



MINISTRY OF WATER & ENVIRONMENT

**WATER SUPPLY AND SANITATION
PROGRAMME**

MANUAL FOR DRILLING SUPERVISION

January 2019



REPUBLIC OF UGANDA MINISTRY OF WATER & ENVIRONMENT

In cooperation with



AFRICAN DEVELOPMENT
BANK GROUP

Project ID No. P-UG-E00-012

MANUAL FOR BOREHOLE CONSTRUCTION AND SUPERVISION

January 2019

LIST OF ACRONYMS

| | |
|--------|--|
| CBO | Community Based Organisation |
| DD | Drawdown |
| ID | Installation Depth |
| DWL | Dynamic Water Level |
| DTH | Down The hole Hammer |
| MWE | Ministry of Water and Environment |
| NGO | Non-Governmental Organisation |
| PVC | Poly Vinyl Chloride |
| RWD | Rural Water Department |
| UNICEF | United Nations International Children Educational Fund |
| WASH | Water Sanitation and Hygiene |
| WES | Water Environment and Sanitation |

TABLE OF CONTENTS

| | |
|--|------------|
| LIST OF ACRONYMS | II |
| TABLE OF CONTENTS | III |
| 1.0 INTRODUCTION | 1 |
| 2.0 GROUNDWATER AND THE HYDROLOGICAL CYCLE | 2 |
| 2.1 THE HYDROLOGICAL CYCLE..... | 2 |
| 2.2 GROUNDWATER OCCURRENCE..... | 3 |
| 2.2.1 <i>Groundwater Movement</i> | 4 |
| 2.2.2 <i>Flow towards a Borehole</i> | 4 |
| 2.3 IDENTIFYING A DRILLING POINT (BOREHOLE SITING) | 5 |
| 2.3.1 <i>Indicators of Groundwater Presence</i> | 6 |
| 3.1 MUD ROTARY DRILLING | 7 |
| 3.2 AIR ROTARY DRILLING | 8 |
| 3.3 AIR PERCUSSION DRILLING..... | 9 |
| 3.4 'CABLE TOOL' PERCUSSION DRILLING..... | 10 |
| 3.5 PLANNING DRILLING OPERATIONS | 10 |
| 4.0 DRILLING SUPERVISION | 12 |
| 4.1 RESPONSIBILITIES OF THE SUPERVISOR | 12 |
| 4.2 SUPERVISION EQUIPMENT/ REQUIREMENTS AND OUTPUTS..... | 14 |
| 4.3 DUTIES AND RESPONSIBILITIES OF THE SUPERVISOR | 16 |
| 4.4 SUPERVISORS RECORDS | 21 |
| 4.4.1 <i>Supervisors Daily Records.</i> | 21 |
| 4.4.2 <i>Supervisors Technical Records</i> | 22 |
| 4.4.3 <i>Supervisors Site Record</i> | 22 |
| 5.0 CONTRACT PRE-COMMENCEMENT CHECKS | 24 |
| 5.1 ACCESSIBILITY | 24 |
| 5.2 SITE INSPECTION | 24 |
| 5.3 EQUIPMENT AND MATERIALS INSPECTION | 25 |
| 5.4 STAFF INSPECTION AND FAMILIARISATION..... | 25 |
| 6.0 DRILLING SUPERVISION | 27 |
| 6.1 BORE HOLE DESIGNS..... | 27 |
| 6.1.1 <i>Borehole Design – A</i> | 27 |
| 6.1.2 <i>Borehole Design – B</i> | 27 |
| 6.2 INITIAL INSTRUCTIONS AT THE BEGINNING OF A HOLE | 29 |
| 6.3 INSTRUCTIONS DURING DRILLING..... | 29 |
| 6.4 OPERATIONAL GUIDELINES DURING DRILLING | 30 |
| 6.4.1 <i>Formation Sampling</i> | 31 |
| 6.4.2 <i>PVC Plain Casings (5" Diameter or 6" or 8" Diameter for Production Wells)</i> | 31 |
| 6.4.3 <i>PVC Screens (5" Diameter or 6" or 8" Diameter for Production Wells)</i> | 31 |
| 6.4.4 <i>Cement Grouting</i> | 32 |
| 6.4.5 <i>Gravel Packing</i> | 32 |
| 6.4.7 <i>Well Development</i> | 33 |

