely or component by component as various parts wear, still using the same borehole.

The term "drilling cost-effectiveness" does not mean short-term cost-savings at the expense of quality. Cost-effectiveness is no excuse for shoddy workmanship, but there are questions about whether boreholes should be designed and constructed so that the lifting device can later be upgraded from a handpump to a submersible pump (Wurzel, 2001). For this to happen, the right kind of aquifer, with enough groundwater potential to supply sufficient water, is also required[6].

What can UNICEF do?

UNICEF recognises that the lowest cost borehole is not always the most cost-effective, particularly if construction quality is compromised to save money. UNICEF, with its relationship to government and dual approach to improving services and supporting the enabling environment can play a major facilitation role in raising the professionalism of groundwater development. Over the last ten to twenty years, UNICEF has shifted away from drilling with its own equipment to contracting the private sector, partnering with NGOs and supporting government-run borehole drilling and rehabilitation programmes.

Nevertheless, to raise quality, there are many examples that can be learnt from and built upon.

[6] See Guidance Note - Part 1- Groundwater resources and climate variability on page 6

Ensuring that boreholes are consistently properly sited, designed and constructed within UNICEF programming can be a foundation for improving the situation in the country as a whole. Raising professional standards more widely is complex, and every country, state, district or county and particular drilling programme has its own particularities. For example, the geology and hydrogeology of a particular aquifer affect how borehole siting is best undertaken. Staffing, skills and knowhow affect what can be expected from government without additional training or mentoring.

Assessments of the drilling sector (Box 1) can document siting, design and construction practices, procurement and contract management realities, who is drilling and how groundwater data is used[7]. Such studies provide key information and can foster interest in improving professionalism. A study, on its own, however, is unlikely to be enough to bring about change. It may need to be accompanied by efforts to improve groundwater understanding by decision-makers, or efforts to revise standards and change policies. Substantial investments in raising capacity may be required; or unrealistic targets and cost estimates that undermine quality may have to be changed. In this case, adjustments to plans may be needed.

Government, private contractors, development partners, political leaders or water users cannot improve groundwater development professionalism alone. Different stakeholders need to communicate, collaborate and hold each other to account. To improve the status quo, there is need to build on existing strengths, and trust may need to be built (or earned). The buy-in of those involved and meaningful dialogue to find incentives and agree on actions may prove to be a core part of bringing about much-needed improvements.

Figure 6: **TRUST IS AN ESSENTIAL PART OF PROFESSIONAL DRILLING**

SOURCE: RWSN, 2016a

An engaging, problem-solving approach involving different stakeholders over many years is required. The particular methods used need to be tailored to the specific context. The starting point, mix of activities, particular sequence or what should be attempted in parallel will vary with the circumstances of the country. Over time, there is need to recognise successes, as well as what is not working, while striving for improvements in a systematic and inclusive way.

[7] The RWSN (2010) Code of Practice for Cost-Effective Boreholes includes nine principles which form a structure for a country drilling assessment. The quick quiz (Annex 1) provides key questions for an in-country assessment of the borehole drilling sector.

For example, it will be difficult for individual projects to systematically improve on their borehole siting if groundwater data cannot be accessed. Thus, if no institution is responsible for the collection and archiving of groundwater data, this needs to be addressed early on. On the other hand, if capacity to procure and manage drilling contracts is extremely weak, then this should be strengthened to ensure that construction consistently meets the required standards and that useful data can be collected. If groundwater data is available, but is not being used, then awareness-raising activities or changes to siting procedures and contract management may be needed.

To help orient UNICEF staff on the complex issue of raising the professionalism of groundwater development, six areas of engagement have been identified, as described below and illustrated in Figure 7:

Figure 7: **ENGAGING IN PROFESSIONAL GROUNDWATER DEVELOPMENT**

- **Institutional framework** – promote initiatives to improve national (or state) policies, regulation, standards and procedures of borehole drilling, including the clarification of roles and responsibilities.
- **Groundwater information** – value groundwater data and ensure that drilling records are collected, quality-assured and collated. This data, together with information generated from it, must be made readily available to help inform future borehole siting and design, as well as groundwater resources management.
- **Project design, implementation and monitoring** – improve the design, implementation and monitoring of specific borehole drilling or rehabilitation projects, and ensure that documentation of the process and results is readily available.
- **Capacity** – raise the skills and knowledge of groundwater development and encourage the availability of suitable equipment in the country.

- **Investment** – invest adequate financial resources to improve and sustain professional groundwater development.
- **Dialogue & awareness** – foster dialogue between government agencies (including regulators), drilling contractors and consultants, NGOs, development partners and civil society. Encourage and support efforts that raise awareness of decision-makers and the public about groundwater potential, management and its exploitation.

Professional water well drilling – six areas of engagement

The guidance below builds on the RWSN (2010) Code of Practice for Cost Effective Boreholes and associated guidelines and the UNICEF (2010) Toolkit for the Professionalization of Manual Drilling[8] (Annex 2). It also draws on relevant materials from other organisations and experiences from countries where initiatives to improve groundwater development policy and practice have taken place (e.g. Box 1).

Box 1: **COUNTRIES WITH ASSESSMENTS OF THE BOREHOLE DRILLING SECTOR**

Between 2003 and 2016, assessments of the borehole drilling sector were undertaken, including for 13 countries in Africa:

- Burkina Faso (Duffau & Ouedraogo, 2009 and Galbane (2011)
- Chad (Danert, 2015a)
- Ethiopia (Carter et al, 2006, Calow et al, 2012)
- Ghana (Adekile & Kwei, 2009; O Dochartaigh et al, 2011b)
- Kenya (Doyen, 2003; Armstrong, 2015)
- Mozambique (WE Consult, 2006, Gesti Canuto, 2011, Macário and Hawkins, 2015)
- Niger (Danert, 2006)
- Nigeria (Adekile, 2007; Adekile, 2008; Adekile & Olabode, 2008a; Adekile & Olabode, 2008b; Adekile & Olabode, 2009; Arafan Mangai et al, 2011; Adekile, 2012, Danert et al, 2014a, Danert et al, 2014b)
- Sierra Leone (Danert & Adekile, 2013)
- Sri Lanka (Ferdinando, 2011)
- Sudan (Government of Sudan, 2012)
- Tanzania (Baumann et al, 2005)
- Uganda (Sloots, 2010)
- Zambia (Armstrong, 2009)

Many of these were supported by or involved UNICEF. The links to all of these assessments are provided in the list of references at the end of the document.

[8] The UNICEF et al (2010) Toolkit for the Professionalization of Manual Drilling is intended for UNICEF Country Offices and other development agencies interested in promoting the emergence of a professional manual drilling sector. It was developed alongside a UNICEF supported project to professionalise manual drilling in Chad, and drew on previous experiences from Enterprise Vita in Niger.

Institutional frameworks

Support efforts to strengthen the institutional framework

Definition	The institutional framework is the system of formal laws, regulations, and procedures, informal conventions, customs and norms that shape socioeconomic activity and behaviour.
The problem	In many countries, the laws, regulations and procedures as well as responsibilities for groundwater development and management of the resources are not clear or are contradictory. Responsibilities may fall between or be divided among ministries and between national and provincial or district administrations. Many countries lack technical guidelines for borehole construction and rehabilitation. The combination of these weaknesses results in overlapping mandates and confusion, and undermines the professionalism of groundwater development.
The solution	**Promote and undertake initiatives that improve the laws, regulations and procedures of borehole drilling and their adherence.**

How to do it?

General recommendations

Consider the country (or federal state) as a whole, rather than one specific project or programme. Be aware that changing laws, regulations and procedures takes considerable time and is a political as well as technical endeavour. Finally, laws, regulations and procedures are only as valuable as adherence to them.

Step-by-step guide

Step 1

Determine whether high quality boreholes are being consistently constructed in the country or federal state. Data on functionality and underlying causes[9] can provide a good starting point, and can be obtained from post-construction monitoring visits and reports as well as project evaluations. If this information is not available, specific studies examining boreholes and the causes of failure can be commissioned. Removal of the pump and investigation with a borehole camera (Box 8) will be required to diagnose many problems of borehole design and construction. National water point mapping data and surveys can also provide useful information, although they may not immediately reveal the reasons behind poor functionality. Formal and informal complaints of poor-quality boreholes or inadequate professionalism may have been made to government or to others. Allegations should be verified through field monitoring.

If no information on borehole quality is available, this raises wider concerns about post-construction monitoring in the country as a whole. If the borehole quality is generally sufficient, keep on monitoring the situation.

Step 2

Map out the different drilling projects and programmes in the country (or state) and the extent of private drilling work. If state-owned enterprises are involved in drilling, clarify their operations; e.g. do they focus on high-risk situations that are not attractive to the private sector or do they operate more widely?

[9] See Guidance Note Part I – *Functionality and failure*

Step 3	Review existing national laws, regulations and procedures for borehole drilling and rehabilitation. Include drilling licencing, abstraction permits, procurement and contract management procedures, data collection and collation and any national quality standards for materials for boreholes and pumps (including borehole casing and screen, gravel, pumps and pump components) in the review. The RWSN (2010) *Code of Practice and Part II of the Drilling quick quiz* (Annex 1) provide guidance for the review and triggers for further discussion. Determine which agencies are responsible for setting regulations and enforcing them and for data collection, and identify any gaps or overlaps. Determine whether the institutional framework supports and effectively oversees a professional drilling sector.
Step 4	Assess whether the laws, regulations and procedures are known or are being adhered to within existing projects and programmes as well as for private drilling (as identified in *step 2* above).
Step 5a	If national drilling standards or codes of practice exist, but are not widely known, raise awareness of them among the organisations that fund, manage, implement, supervise and undertake borehole construction and pump installation.
Step 5b	If there are no laws, regulations or documented procedures for borehole drilling, or if they are inadequate or too complicated, or if responsibilities are not clear, advocate for, or support their development, improvement and clarification. Build on experiences from engagement areas: ■ Project design, implementation and monitoring and ■ Dialogue and awareness.
Step 6	Ensure that any new or modified laws, regulations and procedures for borehole drilling are published and communicated to all relevant stakeholders within the country. Put them in the public domain, including online, and promote them through mass media and public notice boards. Resources for the above steps are set out in Box 2.

What have others done?

Several countries have embarked on journeys to improve the institutional framework with respect to borehole drilling, i.e.:

- Chad – Association for the Promotion of Enterprises Specialised in Low-Cost Drilling (ATPESFORC, 2016)
- Ethiopia – issue drilling licences (Carter et al, 2006)
- Kenya – developing codes of conduct for the drilling sector (KWIA, 2016)
- Mozambique – drillers association with statutes (Macário and Hawkins, 2015)
- Nigeria – publishing a code of practice for drilling (SON, 2010) and establishment of national and state drilling associations (AWDROP, 2016)
- Sierra Leone – developed principles for drilling and rehabilitation (Ministry of Water Resources, 2014)
- Uganda – issue drilling licences (Sloots, 2010); revitalising the drillers association and registering all groundwater consultants.

- Zambia – Water Resources Management Act (Government of Zambia, 2011), establishment of the Water Resources Management Authority (WARMA) and on-going efforts to develop statutory instruments for drilling.
- Zimbabwe has developed borehole drilling standards (Standards Association of Zimbabwe, 2013), but publicity, application and enforcement has been very low (Fred, 2016).