| | | |
|------------|---|-----------|
| 6.5 | INSTRUCTIONS AT THE END OF DRILLING----- | 34 |
| 6.5.1 | <i>Sealing the Borehole</i> ----- | 34 |
| 6.5.2 | <i>Capping the Borehole</i> ----- | 34 |
| 6.5.3 | <i>Clearing the Drilling Site</i> ----- | 34 |
| 7.0 | TEST PUMPING SUPERVISION ----- | 35 |
| 7.1 | INSTRUCTION AT THE BEGINNING OF TEST PUMPING ----- | 35 |
| 7.2 | INSTRUCTIONS DURING TESTING OPERATIONS----- | 36 |
| 7.3 | INSTRUCTIONS ON COMPLETION OF TESTING OPERATIONS----- | 36 |
| 8.0 | INSTRUCTION DURING PLATFORM CASTING AND BOREHOLE INSTALLATION----- | 38 |
| 8.1 | INSTRUCTION BEFORE THE PLATFORM CASTING OPERATION ----- | 38 |
| 8.2 | INSTRUCTIONS DURING PLATFORM CASTING OPERATIONS----- | 38 |
| 8.3 | INSTRUCTIONS ON COMPLETION OF PLATFORM CASTING AND HAND PUMP INSTALLATION----- | 39 |
| 9.0 | A PRACTICAL GUIDE TO CONTRACT MANAGEMENT----- | 40 |
| 9.1 | INTRODUCTION ----- | 40 |
| 9.2 | THE ROLE OF CONTRACTOR, SUPERVISOR/CONSULTANT AND EMPLOYER OR CLIENT | 41 |
| 9.3 | COMMENTS ON IMPORTANT CONTRACT CLAUSES----- | 42 |
| | ATTACHMENTS (STANDARD DATA SHEETS) ----- | 45 |

1.0 INTRODUCTION

There is currently a big drive to meet the Sustainable Development Goals target for drinking water. The world is talking about universal access to safe and affordable drinking water for all by 2030. Whilst this is positive, it is important that quality is not compromised in an effort to serve more people. A poorly constructed borehole can fail after one year, resulting in wasted investment and disappointed users. If drilling and construction of water wells are not adequately supervised by trained professionals, quality will be compromised and services won't last for its timeframe. Governments, NGOs and agencies have a responsibility to ensure that quality is not compromised by a lack of construction supervision.

In Uganda, groundwater sources, namely shallow wells and boreholes, are often the first choice of water source for supplying rural areas. Groundwater sources are found in most places in the country and are relatively easy and cheap to install. These water sources are developed based on the demand of the service and the potential of a given location to yield sustainable amounts.

Though this has been the practice for a long time, lately, there are several challenges that are arising in terms of quality of service delivered. One of the best ways to tackle this problem is to improve the quality and professionalism of water well drilling including supervision.

These guidelines have been produced as a practical guide for the different stakeholders in the water sector, including drilling contractors, supervisors and all stakeholders involved in exploitation of groundwater using boreholes.

It is envisaged that the guidelines will be used by staff or consultants, NGOs and CBO involved in groundwater development in the water sector. As well as constituting a supervisor's manual, the guidelines also outline some general aspects of borehole drilling, development, test pumping, and provides a summary of the broad principles of contract management. Details of technical specifications for borehole drilling and test pumping are prepared in different manuals.

2.0 GROUNDWATER AND THE HYDROLOGICAL CYCLE

Groundwater refers to sub-surface water that occurs beneath the water table in soils and geological formations that are fully saturated. Examples of such geological formations include;

- Gravel;
- Sand;
- Sandstone;
- Weathered rocks (*granite, gneiss, schist etc*) and
- Fractured rocks (*granites, gneisses, schist etc*).

2.1 THE HYDROLOGICAL CYCLE

The term 'Hydrological Cycle' refers to the continuous circulation of water between oceans, rivers, lakes, the atmosphere and the land surface. The main components of this cycle are:-

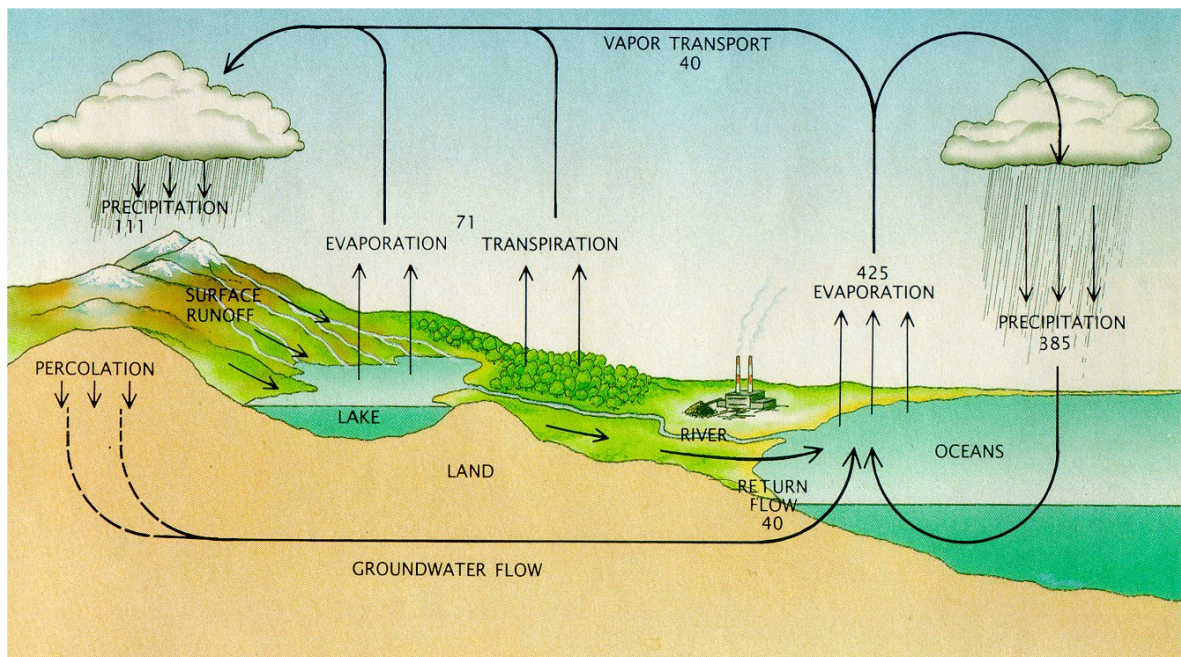
- Rainfall,
- Runoff (*to the rivers, lakes and oceans*),,
- Infiltration (*to the groundwater body*),
- Evaporation and Evapotranspiration and
- Discharge (*from groundwater through springs*).

These components are illustrated in Figure 1 below.

The surface component of the Hydrological Cycle is called **Runoff**, in which some of the rainfall concentrates to form rivers and streams which flow to lakes and oceans.

Some of the rainfall also percolates into the ground to form **shallow aquifers** which may be tapped by shallow wells and which may discharge as **springs**. Some of this shallow groundwater may also infiltrate further down into fractures in the underlying rock, which moves as base flow in the fractures. This deeper groundwater may then provide water to boreholes that draw water from the fractures. At both the shallow and the deeper levels groundwater flows laterally, generally following the topographic slope, towards the surface water bodies which form the groundwater base level and which (*often*) constitute areas of **groundwater Discharge**. These surface water bodies, as well as areas where the groundwater is very close to the surface, are where direct evaporation

and/or **Evapotranspiration** occurs, and from where water is returned to the atmosphere as water vapour.



- O** => Overflow (*Surface streams*)
- I** => Interflow (*for springs & S/Wells*)
- B** => Base flow (*Ground Water for deep boreholes*)

Figure 1: The Hydrological Cycle

2.2 GROUNDWATER OCCURRENCE

Where groundwater occurs in unconsolidated material (*soils; overburden*) or in consolidated but porous geological formations (*e.g sandstone*) it exists in spaces between the solid particle matrix. Particles that are large (*like those of sand*) also have large spaces (*pores*) between them, and thus will allow water to move through them more easily, whereas formations with fine particles (*like clay*) will have small pore spaces and will not allow water to move through them easily. The saturated soils, sand and weathered rocks (*collectively termed 'overburden'*) frequently constitute shallow aquifers, which will yield water to shallow dug or drilled wells.