Box 2: **INSTITUTIONAL FRAMEWORK – AVAILABLE RESOURCES**

1. Borehole sector study reports: Burkina Faso, Chad, Ethiopia, Ghana, Kenya, Mozambique, Niger, Nigeria, Sierra Leone, Sri Lanka, Sudan, Tanzania, Uganda and Zambia (Box 1)

2. Learning resources:
   a. Groundwater regulation, licencing, allocation and institutions – module 6 of *The Integration of Groundwater Management into Transboundary Basin Organizations in Africa* (AGW-Net, 2015)
   b. Groundwater regulation, licensing, allocation and institutions for transboundary aquifer management – presentation of above module (Tindimugaya, 2016)
   c. Groundwater Governance in Kenya – Webinar recording (RWSN, 2015d)
   d. Global Framework for Action on Groundwater Governance (UNESCO-IHP et al, 2015a; 2015b and 2015c)

3. Select regulations and procedures:
   a. Code of Practice for Cost-Effective Boreholes RWSN (2010)
   b. Code of Practice for Water Well Construction for Nigeria (SON, 2010)
   c. Principles for Borehole Drilling and Rehabilitation Principles for Sierra Leone (Ministry of Water Resources, 2014).

4. National drilling association websites:
   a. Chad – Association Tchadienne pour la Promotion des Entreprises Spécialisés en Forage à Faible Coût (ATPESFORC, 2016)
   b. Mozambique – Associação de Perfuração de Moçambique (AMP, 2016)
   c. Nigeria – Association of Water Well Rig Owners and Practitioners (AWROP)

5. Self-assessment tool:
   a. *Drilling quick quiz* – Part 2 (Annex 1)

Groundwater information

Value groundwater data and use groundwater information

Definition

Groundwater data refers to the facts and figures from drilling records, borehole testing and siting/completion reports as well as from water quality surveys and groundwater level monitoring. Such data may be found in databases or documented in hard copy reports and stored in various locations such as drilling enterprise, or government offices.

Groundwater information is groundwater data that have been captured, complied, synthesised or interpreted, and is useful for decision-making. Groundwater maps with a description are an example of groundwater information.

The problem

High-quality borehole siting requires good groundwater data, information and knowledge. Africa is highly groundwater dependent, and its economic and social development depends on a good understanding of groundwater resources. Despite the sizable investment in borehole drilling in Africa, only limited groundwater data is being collected, collated or analysed, and coordination is rare.

If data exists, it tends to be hard to find. Some countries have groundwater databases in some shape or form, but apart from hydrogeologists, very few people understand much about the hydrogeological data, its importance and how it can be used to improve the successful development and sustainability of groundwater supplies.

In summary, groundwater data is not adequately valued and groundwater information is not sufficiently used.

The solution

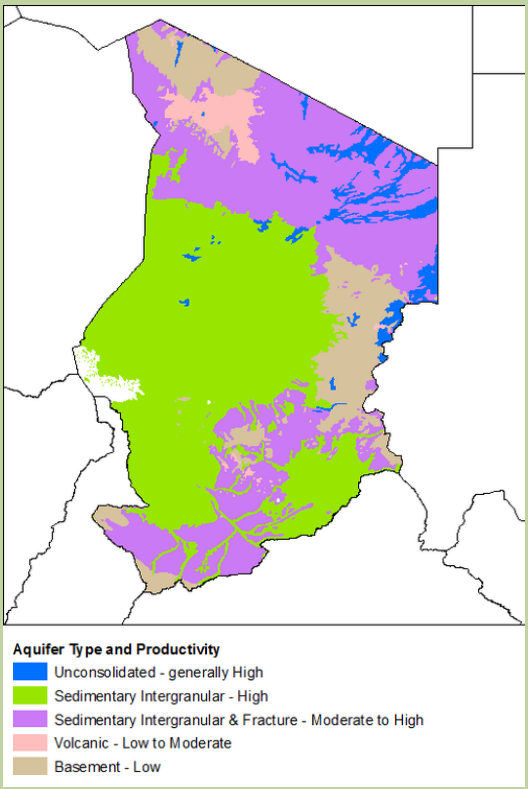
Value groundwater data and ensure that drilling records are collected, quality-assured and collated. This data, together with information generated from it, should be made readily available to help inform future borehole siting and design, as well as groundwater resources management.

How to do it?

General recommendations

It is important to recognise that different scales of groundwater information and data lend themselves to different uses. Thus a national map of manual drilling potential presented on an A4 sheet can be used for advocacy and overall planning purposes, but not to site individual boreholes (Box 3). Also, while groundwater maps are extremely useful, they are limited by the two-dimensional representation of three-dimensional geology and groundwater.

Box 3: DIFFERENT SCALES OF GROUNDWATER MAPS

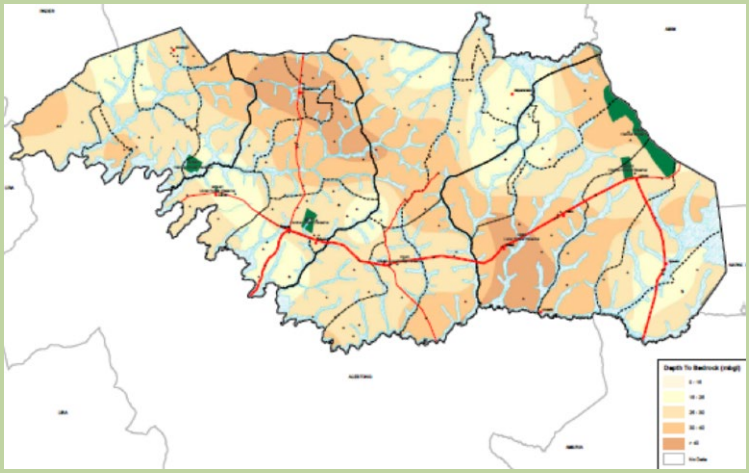


HYDROGEOLOGY OF CHAD (BGS, 2016c)
- Original at 1:5million scale.

map of aquifer productivity in Africa (Figure 2) provides general information for the continent.

Country maps such as those in the Africa Groundwater Atlas (e.g. Figure left), or developed to show manual drilling potential, set out the situation within the country. They can be used for the overall planning of borehole drilling programmes and advocacy.

A hydrogeological map at a scale of about 1:200,000 (e.g. Figure – below), together with data on borehole depths, water levels, yields, pumping tests and water chemistry and studies on groundwater, can be interpreted and used to assist with borehole siting and determination of appropriate reconnaissance techniques (Carter et al, 2010).



INFERRED OVERBURDEN THICKNESS IN OKUTE DISTRICT, Uganda (MWE, 2013) – Original at 1:155,000 scale.

Step-by-step guide

While the actions below are set out as a series of steps, the sequencing will depend on the particular context, and to be effective, some steps may need to run in parallel.

Step 1

Review the groundwater data being recorded by drillers and their clients as well as data collection procedures and adherence to them (Box 4). Assess the mechanisms for depositing, or handing over the siting and drilling data and quality assurance[10] and the ways in which such data is made available to support subsequent siting and drilling activities. Data is recorded in drilling completion reports, siting reports, pumping test results and water quality surveys. Include an assessment of the extent to which data from dry boreholes is collected.

[10] It is important to determine whether there is quality assurance of the data as the quality of siting and drilling data varies dramatically. For example, sometimes, geophysics data or borehole logs are simply copied and pasted from one report to another. There can also be ambiguity over site identification, units used or missing data.

Box 4: **THE FUNDAMENTALS OF GROUNDWATER DATA**

Treat borehole drilling as an opportunity to gain valuable geological and hydrogeological information, with rigorous collection and recording of data throughout the drilling process

O Dochartaigh et al (2011b)

The basis for subsequent use of groundwater data and interpretation is:

- Mechanisms that allow the cumulative data to be accessed and made readily available for future siting and drilling programmes.
- Recording of units of measurement used. Each country should have data standards, including GPS referencing units and sample classification.
- A standard national format for borehole completion records must include location depth drilled, depth of first water strike, geology, static water level, pumping test discharge and select water quality parameters. Standard borehole completion formats set out these data requirements.
- National procedures as well as practices should ensure that data from all boreholes (including dry boreholes) is recorded on site.
- All drilling completion records should be submitted to a central authority.
- Mechanisms should be in place to ensure that drillers comply with data submission requirements, e.g.
  - linking this to the renewal of drilling licences
  - compensation for dry boreholes so that this valuable data is collected
  - a "no data – no pay" strategy, writing into contracts that drillers earn part of their payment for data supplied. Part of their "per metre" rate could be withheld if there were, for example no drillers' logs, depths, water strikes or water levels.
  - Payment could be withheld from those parts of the construction process which really contribute data – development, test pumping discharges and drawdown levels, recovery levels, water samples, or the contractor should be made to repeat them with adequate data collection.
- A system that provides each borehole with its own identification number.

Step 2

Encourage that an agency is designated responsible for the collection of groundwater data and reports (linked to the *institutional* framework – Step 3 and 5b).

Step 3

Actively support efforts to:

- Establish or improve the management of a national groundwater database that stores the data collected.
- Clarify who owns the data and what can be done to encourage data sharing, ideally free of charge.
- Encourage drillers and pump installation contractors to submit full data from all boreholes. As mentioned in Box 4, this can be linked to licence renewal, "no data – no pay" or a payment reductions if data is not submitted.

Step 4

Advocate for, or support agencies to identify and map areas that are (i) particularly challenging, e.g. high risk of drilling dry holes or suffering from salinity, arsenic, fluoride, iron/manganese, low pH or (ii) at risk of falling water tables, natural contamination or man-made pollution and (iii) suitable for manual drilling.

Step 5

Lead by example by supporting the collection of groundwater data in UNICEF programmes and using groundwater data and information for borehole siting and programme management (*linked to project design, implementation and monitoring*). The RWSN (2010) code of Practice for Cost Effective Boreholes provides data collection forms for drilling logs. Carter et al (2010) sets out details for siting.

What have others done?

Examples of efforts to value and use groundwater data and information in Africa include:

- Standard formats for borehole construction, pumping test and (to some extent) water quality data have developed for Nigeria (SON, 2010), Sierra Leone (Ministry of Water Resources, 2014) and Zambia.
- Operational groundwater databases in Botswana, Chad, Tanzania and Uganda with various degrees of systematic data collection.
- Identifiers for the boreholes throughout the country in Botswana.
- Recent projects to prepare detailed groundwater maps with description maps have been carried out in Chad (MEH 2016) and Uganda (MWE, 2012).
- Identification of inorganic constituents of significant risk to health that may occur in groundwater in several countries (BGS and WaterAid, 2016a; 2016b)
- Areas with the potential for manual drilling have been mapped (at national level) for Benin (UNICEF et al, nd-a), Central African Republic (UNICEF et al, nd-b), Chad (MEERH, nd & Danert, 2015), Guinea (GRAIA, 2012), Ivory Coast (UNICEF et al, 2009a), Liberia (UNICEF et al, nd-c), Madagascar (Abric, 2014; MINEAU, nd). Mali (UNICEF et al, nd-d), Mauritania (UNICEF et al, nd-e), Niger (MEELCD, nd), Senegal (UNICEF et al, nd-f; Kane et al, 2013), Sierra Leone (Adekile, 2014b), Togo (Ministre de L'Eau, 2009) and Zambia (MLGHEEEP, 2011). See Danert (2015b) for a summary of the above.

Box 5 provides an overview of select resources on groundwater data and information.

Box 5: **GROUNDWATER DATA AND INFORMATION – AVAILABLE RESOURCES**

1. Learn more about groundwater data and information, its importance and economic value:
   a. The magic and mystery of groundwater data – webinar recording explaining typical problems of groundwater data collection, management and use (RWSN, 2015f).
   b. Reasons for keeping groundwater data and how to use them – chapter 9 of Developing Groundwater (Macdonald et al, 2005).
   c. Groundwater Monitoring and Information Management – module 5 of The Integration of Groundwater Management into Transboundary Basin Organizations in Africa (AGW-Net, 2015).
   d. Transferring groundwater data into information and knowledge, chapter 2 of Mapping for Water Supply and Sanitation (WSS) in Ethiopia (MacDonald et al, 2009).
   e. Sustainable Groundwater Development: use, protect and enhance (Furey and Danert, K (2014).

2. Code of Practice for Cost-Effective Boreholes includes suggested formats for borehole completion reports as do standards (RWSN, 2010) as do the Nigerian Code of Practice (SON, 2010) and the Principles for Borehole Drilling and Rehabilitation Principles for Sierra Leone (Ministry of Water Resources, 2014).
3. Examples of recent groundwater mapping initiatives include:
    a. Groundwater resources of Chad portal (MEH, 2016)
    b. Mapping of groundwater resources in Uganda (MWE, 2012)
4. Africa Groundwater Atlas – provides high-quality information on the groundwater resources of 51 African countries with summary national hydrogeology and geology maps, including sections on groundwater status, use and management, and overview information on related aspects such as climate and surface water (BGS, 2016a).
5. Africa Groundwater Literature Archive includes supporting material and links to further details on groundwater quality, recharge and transboundary aquifers among others (BGS, 2016b).
6. WHYMAP – scanned hydrogeological maps and legends for select countries [to access the maps: go to http://www.whymap.org/whymap/EN/Home/whymap_node.html; choose Map applications/services; choose WHYMAP viewer; choose WHYMIS in bottom left menu; and then tick the box to left of the word 'WHYMIS' that appears mid-bottom of screen (also 'Countries' below this is ticked) – a yellow overlay map appears; Click on any country – a pop up box appears with a list of hydrogeological maps available for that country and the scanned map & scanned legend], (BGR and UNESCO, 2016).
7. Groundwater quality factsheets by country: identify inorganic constituents of risk to health that may be present in groundwater in Bangladesh, Burkina Faso, East Timor, Ethiopia, Ghana, Madagascar, Malawi, Mali, Mozambique, Nepal, Nigeria, Northern India, Pakistan, Southern India, Tanzania, Uganda and Zambia (BGS and WaterAid, 2016a).
8. Groundwater quality factsheet by element: explain the nature of the health risk for each constituent, the origin and occurrence in groundwater, the means of testing and available methods of mitigation. Elements covered are arsenic, fluoride, iodine, manganese and nitrate (BGS and WaterAid, 2016b).
9. The Groundwater Assessment Platform provides information and an exchange platform on arsenic and fluoride contamination of groundwater.

Project design, implementation and monitoring

Improve project design, implementation and monitoring

Definition

A project is a planned piece of work that has a specific purpose and that requires some time to complete. A borehole drilling project includes sensitisation of and training of end users, siting, borehole design, drilling, development and completion, and pump installation. A borehole rehabilitation project will also include diagnosis of the cause of failure to determine what rehabilitation should be done at each site. UNICEF and others are involved in borehole drilling and rehabilitation projects by:

- Supporting governments to site, drill and rehabilitate directly, or contract these services out
- Hiring contractors to drill or rehabilitate boreholes
- Entering into partnership with NGOs that either site and drill directly, or contract this out to the private sector

UNICEF no longer undertakes borehole drilling with its own equipment and staff.

The problem

An unacceptably high number of boreholes fail within a relatively short period of time due to poor siting, construction or development. At the planning stage, targets and unit costs may be assumed without adequate knowledge of local conditions of geology and groundwater. Within the projects themselves, all too often, insufficient attention is paid to technical details of siting and drilling. In the case of rehabilitation efforts to establish why the borehole or pump failed in the first place and whether it is possible to rehabilitate are often lacking. For example, wells inappropriately sited, drilled too shallow or installed with the wrong filter pack or screen can result in the service failing, and become abandoned within years, months or even days.

Record keeping from borehole drilling is often neglected, and rehabilitation does not always follow a proper diagnosis. Without systematic documentation, lessons cannot be easily used for the future.

Lack of post-construction monitoring means that construction (and rehabilitation) programmes are not paying adequate attention to water service sustainability and long-term outcomes. This undermines essential learning from past successes and failure.

The solution

Improve the design, implementation and monitoring of specific borehole drilling or rehabilitation projects, and ensure that documentation of the process and results is readily available.

How to do it?

General recommendations

Note that the way that UNICEF drilling initiatives and those supported by others are designed and implemented affects the quality of the borehole and the longevity of the water supply service. This applies to both manual and mechanised drilling. Weaknesses in the design of an overall programme or specific project can lead to wasted investments. This does not fulfil UNICEF's Core Commitments, with UNICEF and its partners risking reputational damage. Borehole drilling is particularly at risk of corruption, and not only in relation to procurement (Box 6).

Box 6: **CORRUPTION RISKS IN THE DRILLING SECTOR**

Internationally, water is viewed as bearing a high risk of corruption because of the financial flows, weak government oversight, and significant public-private interactions involved in infrastructure provision. Water corruption includes bribes, fraud, nepotism and embezzlement, and interactions that are particularly at risk in the borehole drilling sector comprise:

- licencing policies – e.g. prohibiting new market entrants
- favouring large capital-intensive works – providing high opportunities for bribery and rent seeking
- tendering and procurement – a selection of contractors and service providers offering opportunities for nepotism and bribery, public contracting offering possibilities for interdepartmental or agency collusion
- collusion and non-competition between contractors to maintain artificially high prices
- documentation – lack of transparency in funds utilisation for drilling and rehabilitation, as well as inadequate information to trace who sited, drilled or supervised provide opportunities for embezzlement
- oversight – inadequate oversight and field supervision providing opportunities for marked-up pricing and poor borehole quality or bribery for sign-off for payment of dry or marginal boreholes
- contract management and payment – opportunities for bribes to "speed things along", fraudulent invoicing, document falsification and silence payments
- unbalanced contract pricing encouraging excess drilling rather than the equally important development, testing and completion tasks – although this may be more a technical than a corruption issue

Source: adapted from Calow et al, (2012) and Plummer and Cross (2007)

Constructing boreholes of good quality requires a basis of solid policies and regulation, upon which project design, planning, tendering and procurement, construction and payment sit. Proper consideration needs to be given to:

- effective project management of the entire process
- technology choice – selection of the most appropriate borehole designs for the local hydrogeological conditions and the most suitable drilling methods to construct them
- selection of the best way to procure and manage the programme (e.g. contracting directly, partnering NGOs or funding government programmes)
- preparation of realistic cost and price estimates for siting, drilling, supervision and oversight
- proper borehole siting using appropriate methods for the local conditions – to select the most suitable location
- careful drilling supervision – to ensure good quality drilling and data collection
- quality borehole construction – by a professional driller
- borehole yield and water quality testing – to ensure that pumping can be sustained and that water is fit for human consumption
- diagnosis of failure – to ensure that appropriate rehabilitation is undertaken
- record keeping – so that future projects, and the country as a whole, can learn from past experiences

Annex 3 sets out key good practices of siting and construction, and the implications of getting them wrong.

Step-by-step guide

Step 1

Find out whether high quality boreholes are being consistently sited and constructed in UNICEF and partner drilling projects. Data on functionality and underlying causes[11] can provide a good starting point. As noted under *Institutional Frameworks*, this can be obtained from some post-construction monitoring visits and reports and review or evaluation reports. It may also be part of the sustainability check reports[12]. National water point mapping data and surveys can also provide useful information. Formal and informal complaints of poor quality boreholes or inadequate professionalism may also have been made. Note that allegations should be verified through field monitoring.

If no information on borehole quality is available, this raises wider concerns about post-construction monitoring which should be discussed in-country or with the regional office.

Step 2

If the borehole quality on the initiatives, or specific projects supported by UNICEF is good, keep on monitoring the situation.

If there are concerns about borehole construction quality, the next step is to try and identify the underlying causes[13]. The *drilling and rehabilitation quick quiz – part 1* (Annex 1) provides project managers and field staff with questions for a rapid assessment of the projects and to visualise key strengths and weaknesses.

Step 3

Particular weaknesses should be addressed, i.e.:

- **Area of programme deployment** – while there is often political/social/donor pressure to spread investment thinly, there can be a big cost to this – highly dispersed programmes are likely to be impossible to supervise in any meaningful way. Technical supervision and hence better value for money could be obtained from programmes that are less dispersed, with drilling rigs closer together at any one time to make it logistically easier for programme staff or consultants to supervise key steps in the construction process.
- **Planning and project design**: prepare engineers estimates of borehole costs that give due consideration to geology and hydrogeology as well as other key aspects like distance from contamination sources and accessibility by users. Estimate costs for siting, supervision and monitoring as well as community engagement. Check whether these estimates are in line with assumed unit costs in programme documents and budgets. If there are major discrepancies, take up this issue with management in-country. Clearly, the best time to overhaul estimates is when the country programme is being developed, or when funding proposals are being prepared.
- **Investment**: evaluate the extent to which programme targets and associated human and financial resources for procurement and contract management are realistic. If it is not, take this needs to be taken up with in-country (or even regional) management.
- **Siting**: clarify siting procedures, including responsibility for the final site selection. Do not leave the job of siting to the driller, but rather employ, or hire a competent and experienced hydrogeologist or retrained engineer to undertake siting, including marking the specific drilling locations in the community. Include site selection information in the collected and archived data to improve knowledge for future projects

[11] See Guidance Note Part I - *Functionality and failure*

[12] See Anscombe (2011) for an example short study that covers drilling quality

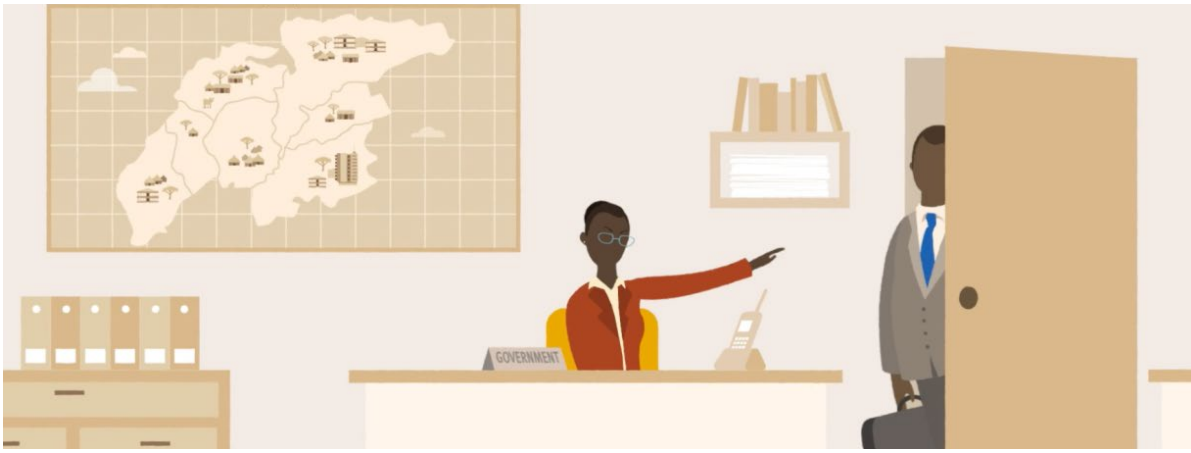
[13] See Guidance Note part 1 – *... and underlying*

Figure 8: GOOD BOREHOLE SITING IS ESSENTIAL FOR QUALITY BOREHOLES

SOURCE: RWSN, 2016b

- **Procurement** – improve procurement practices such as pre-qualifying drilling contractors to ensure that only competent companies can tender and brief-case companies are weeded out (Figure 8). Ensure that pre-qualification lists are put into the public domain, such as the newspaper or website.
- **Pricing** – ensure that the prices set out in a Bill of Quantities in drilling contracts have the right balance between 'per metre' rates for drilling and 'per hour' or 'lump sum' rates for cleaning and development, test pumping, sanitary seals and other completion tasks. If not, and the driller earns far more from drilling than the other equally important construction activities, then the latter will be skimped on or missed out altogether and the contractor move on as quickly as possible to the more lucrative drilling.
- **Contract management and supervision**:
  - Issue contract package/lots that are a realistic size given the capacity of competent drilling enterprises, even if they are only for a few boreholes.
  - Engage the services of competent drilling supervisors for full time, or at the least part time, or milestone supervision. Random spot checking is not sufficient. Link siting and supervision so that they are undertaken by the same professional.
  - Consider contracts that roll over from one lot or season to the next if drilling is consistently high quality at a realistic price.