In the case of massive consolidated rocks such as granite, gneiss, quartzite etc., (*collectively termed bedrock*), there are no pore spaces and water does not penetrate the rock mass at all. Groundwater can only infiltrate into and exist in

such rocks in fractures, joints and fissures. Any aquifers in these formations are termed 'fracture aquifers'. Such fracture aquifers are usually relatively deep (30–100 metres, or more, below surface) and are usually of limited dimensions and may or may not be interconnected with other similar aquifers.

Fracture (bedrock) aquifers will most often provide relatively higher yields to deeper drilled boreholes than shallow (overburden) wells, since fractures allow easier and more rapid groundwater flow than pore spaces in overburden materials.

2.2.1 Groundwater Movement

The natural level of groundwater in an aquifer is termed the 'water table', except in circumstances where the groundwater is under natural hydrostatic pressure (is 'confined') when it is termed the 'piezometric surface'. The water table is rarely horizontal, with the result that groundwater is always 'flowing' towards the lowest point of the water table (usually a groundwater discharge point such as a spring, river or lake). Due to the nature of the aquifers in Uganda, the water table also usually 'mirrors' the topographic surface to a very large degree (Figure 2).

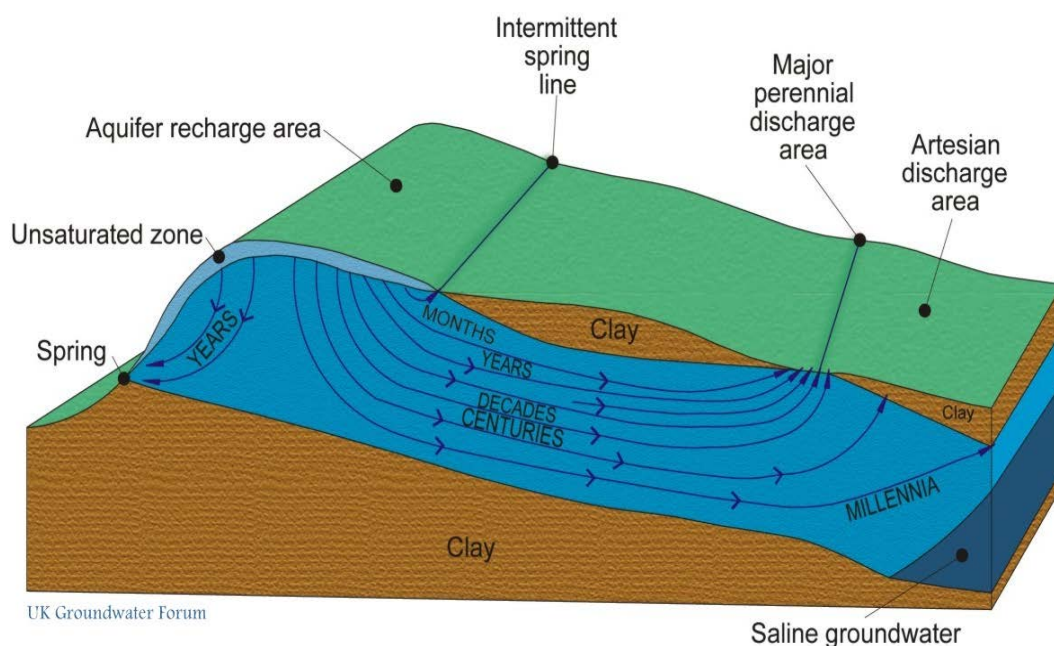


Figure 2: Basic illustration of groundwater Movement in the Earths Crust

2.2.2 Flow towards a Borehole

If water is pumped from a borehole, the natural water table in the vicinity of the borehole drops and groundwater starts flowing towards the borehole. This fall

in water level is termed 'draw down' (*DD*), and is the difference between the static water level (*SWL*) i.e. the natural level before pumping, and the dynamic water level (*DWL*) i.e. the imposed water level due to pumping (*Figure 3*). In order to express draw down as a positive number, this is normally stated as:

$$\text{DRAWDOWN (DD)} = \text{DYNAMIC WATER LEVEL (DWL)} - \text{STATIC WATER LEVEL (SWL)}$$

In a homogenous aquifer the inward flow of groundwater is radial, groundwater flow velocity increases as it nears the well where the water table becomes increasingly steep, and the water table assumes the shape of a cone termed the 'cone of depression'. The distance around a borehole that is affected by the cone of depression is termed the 'radius of influence'.