Figure 9: PREVENT DRILLING CONTRACT AWARD TO BRIEFCASE COMPANIES



SOURCE: RWSN, 2016a

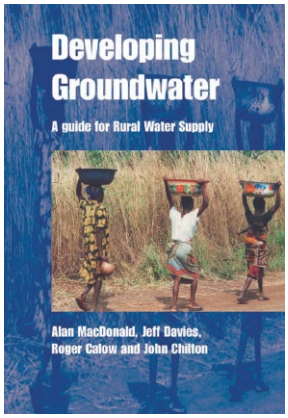


Figure 10: ONLINE RESOURCE – DEVELOPING GROUNDWATER

- **Risk and payment for dry boreholes:**
  - Recognise that even if the programme is not paying for dry boreholes directly, they are is being paid for indirectly (e.g. through elevated costs for successful boreholes).
  - Find ways to deal with the uncertainties of drilling in difficult hydrogeological environments so that the risks of drilling a dry borehole are not all passed on to the drilling contractor and actual costs are hidden. The RWSN (2010) Code of Practice (Annex B) provides a Model to Categorise Risk and Payment Structures.
- **Record-keeping** – strengthen procedures for record-keeping in national and local government, including clear guidelines for the compilation and use of borehole completion reports (this is linked to *Value Groundwater data and use groundwater information* above).
- **Capacity** – if the organisation managing the drilling process has technical weaknesses, or inadequate human resources, there is need to bring in staff, or hire qualified and professional consultants. If there are few firms or individuals in the country, there may be need to hire foreign expertise. However, this must be undertaken alongside efforts to train and mentor in-country professionals and thus raise capacity (this is dealt with in more detail under *capacity*).

Step 4

Support post-construction monitoring of user satisfaction and the water supply service by the programme and embed these into national monitoring processes. Make use of borehole cameras (Box 8) for spot checks on boreholes. Ensure that UNICEF and others receive information on functionality and cause of breakdown so that actions can be taken to remedy the situation by the appropriate authority. Ensure that infrastructure inventories link boreholes to financing modalities and implementing organisations. Information from monitoring, particularly in relation to borehole quality, should directly feed into *Step 1* above.

Note that monitoring should complement established systems for operation and maintenance and should be scheduled on a regular basis. In many countries, post-construction monitoring is the responsibility of the district or local government authority, but local governments often lack the financial and human resources for the monitoring and to carry out the required remedy. They need support by the state, central government or partners.

What have others done?

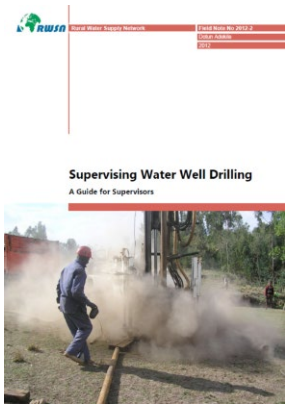


Figure 11: ONLINE RESOURCE – SUPERVISING DRILLING

In 2014, UNICEF Mali overhauled their drilling procurement and project management procedures, with an emphasis on easier contracts and extensive verbal communication to build understanding and trust with the contractors (UNICEF, 2015; RWSN 2015b; RWSN, 2015c).

Having struggled with low drilling success rates in Northern Ghana, UNICEF Ghana contracted the British Geological Survey (BGS) review groundwater development practices as well as gather hydrogeological data, provide a two-week training course and produce a preliminary groundwater map (O Dochartaigh et al, 2011b).

Box 7: **BOREHOLE DRILLING AND REHABILITATION PROJECTS: AVAILABLE RESOURCES**

1. Project assessment:
   a. Drilling and Rehabilitation Quick Quiz – Part 1 (Annex 1)
   b. Diagnosis of the reasons for borehole failure (Anscombe, 2011; Anscombe, 2012)
   c. Report of Assessment of groundwater development practices in Ghana (O Dochartaigh et al, 2011b)
   d. Methods to examine the likelihood and origin of corrosion: – The role of handpump corrosion in the contamination and failure of rural water supplies (Casey et al, 2016)
   e. UNICEF experiences in Water Well Drilling (Danert, 2009)

2. Developing Groundwater: A guide for rural water supply (MacDonald et al, 2005) is a user-friendly guide on groundwater development, bringing information on effective techniques for siting wells and boreholes, constructing boreholes and testing the yield of boreholes and wells (pumping tests) and monitoring groundwater quality.

3. Water Well Guidelines for use in Developing Countries (Schneider, 2014) provides requirements for basic groundwater protection, the health and safety and addresses basic water supply well construction, pumping equipment and maintenance issues. Water supply wells include wells designed for domestic, municipal, community, industrial, commercial, irrigation and/or livestock water supply use in addition to aquifer storage (injection) and recovery wells.

4. RWSN Guidelines:
   a. Code of Practice for Cost-effective Boreholes (RWSN, 2010)
   b. Siting of Drilled Water Wells. A Guide for Project Managers (Carter et al, 2010)
   c. Costing and Pricing – A Guide for Water Well Drilling Enterprises (Danert, Luutu et al, 2014)
   d. Procurement and Contract Management of Drilled Well Construction A Guide for Supervisors and Project Managers (Adekile, 2014a)
   e. Supervising Water Well Drilling. A guide for supervisors (Adekile, 2012b)

5. Studies on and tools to tackle corruption and improve integrity:
   a. Rural water supply corruption in Ethiopia (Calow et al, 2012).
   b. The Many Faces of Corruption: Tracking Vulnerabilities at the Sector Level (Campos and Pradhan)

6. Drilling Cost Studies and Models:
   a. Drilling costs in West Africa (ANTEA, 2007)
   b. Drilling costs in Kenya (Doyen, 2003)
   c. Borehole Costing Model (Heath et al, 2009; Heath, 2009)

7. Templates and sharing of experiences:
   a. Drilling Procurement and Contract Management Documents and Templates from UNICEF Mali (UNICEF, 2015)
   b. Borehole completion record/drill log templates see Annex E of Code of Practice for Cost-effective Boreholes (RWSN, 2010)
   c. Boreholes that last for a lifetime improving practices by UNICEF Mali (RWSN, 2015b)
   d. Who is going to drill the African boreholes (Robinson, 2006) provides insights into how to support private drilling enterprises

Capacity

Raise capacity though education, training and hands-on experience

Definition

Capacity is defined as the ability of a person or organisation or resource to perform work to a sufficient quantity and quality over an extended period of time.

The problem

Ensuring high-quality boreholes is often thwarted by a lack of capacity of individuals and organisations. Technical and management skills and experience in the country in the key aspects of borehole siting and construction are often lacking. Drilling equipment and the essential tools and knowledge for proper siting, supervision and diagnosis of borehole failure are often inadequate.

The solution

Raise skills and knowledge of borehole drilling and its management and encourage the availability of suitable equipment in the country.

There are not enough appropriately skilled water professionals to support the attainment of universal access to safe water and sanitation ... the developing world alone will need an additional 3.3 million professionals to achieve universal coverage of drinking water supply and sanitation services.

(IWA, 2016)

How to do it?

General recommendations

To ensure sufficient capacity to design, implement and monitor projects professionally, there is no substitute for structured, long-term programmes of education, training and mentoring of groundwater professionals. In the medium to long term, the topics of borehole siting, supervision, drilling, procurement and contract management, as well as groundwater resources management, need to be incorporated into the syllabus in reputable educational establishments in Africa. Institutions have to offer different levels of higher education from certificate level to masters, or MScs.

The linkages with government mean that UNICEF is in a very strong position to encourage and support long-term initiatives to improve the education, training and mentoring of groundwater professionals. While education and training are extremely important, for capacity to be raised, the new knowledge needs to be put into practice. Since UNICEF is funding, and in some cases managing, borehole drilling initiatives, it is in an excellent position to establish mechanisms within on-going projects to mentor future professionals. UNICEF has already demonstrated its ability to encourage the development of a professional manual drilling sector.

"We teach our young people to look after cows, and then we give them one – it's no good giving the training without the cow"

Senior Government officer, Uganda (Carter, 2015)

Specific actions

There is no simple step-by-step guide to raising capacity. The following specific actions should all be considered and UNICEF's support prioritised given the particular context, including major weaknesses and opportunities.

Action 1: Analysis of human capacity needs

A number of countries have already undertaken assessments of capacity needs, which include groundwater development (e.g. Box 10). Before embarking on such an assessment, it is important to determine what has already been undertaken as this may be sufficient. If no such analysis has been undertaken, or of the findings are dated, then a capacity needs assessment for groundwater development should be undertaken. When examining the human capacity of the private sector, business management expertise as well as technical know-how is essential.

Action 2: Opportunities for education, training and hands-on experience

Take steps to find out what education, training and mentoring opportunities for groundwater development already exist in the country or region and share this information with sector stakeholders. See how these can be built up and linked to national licencing or certification processes. Despite the enormous need, relatively little information has been consolidated about the courses available or their quality.

Action 3: Embedding education, training and mentoring in UNICEF Programmes

Explore how UNICEF-funded and UNICEF-managed borehole drilling programmes can enable capacity to be built by providing scholarships. Embed mentoring and opportunities for hands-on experience into on-going projects and specific programmes. Support other partners, including government and relevant associations, in doing the same. Ideally link education with hands-on experience, so that individuals have a complete package of professional development.

Action 4: Inspiring long-term capacity development through short courses

Short courses can be a very effective way to build on existing knowledge or to introduce new topics. Experience has shown that a good short course can trigger government to invest in longer-term capacity development.

UNICEF can support short courses by highly skilled and experienced trainers. Practical exercises, including role play, should be combined with lecturing and group discussions and conventional lectures.

Figure 12: **TRAINING FUTURE DRILLING SUPERVISORS & MANAGERS (SIERRA LEONE)**

SOURCE: KERSTIN DANERT

Although important, a short course in, say, supervision will not create a professional supervisor overnight. And so in cases where the trainees have little prior experience and lack opportunities for longer-term education, some form of mentoring by experienced professionals over several months, a year or more should be considered.