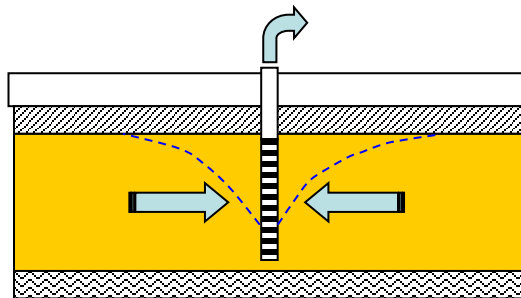


Figure 3: Schematised Flow towards a pumped groundwater well

When pumping is stopped the cone of depression fills by natural flow and the dynamic water level rises back to the static water level. The rate at which this recovery of water level occurs gives an indication of the 'permeability' (or *water transmitting capacity*) of the aquifer. Rapid groundwater recovery indicates an aquifer with a high permeability.

2.3 IDENTIFYING A DRILLING POINT (BOREHOLE SITING)

Identifying a probable drilling point involves a series of steps that include both office/desk work and field work. The office/desk work involves a thorough review of existing borehole data, a study of the aerial photographs and satellite imagery, identifying areas with thick overburden, the prominent fracture and fault zone and the fault directions.

This is concluded by pin-pointing the most feasible location on the ground where the field work should start. Field work is started by making observations on

ground. Ground observations are aimed at identifying existing tracers/indicators of groundwater occurrence and flow.

2.3.1 Indicators of Groundwater Presence

There are a number of features, both natural and man-made, which may indicate the presence of groundwater and aid in the location of a probable drilling point. These include:-

- Valleys, particularly those that are linear, since valleys often occur along bedrock fracture zones.
- Linear distribution of natural vegetation, particularly large trees. This may be indicative of underlying fracture zones, since large trees will have roots into the permanent water table in such fractures.
- Broad areas of permanently green vegetation, since generally healthy vegetation throughout the year indicates the presence of shallow groundwater.
- Existing water sources such as perennial hand dug water holes, perennial springs, indicating the presence of shallow groundwater
- Existing boreholes.

Once pin-pointed, more precise methods are used to locate a point where borehole drilling is implemented.

The details on hydrogeological investigations/ borehole siting are detailed in the Borehole Siting Manual.

3.0 COMMON DRILLING METHODS

3.1 MUD ROTARY DRILLING

In this method of drilling, a borehole is created by a drilling bit attached to the bottom set of drilling rods which are of a lesser diameter than the bit and which are rotated by means of a hydraulically driven drive unit/system on the drilling rig. The rotation of the bit together with the weight of the drilling 'string' (*i.e. the drill rods, any drilling collars used to provide weight and the bit itself*) cuts and breaks up the rock/soil as it penetrates the formation. In order to remove this broken material a circulating fluid (*loosely termed 'drilling mud'*) pumped via a number of 'mud pits' is used.



Figure 4: Illustration of mud drilling and the location of the mud pit

In a conventional fluid flush system, drilling mud is pumped from a 'suction pit' through the rotating drilling string and out through holes in the drill bit. This mud picks up the soil/rock materials cut by the bit in the bottom of the bore (*'cuttings'*), then flows upward in the 'annular space' between the drill rods and the wall of the borehole, carrying the cuttings to the ground surface and clearing the hole. The drill string and bit will then continuously move downwards and deepen the borehole. The greater the fluid flow, or lower the viscosity, the more

efficient the hole cleaning process and in general, the faster the drilling penetration.

At the surface, the returning drilling fluid (*drilling mud + cuttings*) flows to a 'settling pit' where the cuttings are allowed to settle out of the fluid to the bottom of the pit. From the settling pit the recovered fluid then overflows back into the suction pit from where it is sucked up by the mud pump and re-circulated again through the drill string.

This drilling method is much preferred in loosely consolidated formations. Such formations usually comprise of sand and highly weathered rock material. It is the drilling method that is most appropriate and preferred in the sedimentary environment.

3.2 AIR ROTARY DRILLING

The essential components of the air rotary method are the same as the mud rotary method, except that compressed air is used as the circulating fluid that is forced down the drill string, through the drill bit and back via the annular space to the surface. The cuttings are forced up through the annular space by the pressure of the ascending velocity of the air, and are carried to the surface. At the surface the cuttings are collected either in a bucket trap or an 'extractor'.