Action 5: Equipment

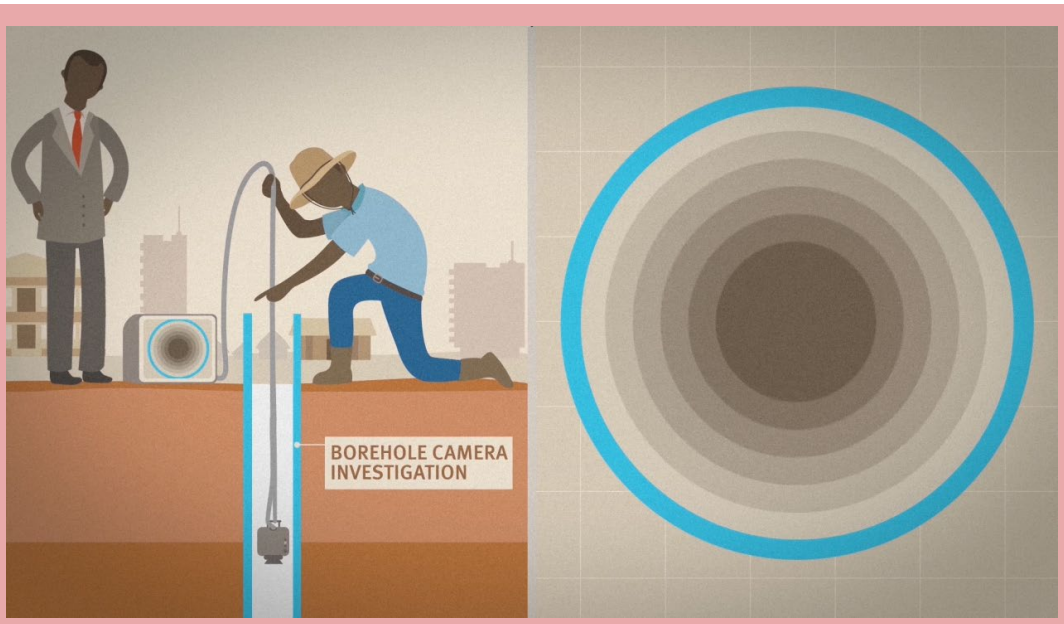
Decisions with respect to appropriate borehole designs and rigs/compressors for various hydrogeological conditions require high level capacity. Appropriate equipment for siting (Carter et al, 2010) and borehole investigation is essential. Box 8 explains more about a borehole camera. UNICEF can ensure that essential equipment is available in a country by including it in contract specifications. Mechanised drilling equipment, including compressors, is expensive, and in Africa, interest rates on bank loans tend to be really high. It is very difficult for the private sector to invest in drilling equipment and well trained staff if demand for services is low or if there is high uncertainty about future work (Robinson, 2006). Thus improving the equipment available in-country is linked to confidence in the reliability and growth of the market for boreholes, or specific initiatives. Box 9 provides a good example of private sector development.

Action 6: manual drilling

Manual drilling techniques are suitable for reaching shallow groundwater in fairly soft formations. The equipment can also reach remote areas that can be difficult to access with mechanised drilling equipment (Danert, 2015b). Building the capacity of private enterprises on manual drilling technologies, hydrogeology and business management takes at least 3-5 years. A nationally recognised certification process for the drillers is recommended.

Box 8:

A BOREHOLE CAMERA: ESSENTIAL EQUIPMENT FOR INVESTIGATION



A down-the-hole closed-circuit television (CCTV) camera (referred to as a borehole camera) is an essential piece of equipment for checking borehole construction and diagnosing the physical causes of borehole failure. It enables the inside of the borehole to be viewed on a monitor as the camera passes through the screen, joints and casing. Infiltration of fine materials through the screen, silting and blockages and broken casing can thus be seen.

Box 9: **WATERAID SUPPORT TO FATIGEN DRILLING (Adapted from Adekile, 2016)**

In the early 2000's, Water Aid Nigeria franchised drilling equipment to a driller called Sunday Arafan Mangai instead of operating it themselves or handing it over to the State Rural Water Supply Agency. The franchise was very successful. Water Aid achieved the desired number of boreholes, the rigs were well maintained and Sunday was able to drill private boreholes from which he saved money to buy his own equipment. The model was proposed at the RWSN forum in Accra in 2006 as the way forward for external support agencies and donors to promote borehole drilling by young entrepreneurs, instead of supplying equipment directly to state agencies.

However, it was soon realised that the success of the model was largely due to the honest and transparent manner with which Sunday operated. Sunday went on to found one of the most successful and professional drilling operations in West Africa, Fatigen Drilling Company, with operations in Nigeria, Liberia and Sierra Leone. With his death in early 2016, Africa lost one of her best drilling engineers.

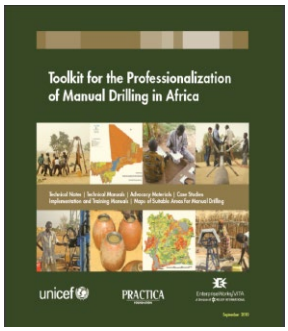


Figure 13: TOOLKIT FOR THE PROFESSIONALIZATION OF MANUAL DRILLING IN AFRICA

The Toolkit for the Professionalization of Manual Drilling (UNICEF et al, 2010) sets out steps for building capacity, i.e.:

a. Rural Water Supply Sector Assessment
b. Selection of Drilling Enterprises
c. Training of Drilling Enterprises
d. Training of Supporting Businesses
e. Certification of Drilling Enterprises

What have others done?

Studies of the drilling sector have been published for at least ten countries (Box 1 and Figure 14). Most include some analysis of national drilling and drilling management capacity in relation to need. Broader capacity needs assessments may also have included groundwater development.

The extent of relevant vocational training in Africa seems to be rather limited. Hydrogeology modules are included in some geology degree courses, and there are several institutions in Africa offering hydrogeology at MSc level.

The New Partnership for Africa's Development (NEPAD) has established a network of Water Centres of Excellence in West and Southern Africa. One of their specific goals is to strengthen national and regional capacities for water resources management.

The African Groundwater Network (AGN-Net) brings together over 300 groundwater professionals from all over Africa. With a capacity-building mandate, over the years, they have run a number of short courses on Groundwater Management and Development (AGW-Net, 2016).

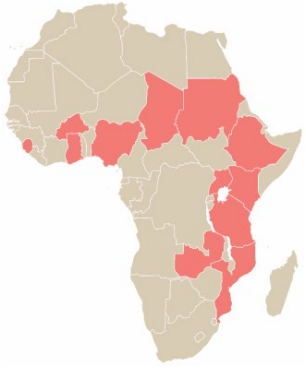


Figure 14: AFRICAN COUNTRIES WITH ASSESSMENTS OF THE BOREHOLE DRILLING SECTOR

UNICEF, UKAid, WaterAid and SDC have supported various short courses in Zambia, Sierra Leone, Uganda and South Sudan respectively. UNICEF's one-week short course on Procurement, Contract Management and the Costing and Pricing of Boreholes in Zambia brought 28 procurement officers, engineers, drillers, consultants and those working at national, province and district level together (Adekile and Danert, 2016). The course has galvanised government interest in establishing further training opportunities in the country.

Over the last decade, there have been considerable efforts to introduce and professionalise manual drilling in over 20 countries in Africa, as summarised in the RWSN Manual Drilling Compendium (Danert, 2015b).

Box 10: **GROUNDWATER DEVELOPMENT CAPACITY: AVAILABLE RESOURCES & LINKS**

1. Key books on groundwater development:
   a. Developing Groundwater: A guide for rural water supply (Macdonald et al, 2005) can be downloaded free from Practical Action.
   b. Water Wells and Boreholes (Misstear et al, 2006)
   c. Drilling for Water (Rowles, 1995) includes a standard procedure for costing the drilling element also is presented.

2. Generic capacity needs assessment tools
   a. Capacity Assessment Tool (UNDP, 2008a) and Users Guide (UNDP, 2008b)

3. Manuals and short-course training materials:
   a. The Integration of Groundwater Management into Transboundary Basin Organizations in Africa (AGW-Net, 2015)
   b. See RWSN Manuals (Box 6 – no 3)
   c. Basic Hydrogeology and Borehole Siting (Sierra Leone, 2014)
   d. Procurement and Contract Administration and the Costing and Pricing of Boreholes for
      i. Sierra Leone (Adekile and Thomas, 2013)
      ii. Zambia, (Adekile and Danert, 2016)
   e. Drilling Supervision (Sierra Leone, 2014)
   f. Financing Options for Low-Cost Water Well Drillers & Communities for Rural Water Supply (UNICEF et al, 2010)
   g. Understanding groundwater and wells in manual drilling (in English, French and Swahili) (UNICEF et al, 2010)
   h. Instruction Handbooks for manual drilling:
      – Augering
      – Jetting
      – Percussion
   i. Groundwater Management in IWRM (Cap-Net, 2010)

4. Information about equipment for siting:
   a. Siting of Drilled Water Wells. A Guide for Project Managers (Carter et al, 2010)
   b. Finding Groundwater (MacDonald et al, 2005)

5. Select associations, networks, training institutions focusing on groundwater:
   a. International Association of Hydrogeologists (IAH) – raising awareness of groundwater issues and working with national and international agencies
   b. Africa Groundwater Network (AGW-Net) – membership of over 300 groundwater professionals in Africa. AGW-Net has training materials and run courses.

c. RWSN's online communities provide a forum for asking questions, sharing experiences and learning directly from others (https://dgroups.org/rwsn). Relevant communities include:

   i. Sustainable Groundwater Development

   ii. Handpump services

   iii. Manual Drilling

d. NEPAD - Water Centres of Excellence – Water CoE

6. Agencies with considerable experience of providing technical support and training:

   a. British Geological Survey (BGS),

   b. Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) – German Federal Institute for Geosciences and Natural Resources,

   c. French Geological Survey (BGRM)

   d. UNESCO-IHE

Dialogue & awareness

Foster dialogue & raise awareness

Definition	Dialogue is the exchange of ideas or opinions between two or more people on a particular issue, with a view to reaching an amicable agreement or settlement. To foster dialogue is to encourage and support this exchange. Public awareness is the extent to which people are informed about a particular issue.
The problem	Groundwater development is a highly technical and expensive business and entails considerable risk if not done well. Good groundwater development requires specialist skills and knowledge. As countries move towards more complete rural water supply coverage, borehole construction will increasingly take place in areas with a high risk of failure, or which are hard to access. Differences of opinion, a sense of unjust practices or allegations of corruption can lead to tension, arguments and conflict. Unfortunately, the basics of groundwater development, including the particularities of the local context, are not always sufficiently understood by those who set policies or develop and manage borehole programmes. Likewise, members of the public and businesses that invest in their own boreholes often lack the knowhow to manage drilling contractors, enforce national standards, ensure supervision or understand the risks involved.
The solution	**Foster dialogue between government agencies (including regulators), drilling contractors, consultants, NGOs, development partners and civil society. Encourage and support efforts that raise awareness of decision-makers and the public about groundwater potential, management and its exploitation.**

How to do it?