This drilling method requires no mud pits or pump, but the efficiency of the hole cleaning and hence drilling penetration is very much influenced by the volume and pressure of the air (*i.e. the capacity of the compressor*).

This drilling method is effective in relatively competent consolidated formations where little or no collapsing of the borehole is encountered.

3.3 AIR PERCUSSION DRILLING



Figure 5: Air percussion drilling.

This drilling method is the now most commonly used in Uganda, and is essentially the same as the air rotary method, except that air pressure is used to operate a down hole percussion ‘hammer’. The hammer relies upon percussive impact and rotation rather than solely rotary action to break up the rock and create the borehole. Cuttings produced by the hammer are similarly returned to the surface by the rising column of air, with the rate of penetration and the efficiency of hole cleaning depending greatly on the pressure and volume of the compressor.

A very significant advantage of this method of drilling is that the percussive action of the hammer bit (*which is usually tipped with hardened tungsten carbide ‘buttons’*) allows the rapid penetration of hard formations which may not be easily penetrated by the rotary method.

This drilling method is most suitable in consolidated lithology including the competent overburden (*such as laterite*) and hard rock. The mode of drilling makes the method suitable for areas with massive rock outcrops since the drilling hammers can easily crush and penetrate even the hard rock.

The method is rather suitable in most parts of Uganda which are principally underlain by granite/gneiss bedrock.

3.4 'CABLE TOOL' PERCUSSION DRILLING

A cable tool percussion rig operates by repeatedly lifting and dropping a heavy string of drilling tools on a cable into the borehole. The heavy solid steel drill bit on the bottom of this string mechanically breaks or crushes consolidated rock into small fragments. If water is present in the penetrated formation the crushed rock will form a 'slurry'; otherwise water must be added to the hole to create the slurry.

As drilling proceeds slurry accumulation increases and eventually reduces the percussive impact of the drilling tools. When the penetration rate becomes unacceptable, the slurry is removed at intervals from the hole by a sand pump or bailer. Bailers used to remove the slurry consist of a pipe with a simple check valve at the bottom, which is open as the bailer is dropped into the slurry, but closes as the bailer is raised. A sand pump or suction bailer is fitted with a plunger so that an upward pull on the plunger tends to produce a vacuum that opens the valve and sucks sand or slurred cuttings into the tubing.

Although the cable tool percussion drilling method requires relatively unsophisticated equipment and is adaptable to varying geological environments (*both soft and hard formations*), it has the disadvantages that the penetration rate is generally slow (*particularly in hard rocks*). It may also be difficult to ensure a truly straight hole (*due to the absence of a rigid drill string*), particularly in hard fractured formations.

3.5 PLANNING DRILLING OPERATIONS

Planning a drilling operation is a process that involves several stakeholders at different levels namely:-

- Donors – sources of funding
- Government; Ministries Departments and Agencies – who provide the technical capacity and organise water works and services in contracts.
- The beneficiary community – who prepare for the recipient of the final product and operation and maintenance. The village feedback meeting, community understanding of why particular site selection, getting consent of landlords and making sure that community structures are in place.
- The implementers of the activity including consultants and contractors.

Each of the above-listed group has a very important role that they play for the successful implementation of a borehole drilling operation/program. However, it is only in the

interest of this manual to further highlight the expected operations of only one set of key players i.e. the consultant/contractor and the client.

Prior to the on-set (*mobilisation to site*) of a drilling program, the consultant should check and verify whether the contractors' equipment, personnel tools and the borehole construction materials procured are in accordance with the technical specifications of the contract. Critical checks should be carried out prior to mobilisation and as detailed in the chapter that follows.



Figure 6: Inspection of the contractors' equipment prior to the start of the drilling program.

4.0 DRILLING SUPERVISION

Good supervision of water well drilling is essential for the provision of long-lasting water wells. This section deals with the key aspects of supervision aimed in guiding geologists and engineers in charge of the supervision of borehole construction, as well as project managers.

The supervisor is expected to display great professionalism in carrying out his or her duties. A good knowledge of geology, hydrogeology and borehole construction is essential. Although the supervisor represents the client, he or she is expected to act with honesty, impartiality and fairness in any dispute over the contract.