General recommendations

Recognise the importance of building public confidence and ensuring inclusiveness of stakeholders (OECD, 2015). Be mindful of the fact that the uncertainty and risk associated with borehole drilling (where most of the work is hidden underground) can lead to misunderstandings and conflict (Box 11) Recognise that a basic understanding of groundwater and drilling is required by those who govern and take decisions (e.g. political leaders, lawmakers, and regulators).

Consider whether there are incentives to strive for professional groundwater development. Documents setting out standards and procedures are only as good as the culture of their implementation. Without adequate drive and determination at different levels, it is extremely difficult for positive change to take place.

Box 11: **FOUR DRILLING CONTENTIONS**

1. The client tries to squeeze the driller to work for a very low (and at times unrealistic) price. Or the driller takes on a job, knowing that the conditions are not ideal, and takes shortcuts on quality to limit financial losses.
2. Lack of willingness of the client to offer direct financial compensation for drilling dry boreholes in high risk areas. In cases where the client does not directly compensate for the costs of drilling dry boreholes, the contractor will try to recuperate these losses in other ways that ultimately result in costs, or lost investment for the client. The contractor may cover the high risk by increasing the price for successful boreholes, may compromise on construction quality or may pass off marginally-yielding boreholes as successful and therefore due for payment. In such cases, it is the client, and ultimately the water users, who finally bear the cost. However, the costs are borne indirectly and are thus not transparent
3. Experience of, or concerns about corruption in the procurement, contract award and contract management process for certain clients. In such cases, professional drillers inflate their prices, may not tender at all, or end up subcontracted by a "middleman" or briefcase company that takes a cut. In the latter case, oversight and supervision are likely to be lacking, with a potential knock-on effect on construction quality.
4. There is a role for low-cost drilling options (where feasible), particularly to access hydrogeologically-suitable areas where heavy drilling equipment cannot reach or where funding is particularly constrained. Some stakeholders are very sceptical about manual drilling, usually with concerns about construction quality, tapping groundwater that is not well-protected and associated contamination or poor water quality. On the other hand, organisations promoting manual drilling technologies tend to be convinced of their suitability, and are not always open to critique, or willing to invest in mechanisms to effectively regulate a mushrooming local private sector.

Figure 15: **GROUNDWATER AND BOREHOLES – PLENTY OF SCOPE FOR MISUNDERSTANDINGS**

SOURCE: RWSN, 2016a

Alas, when it comes to drilling, clients (including UNICEF), drilling contractors, consultants and government sometimes operate in a confrontational and antagonistic, rather than a cooperative manner. There may be a lack of trust, with each stakeholder trying to ensure that they get the best deal for themselves in a difficult and uncertain situation (Box 11). To ensure professionalism, there is need for cooperation, rather than antagonism. This requires mutual understanding and trust.

Step-by-step guide

Step 1: Regular dialogue

Ensure that regular meetings (e.g. quarterly) are held between government agencies (including regulators), drilling contractors, consultants, NGOs and development partners. These provide a platform for dialogue and reflection on opportunities, problems and to identify incentives for change and develop solutions for groundwater development. Attendance can be incentivised through formal means (such as establishing a national technical working group with mandatory representation), or more informally (e.g. through peer pressure to attend). High quality facilitation as well as the development of realistic plans and realisation of agreed actions such as training courses, or improving tender documents is essential for the dialogue to be meaningful and continue. Such dialogue should yield short-term as well as long-term benefits.

When undertaking training, such as in the courses suggested above[14], ensure that participants are not only from one stakeholder group, but rather from a mix, so that for example, government staff and drillers get to know each other, hear different perspectives and engage in dialogue.

Step 2: Include groundwater in on-going review processes

Provide mechanisms for stakeholders from different government departments or agencies to share their perspectives on drilling (e.g. procurement officers and water engineers; national and local government). If other gatherings take place, such as government or multi-stakeholder WASH coordination meetings, the subject of drilling could be incorporated into the agenda.

Step 3: Associations

Support initiatives by the machine drilling and manual drilling industry themselves, such as the formation and running of associations, training, national or regional meetings or self-regulation (e.g. Kenya and Nigeria). Find ways of bringing private sector drillers together, or encouraging them to do so, so that they can share their areas of common interest and ideas for improvement. Such exchange may trigger ideas for self-regulation or establishing a drillers association, for example.

Ensure that programme managers who are responsible for drilling activities get into the field to understand the realities of drilling and the perspectives of drilling contractors and hydrogeologists in particular.

Step 4: Exchange between countries

Enable drilling contractors, consultants and government staff from different countries to share their experiences and thus learn from each other through south-south or north-south exchange. This can be online, e.g. through discussion groups and social media, or face-to-face, e.g. through study tours or in international gatherings including dedicated networking and sharing events.

Step 5: Public awareness-raising

Public awareness-raising of the need for professional drilling construction, and how public support can help this to be realised. Use factual, accessible and clear information that can be easily understood by a wide audience. Bear in mind that information needs to be articulated and presented through credible and trusted channels. Local champions may discuss the implications of such information (which may be new).

[14] See Guidance note part II – 2. Raise capacity on pages 28

Radio, TV and newspapers provide ideal platforms for sharing information with the general public, and even enabling discussion, such as through phone-ins, or texting questions and opinions to live programmes or a regular column. Online media provide another channel, but participation may be more limited to a specific interest group and not reach the general public, unless it is undertaken through a specific campaign. Fliers and posters that explain the key tenets of groundwater and drilling for the particular national (or more local) context can also be used.

A well-illustrated code of practice (or code of conduct) in plain and simple language for the general population is not only useful, but important in demystifying this highly technical and specialised area. It should set out the key principles of good borehole design and construction.

Step 6: Advocacy

While there may be some reluctance to directly engage decision-makers, including political leaders in awareness-raising, it is important. The capacity of political leaders at both national and local level to understand natural resources management issues, including groundwater governance, varies considerably (UNESCO-IHP et al, 2015a). Groundwater databases are a case in point. Although they may exist, very few people (other than hydrogeologists) understand much about the importance of such data, and how it can be used to benefit the development of the country.

Advocate for efforts to actively inform political and opinion leaders and other decision-makers about professional drilling policies, standards and practices, and the implications of these not being adhered to or a lack of regulation. Seek out ways to enable key stakeholders to learn more about groundwater and drilling in an environment that is non-threatening and where there is no need to save face. What about supporting a "groundwater for executives" seminar (or whatever sounds more appealing), so that those with influence have the opportunity to ask simple (but important) questions? Or what about a groundwater role-playing game?

What have others done?

The improvements made to drilling procurement and contract management by UNICEF in Mali (UNICEF, 2015) included spending considerable time talking to and listening to the perspectives of private drilling contractors (RWSN 2015b and RWSN 2015g).

Figure 16: **COMMUNICATION BETWEEN THE CLIENT AND POTENTIAL DRILLING CONTRACTORS**

SOURCE: RWSN, 2016a

Development of the Principles for Borehole Drilling and Rehabilitation in Sierra Leone in 2013 and 2014 (funded by UKAid through the WASH Facility) involved the facilitation of dialogue between different stakeholder groups in workshops and training courses (Danert and Adekile, 2014).

UNICEF Chad has hosted delegations from Niger and Guinea to learn about the viability and applicability of manual drilling. UNICEF DRC and UNICEF CAR have both brought manual drilling expertise from Chad to build skills and raise understanding of both government and the private sector in the respective countries.

Box 12: **DIALOGUE AND AWARENESS: AVAILABLE RESOURCES & LINKS**

1. Four short animated films to trigger discussions between stakeholders developed jointly by UNICEF, WaterAid, Skat Foundation and the National Ground Water Association:
   - Siting – The importance of good borehole siting (RWSN, 2015a) explains that groundwater cannot be found everywhere. If properly located, a borehole can provide a good supply of water. If it is not, it will fail, resulting in wasted investment. Good borehole siting is essential. – French version.
   - Supervision - A borehole that lasts for a lifetime (RWSN, 2015b) explains the procedures needed to provide a good drilled water supply that can last for many years. – French version.
   - Procurement and contract management: Four steps to better drilling contracts (RWSN, 2016a) explains a procurement plan, a systematic contract award process, professional contract management and monitoring and reporting. – French version.
   - Construction quality: Why are some boreholes better than others? (RWSN, 2016b) explains the key tenets of borehole construction. – French version.
2. The Role of Stakeholder Participation and Communication in Groundwater Management – module 7 of *The Integration of Groundwater Management into Transboundary Basin Organizations in Africa* (AGW-Net, 2015).
3. Briefing Notes Series on Groundwater Management to provide reader-friendly information on groundwater management and protection (World Bank, 2016).
4. Radio for Rural Water Supplies – Webinar recording that provides inspiration and ideas for how to harness the power of radio (RWSN, 2015e).

Investment

Invest in professionalism

Definition	Investment is when time or money is put into something hoping that the returns will be greater than what was originally put in.
The problem	Lack of adequate investment to strengthen the institutional framework, make use of groundwater data, systematically improve borehole drilling, raise capacity, foster dialogue and raise awareness inhibits sustained improvements in water supplies and will ultimately undermine the achievement of the SDG target for drinking water. Insufficient investment of finance and human resources is preventing individuals from undertaking a professional job, and, in some cases from even gaining experience. Although investment is not the whole answer, of course, finance is essential to oil the wheels of professionalism, and time is needed for the vehicle of professionalism to move forwards.
The solution	**Invest adequate finance and time to improve and sustain professional groundwater development.**

How to do it?

An initial step is to acknowledge that there may be an underinvestment in the first place. Thus, recognise the following five critical points:

1. Current capital expenditure in many African countries is grossly inadequate to make sufficient progress to meet the SDG targets for drinking water (Box 13).
2. Lack of investment in water supply and sanitation has social and economic cost while public investment in water (and sanitation services) delivers results. Hutton (2012) estimates the benefit-cost ratio for enabling everyone to have access to water supply services in sub-Saharan Africa is 2.5, and the global economic return on water supply spending is US$2.0 for every dollar invested.[15] Botswana is a case in point where substantial public investments have been made, and delivered results (Llano-Arias & Renouf, 2016).
3. In order to ensure that water supply services last, investment is required for capital expenditure and other aspects including training, planning, policy making and regulation, operation and minor maintenance, major maintenance and the cost of borrowing money (Figure 17). Notably, investment in post-construction support and development of professional expertise is often inadequate.
4. Investment to raise drilling professionalism competes with other priorities whether within Water, Sanitation and Hygiene (WASH), or with other sectors. However, given Africa's dependency on groundwater, inadequate investment in professional drilling over a sustained period will mean that the SDG target for drinking water to be not be met.

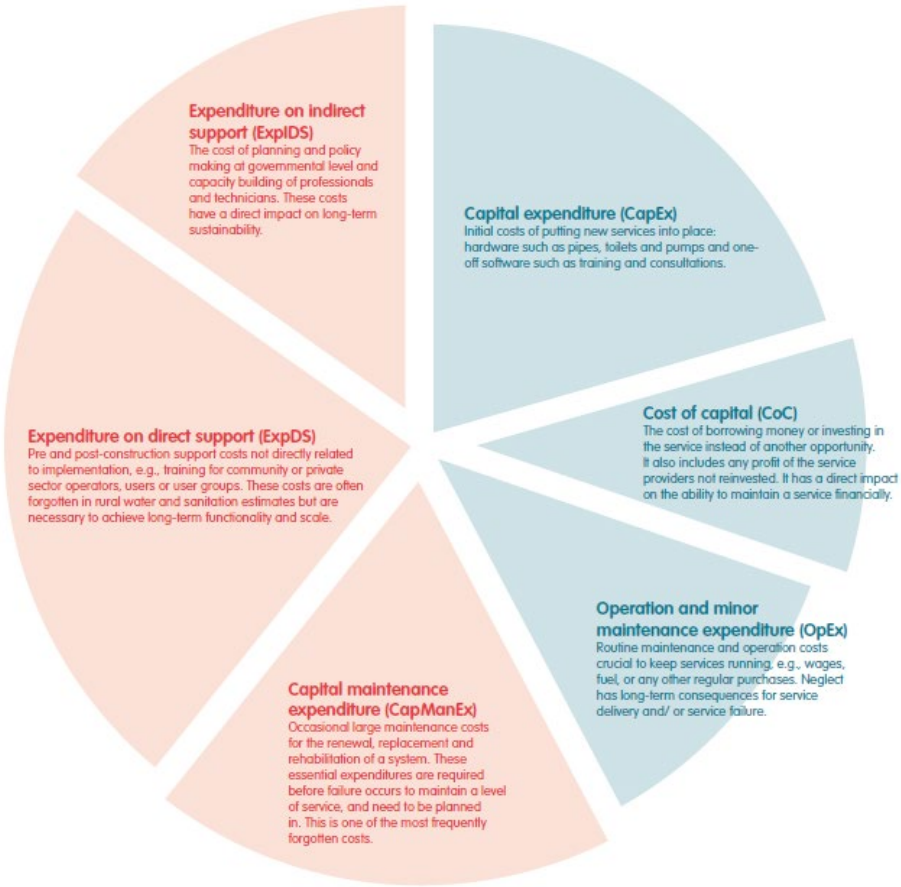
[15] Benefits from improved water supply and sanitation services include reductions in cases of and deaths from diarrhoeal disease and indirect adverse health impacts such as malnutrition, and time benefits resulting from the proximity of improved services. Economic benefits range from seeking less health care to reduced losses of productive time due to disease and to a reduction in premature mortality (Hutton, 2010).

5. The SDG targets for Water, Sanitation and Hygiene are unlikely to be met by depending on traditional bi- or multilateral aid. Although water users are investing in the construction of their own water supplies (Self-supply) much more investment is needed from tax revenues of developing country governments and from the private sector.

Box 13: MEETING THE SDG TARGETS FOR DRINKING WATER – INVESTMENT REQUIREMENTS

Hutton and Varughese (2015) estimate that the capital costs of meeting the SDG targets for Water, Sanitation and Hygiene in rural Africa are $15.8 billion per year for 15 years. Capital spending in sub-Saharan Africa has to increase considerably, with sub-Saharan Africa needing to spend 2% of its Gross Regional Product[16] to meet the targets. However, more than capital inflows will be required to ensure that capital investment translates into effective services.

Figure 17: COST CATEGORIES OF THE LIFE-CYCLE COST APPROACH (IRC, 2016)



In terms of action by UNICEF, and partners that are championing professional borehole drilling, this guidance note recommends the following:

- Determine whether the UNICEF country office and local offices have sufficient, trained and experienced staff to properly manage and oversee borehole drilling and rehabilitation efforts. Examine whether the staff members have sufficient time and the projects have adequate financial resources to actually do a professional job. Take action on the findings, which may necessitate discussions with the country representative, regional WASH representative, and also UNICEF headquarters.

[16] Gross Regional Product is the combined gross produce for the region.

- Invest time to determine the key strengths and weaknesses of UNICEF and other programmes in relation to borehole drilling. Discuss the findings, determine where more (or less) investments are required, take action where possible and advocate for change more widely.
- Find out how the guidance to raise professionalism set out in this guidance note relates to on-going policy reforms, institutional strengthening, regulation and efforts to improve monitoring and evaluation. Advocate for the incorporation of measures put forward in this guidance note.
- Last but not least, build up a team of champions to advocate for raising drilling professionalism, including leading by example.

What have others done?

Of the six areas of engagement set out in this guidance note, raising investment is the least documented. However, as awareness of the extent of the problem grows, and efforts are taken, more can be shared. Box 14 sets out a limited number of resources and links that help in raising investment in water supply services, including in drilling professionalism.

Box 14: INVEST IN PROFESSIONALISM: AVAILABLE RESOURCES & LINKS

1. The WHO publication, Global costs and benefits of drinking-water supply and sanitation interventions to reach the MDG target and universal coverage (Hutton, 2012), provides information to help to justify governments and donors of low- and middle-income countries to allocate adequate budget for water supply and sanitation services.

2. Public Finance for WASH (2016a) provides information and supporting arguments for domestic public finance for water and sanitation including:
   - Subsidising water in Botswana: Is it sustainable? (Llano-Arias & Renouf, 2016) examines how Botswana financed 96% of the country's population to have access to an improved drinking water source by 2015.
   - Domestic Resource Mobilisation in Uganda (Renouf & Norman, 2016) examines efforts underway to increase domestic resource mobilisation potentially unlocking new sources of revenue that could be channelled into improving WASH services.

3. Water as a human right as a catalyst for investment
   - Water and sanitation services as human rights (Neumeyer et al, 2016) is a set of materials intended for use by organisations and staff who work closely with local government officials and who want to foster a practical approach to integrating the human rights to water and sanitation into everyday work. This includes encouraging more and better targeted investment. The materials[17] take a pragmatic approach to the concept of human rights and have been developed from the perspective of local government officials.
   - The Manual of the Human Rights to Safe Drinking Water and Sanitation for Practitioners (IWA, 2016) presents options to systematically address the human rights principles and criteria, focusing on the implications of the new human rights obligations for laws, regulations, operations, management and investment.

[17] The materials were jointly developed by WASH United, WaterAid, UNICEF, Institute for Sustainable Futures | University of Technology Sydney, End Water Poverty and RWSN.

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Annexes

Annex 1: Drilling quick quiz

This quick quiz enables project managers and field staff to undertake a rapid assessment of drilling professionalism in their projects/programmes and to identify the main strengths and weaknesses, as well as to consider the wider drilling context. The quiz is divided into two parts – PART 1 comprises questions that relate to the way that UNICEF supports drilling programmes/projects, while PART 2 has questions about the wider drilling context in the country. The responses can be used to develop a visual traffic-light oversight of good (green), medium (orange) and poor (red) practices in the country. The quiz questions, together with the probing questions for further discussion, provide the basis for developing an assessment of drilling sector professionalism. Such an assessment could act as a basis for future work planning.

The quick quiz Part 1 and 2 is available for download as an excel file from the UNICEF Website.

Quiz Part 1: Professionalism of UNICEF Programmes and Projects

Question zero and 1 provide context. The subsequent questions (2 to 10) ask about perceptions of various aspects of the professionalism of UNICEF supported drilling programmes and projects. The responses can be used to provide a traffic-light visual oversight i.e.

- always = green;
- sometimes = orange;
- never = red;
- don't know = grey

It should be noted that in cases where other agencies, such as government, procure and manage the drilling contract (funded by UNICEF), quiz part 2 also needs to be used.

Quiz Part 2: National Drilling Sector

All questions are to be answered with yes, no, or don't know. In countries with a federal political system, it may be more appropriate to undertake the quiz at state level. The responses can be used to provide a traffic-light visual oversight i.e.

- yes = green;
- no = red;
- don't know = grey

Quiz Part 1: Professionalism of UNICEF programmes and projects – response sheet

Name: _____ Position: _____

Country: _____ Duration of Work in WASH in Country: _____

Date: _____

Please note that the quiz should be filled in for one country only – the country in which you are currently working.

No	Subject/Question	Response					
0.	**Engagement in Drilling**						
0.1	**Type of engagement:** How is UNICEF engaged in borehole drilling or rehabilitation?	None	Funding government programmes	Financing NGOs (PCA)	Contracting out directly	Using UNICEF-owned equipment	If other, please explain:
0.2	**Context:** Is UNICEF's support to drilling or rehabilitation undertaken in the context of emergency or development projects or programmes?	Emergency	Development	Both	If other, please explain		
0.3	**Technology:** What type of drilling technology is UNICEF supporting?	Mechanised	Manual	Both	If other, please explain		
1.	**Scale**						
1.1	How many boreholes did UNICEF support the construction, or rehabilitation of in the last reporting period (note the reporting period)?	_____constructed (between _____ & _____) _____rehabilitated (between _____ & _____)					
2.	**Siting**						
2.1	Is siting of the boreholes undertaken by the drilling contractor, by an independent consultant or by a member of staff?	Government	Consultant	UNICEF	Contractor	Don't know	
2.2	Is siting undertaken by a qualified and experienced hydrogeologist or retrained engineer?	Always	Sometimes	Never	Don't know		
2.3	Does the siting process make use of available hydrogeological data, including past drilling logs and information such as hydrogeological maps & reports?	Always	Sometimes	Never	Don't know		
2.4	In the case of manual drilling, is UNICEF making use of maps & reports to show suitable areas for manual drilling?	Yes	No	No maps	Don't know		

No	Subject/Question	Response			
3.	**Community and Committee Preparation**				
3.1	Do the community (as a whole) receive information regarding the siting and construction process, and what is expected of them?	Always	Sometimes	Never	Don't know
3.2.	Is a water user committee (or equivalent) put in place and trained?	Always	Sometimes, or partially	Never	Don't know
4.	**Procurement by UNICEF (if undertaken)[18]**				
4.1	Do the tender documents specify the locations and specific sites of the boreholes to be drilled?	Always	Sometimes	Never	Don't know
4.2	Does UNICEF undertake a process to pre-qualify competent contractors?	Always	Sometimes	Never	Don't know
4.3	Are drilling contracts awarded to experienced & qualified drilling contractors?	Always	Sometimes	Never	Don't know
4.4	Is there any oversight of the procurement of pump materials?	Always	Sometimes	Never	Don't know
5.	**Design & Construction (of boreholes contracted by UNICEF or NGOs in a PCA)**				
5.1	Is the borehole design specified in the drilling contract?	Always	Sometimes	Never	Don't know
5.2	Is the borehole design modified during drilling in light of field realities & hydrogeology?	Always	Sometimes	Never	Don't know
5.3	Are corrosion-resistant pumps installed when the pH of the water is <6.5?	Always	Sometimes	Never	Don't know
6.	**Supervision (of boreholes contracted by UNICEF or NGOs in a PCA)**				
6.1	Is there independent supervision of borehole construction & completion?	Always	Sometimes	Never	Don't know
6.2	Are the supervisors qualified and experienced hydrogeologists?	Always	Sometimes	Never	Don't know
7.	**Contract Management & Payment (of boreholes contracted by UNICEF or NGOs in a PCA)**				
7.1	Are drillers paid according to a bill of quantities, i.e. paid for the metres that they drill and the materials that they install?	Always	Sometimes	Never	Don't know
7.2	Are drillers paid for dry holes?	Always	Sometimes	Never	Don't know
7.3	Are consultants (that have sited the boreholes) paid for dry holes?	Always	Sometimes	Never	Don't know

[18] It should be noted that in cases where other agencies, such as government procure and manage the drilling contract (funded by UNICEF), quiz part 2 also needs to be used.

No	Subject/Question	Response			
8.	**Data (of boreholes contracted by UNICEF or NGOs in a PCA)**				
8.1	In the case of successful boreholes, does UNICEF obtain drilling logs from the contractor?	Always	Sometimes	Never	Don't know
8.2	In the case of unsuccessful boreholes, does UNICEF obtain drilling logs from the contractor?	Always	Sometimes	Never	Don't know
8.3	In the case of successful boreholes, does UNICEF obtain test pumping records from the contractor?	Always	Sometimes	Never	Don't know
8.4	In the case of successful boreholes, does UNICEF obtain water quality testing results from the contractor?	Always	Sometimes	Never	Don't know
9.	**Groundwater Database and Record Keeping**				
9.1	Is there an agency/department that collects drilling records?	Always	Sometimes	Never	Don't know
9.2	If so, does UNICEF ensure that the data from your supported projects is submitted?	Always	Sometimes	Never	Don't know
9.3	Is post-construction monitoring being carried out?	Always	Sometimes	Never	Don't know
10.	**Rehabilitation**				
10.1	Does UNICEF have a process for diagnosing the reason for the broken down borehole and suitable rehabilitation?	Yes	No	Don't Know	

The following probing questions can be used to guide further discussion from part I and could form the basis of a more detailed assessment of the professionalism of drilling programmes.

- **Scale** – Has the number of boreholes constructed/rehabilitated within the UNICEF programme gone up or down since last year? Do you think that your project/programme have enough staff and flexibility of funding to assure quality?
- **Siting** – Who undertakes siting and what process is followed? Does it involve a desk study? Does the consultant/member of staff visit the communities to site the boreholes? Are there sufficient qualified and experienced hydrogeologists in the country? Reflect on the recommendations in RWSN Siting Film.
- **Community and Committee Preparation** – What are the consequences of not preparing communities? If there are problems in preparing communities, what are they, and how can they be solved?
- **Procurement by UNICEF (if undertaken)** – If there are problems with the procurement process, what are they? How could these problems be addressed? If the procurement process is particularly strong, what lessons and advice so you have for other programmes?
- **Design & Construction (of boreholes contracted by UNICEF or NGOs in a PCA)** – If specifications are lacking, or cannot be adjusted, why is this the case? Has this caused any problems to date in terms of borehole quality or lifespan? If corrosion-resistant pumps are not being installed, why? If they are, what pumps are being used, and is there any advice that you can give to other programmes?

- **Supervision (of boreholes contracted by UNICEF or NGOs in a PCA)** – If there is no independent supervision, why not? If there is, is it full-time, or part-time, and why? For the latter, what milestones are supervised?
- **Contract Management & Payment (of boreholes contracted by UNICEF or NGOs in a PCA)** – If drillers are not paid for dry boreholes, why not? What effect do you think that this is having on the drilling industry and your programme? If they are paid, why and what effect do you think that this is having on the drilling industry and your programme?
- **Data (of boreholes contracted by UNICEF or NGOs in a PCA)** – If there are no drilling logs, why is this the case? Do you think that drilling logs, test pumping and water quality data are important? If so, was this always the case, and is there any advice that you can give to other programmes?
- **Groundwater Database and Record Keeping** – Do you see any value in groundwater data? If so, what is it? If not, why not? If UNICEF undertakes post-construction monitoring, how have the results changed the way that the programme is run?
- **Rehabilitation** – If there is not an explicit process for diagnosis, do you think that it would be useful to undertake do this, and what would it entail?

Quiz Part 2: National drilling sector – response sheet

Name: _____ Position: _____

Organisation: _____ Duration of Work in the Organisation: _____

Country: _____ Date: _____

No	Subject/Question	Response			Probing questions for further discussion or assessment
1	Do you know the estimated number of people or proportion of the population that use a borehole fitted with a pump as their main source of drinking water?	Yes		No	The data can be found in the JMP country files (http://www.wssinfo.org/). The changes in borehole use over time indicate the growth (or decline) of the importance of this technology.
2	Has government published national guidelines or standards for borehole drilling and rehabilitation?	Yes	No	Don't Know	If no, do you think that UNICEF should be doing something to address this issue, and if so, what is it? Does the country programme have the means and capacity?
3	Does government generally award drilling contracts awarded to experienced & qualified drilling contractors?				
4	Does government ensure that independent supervision of the borehole construction & completion takes place?	Always	Sometimes	Never	
5	Are drillers paid according to a bill of quantities, i.e. paid for the metres that they drill and the materials that they install?	Always	Sometimes	Never	
6	Is there a national drillers association?	Yes	No	Don't Know	If yes, is the association active? What does it do, or what is it trying to do? How could it be supported? Are there local associations? If no, is there need for an association?
7	Is there any regulation of drillers in terms of licencing?	Yes	No	Don't Know	What are the regulations? Are they widely known about? Are they enforced?
8	Is there any regulation of water users in terms of land permits?	Yes	No	Don't Know	What are the regulations? Are they widely known about? Are they enforced?
9	Do you have confidence that there are sufficient skills, knowledge and experience of siting, supervision or drilling professionals in the country?	Yes	No	Don't Know	If no, do you think that UNICEF should be doing something to address this issue, and if so, what is it? Does the UNICEF country programme have the means and capacity?
10	Are there any initiatives taking place in the country to raise the skills, knowledge and experience of siting, supervision or drilling professionals?	Yes	No	Don't Know	If yes, what are they, and are they one-off, or regular? If no, how could these be initiated and kept going?

No	Subject/Question	Response			Probing questions for further discussion or assessment
11	Is there a national groundwater database?	Yes	No	Don't Know	If yes, is drilling data submitted from all projects? What data is stored? Is the data reliable and can it be accessed to support siting and drilling activities?
12	Are there areas with particularly challenging groundwater for development, e.g. high risk of dry hole, salinity, iron/manganese, low pH) or groundwater hotspots, e.g. concern about falling water tables or pollution?	Yes	No	Don't Know	Where are they? What are the problems? How are the water needs and rights of people living in these areas addressed?

Annex 2: Links to Manual Drilling Toolkit and Code of Practice

The two tables below summarise the linkages between the earlier guidance published by UNICEF and RWSN.

Manual Drilling Toolkit Aspect, Step and Gap		Guidance Note
Aspect	The toolkit emphasises building the capacity of private enterprises over a period of 3 to 5 years on manual drilling technology, hydrogeology and business management.	**CAPACITY**
	A nationally recognised certification process for the drillers is recommended. Training of "supporting businesses" for the actual drilling, i.e. quality control firms, drilling tool makers, social mobilisation firms and pump installers.	**INSTITUTIONAL FRAMEWORK** **CAPACITY**
	Tailor to the needs and means of different country programmes based on a specific assessment.	**All AREAS and general advice**
	Recommended implementation approaches are given for three different scenarios (i.e. no local manual drilling capacity, local manual drilling capacity and local manual drilling capacity with self-supply).	***This level of detail is beyond the scope of the guidance note.***
	Alongside the toolkit, work has been undertaken to map the potential for manual drilling in 12 African countries. The mapping reports comprise colour-coded national scale maps and a description of the manual drilling potential.	**GROUNDWATER INFORMATION**
	Manuals and teaching materials on manual drilling methods, finance and business practices.	**CAPACITY**
	The toolkit makes it very clear that professionalising manual drilling is not just a one-off training activity by external agents, but rather a multi-year process.	***Emphasised in Guidance Note***
Step	The toolkit, recommends five steps to be followed:	
	■ Rural Water Supply Sector Assessment	**All AREAS**
	■ Selection of Drilling Enterprises	**DESIGN & IMPLEMENTATION** **INSTITUTIONAL FRAMEWORK**
	■ Training of Drilling Enterprises	**CAPACITY**
	■ Training of Supporting Businesses	**CAPACITY**
	■ Certification of Drilling Enterprises	**CAPACITY**
Gap	No guidance on roles and responsibilities of local and national government.	**INSTITUTIONAL FRAMEWORK**
	Guidance for regulatory mechanisms is limited.	**INSTITUTIONAL FRAMEWORK**
	Little reference to good drilling practices from mechanised drilling, such as ensuring verticality, borehole development and test pumping and maintaining drill logs.	**DESIGN & IMPLEMENTATION**

Code of Practice Principle		Guidance Note
1.	Professional Drilling Enterprises and Consultants – Construction of drilled water wells and supervision is undertaken by professional and competent organisations which adhere to national standards and are regulated by the public sector.	Project design & implementation Capacity Institutional framework
2.	Siting – Appropriate siting practices are utilised and competently and scientifically carried out.	Project design & implementation Capacity
3.	Construction Method – The construction method chosen for the borehole is the most economical, considering the design and available techniques in-country. Drilling technology needs to match the borehole design.	Project design & implementation Capacity
4.	Procurement – Procurement procedures ensure that contracts are awarded to experienced and qualified consultants and drilling contractors.	Project design & implementation Capacity Institutional framework
5.	Design and Construction – The borehole design is cost-effective, designed to last for a lifespan of 20 to 50 years, and based on the minimum specification to provide a borehole which is fit for its intended purpose.	Project design & implementation Capacity
6.	Contract Management, Supervision and Payment – Adequate arrangements are in place to ensure proper contract management, supervision and timely payment of the drilling contractor.	Project design & implementation Capacity Institutional framework
7.	Data and Information – High quality hydrogeological and borehole construction data for each well is collected in a standard format and submitted to the relevant Government authority.	Groundwater Information
8.	Database and Record Keeping – Storage of hydrogeological data is undertaken by a central Government institution with records updated and information made freely available and used in preparing subsequent drilling specifications.	Groundwater Information
9.	Monitoring – Regular visits to water users with completed boreholes are made to monitor functionality in the medium as well as the long term with the findings published.	Monitoring, documentation & sharing

Annex 3: Implications of poor groundwater development practices

	Good Practice	Poor Practice	Implications of Poor Practice
Siting	At least 30 metres from contamination source. Use of scientific reconnaissance techniques and historical information on drilling in the area concerned. Good chemical and groundwater quality. Area with sufficient groundwater recharge.	Close to latrine, septic tank or soakaway Tapping water of unacceptable quality (e.g. levels of fluoride, arsenic, nitrates). Area with insufficient recharge.	Borehole contamination, aquifer contamination & risk of cholera. Water not fit for human consumption and damage to health. Low yield hole that is abandoned.
Depth	Deep enough for sufficient yield. Vertically drilled.	Drilled too shallow. Borehole not sufficiently vertical.	Water supply dries up in the dry season or when there is drought. Difficult or impossible to install pumps with a rigid rising main.
Casing	Grade 3 uPVC pipe	Waste disposal pipes. Corrosion-prone materials.	Borehole collapse & slots cannot be properly cut. Water not fit for human consumption.
Screen	Factory slotted screen with correct slot sizes, and geotextile sock in very fine materials. Screen length to match aquifer thickness.	Large slots cut on site, and no geotextile sock in very fine materials. Screen too short.	Slots too big, so fine material enters and clogs borehole. Low pumping rates or cannot pump continuously.
Gravel Pack[19]	Sieved and washed sand of appropriate particle size.	Unwashed, un-sieved river or beach sand or crushed stones as gravel pack. No gravel pack.	It takes long to develop the borehole. Fine materials or sand flows into well; turbid water and borehole silts up.
Sanitary Seal[19]	Cement grout to 5 or 6 metres below ground level	No grout, or less than 5 metres of grout	Inflow of surface water, borehole contamination; aquifer contamination & risk of cholera.
Borehole Development[19]	Develop until water is clear and sand free.	None or inadequate development	Turbid water, sandy water, reduced pump life.

[19] See glossary on page viii for definitions.