The aim of supervising borehole drilling is to ensure that boreholes are produced as designed and all the data collected during the drilling is accurately recorded and reported to the relevant agencies. Good supervision is essential for a high quality borehole, even if a competent drilling contractor (*henceforth referred to as the 'Driller'*) is employed. Without good supervision, the quality of the work may be compromised.

4.1 RESPONSIBILITIES OF THE SUPERVISOR

Drilling supervision may be defined as the continuous monitoring of the day-to-day drilling, test pumping, casing and installation activities on a drilling site, including “on-site” guiding of the drilling contractor in the order and implementation of drilling works.

Supervision is usually done either by the Client’s staff or by a consultant. The Supervisor may be a hydrogeologist, an engineer, or a technician. Although the Driller and the Supervisor work together to deliver the product, their roles are different. The Supervisor’s responsibility is to ensure that the Driller adheres to the *technical specification*, makes all the required measurements, keeps all records accurately and ensures that health and safety procedures are adhered to.

At the same time, the Supervisor must act in the best interests of the Client (*or Employer*) in order to achieve works completion within the budget and time approved. The Supervisor must thus make decisions on site that ensure professional workmanship to the highest standards, that minimise costs to the Client, that maximise efficiency of operation, and that wherever possible ensure a harmonious working relationship between the agreed parties.

There are three levels of drilling supervision:

- 1. Full-time supervision:** A Supervisor stays with the drilling team throughout the drilling process, from the inspection to demobilisation. On large drilling programmes with multiple rigs, several supervisors are deployed, and they stay in the Drillers' camp and go out with them each morning. While this supervision level is ideal, the resources needed are not always available.

- 2. Part-time milestone supervision:** One Supervisor is in charge of several drilling rigs and may only witness crucial stages (*milestones*) of the drilling. The stages that must be carried out in the presence of the Supervisor need to be specified in the contract document and the consequences of not abiding by them stated. However, the Supervisor is expected to be promptly on site and should not cause undue delays. The milestones are:

- Mobilisation
- Site check / site selection / site confirmation
- Termination of drilling
- Lining of the borehole
- Borehole development
- Pumping test
- Demobilisation
- Platform construction and pump installation (*may be delegated, depending on contract*).

The 'Record Keeper: One of the members of the Driller's team plays a very important role. He/she is designated to collating the measurements and preparing the forms at all stages of the process set out in the milestones above. This role should be specified in the contract documents.

- 3. End of contract supervision:** This is not actually supervision but a site inspection, where the Supervisor goes through the records and inspects the functionality of the borehole on completion. Where this is the planned level, the supervising role of the community members is particularly important. As in the case of part-time supervision, the role of the 'Record Taker' is also very important.

4.2 SUPERVISION EQUIPMENT/ REQUIREMENTS AND OUTPUTS

Vehicle: Ideally, the Supervisor should be independent. However, this may not be possible, in which case the Driller provides transport to and from the site

Down-the-hole camera: This is useful for preventing arguments about casing lengths. The Driller may hurriedly drill boreholes, not allowing any supervision. The camera allows you to know whether the borehole is open hole or lined. It would be good if every project has one camera.

Other: Boots; hard-hat; clipboard; notebook; duplicate book; digital camera; *Global Positioning System (GPS)* device; mobile phone; calliper; spirit level (*for checking verticality of drill mast and pedestal as well as slope of run-off drains*); dip meter; measuring tape; magnifying glass; stop watch; pH stick meters and a first aid kit.



Figure 7: Some common kit items – Depth meter, Electronic dipper, Tape, EC and PH meters, Handheld Global Positioning System (GPS) device

Whichever level of supervision is adopted it is essential that community members are involved in the entire drilling process. This should foster the spirit of ownership and understanding of post-construction operation and maintenance.

With respect to drilling, test pumping, casing and installation supervision, the output of the Supervisor is largely similar and should be adapted from the list below, as necessary for each activity.

The Supervisor's outputs shall be:

- Introduction of the Contractor to the community and indication of the exact location of the drilling site.
- A Supervisor's logbook with daily entries
- Completed forms: "Daily Log for Drilling Supervision" for each borehole.
- Completed form "Check list for various materials to be provided by the Contractor during drilling, installation of casing and screen, development and test pumping" for each time drilling starts after demobilisation.
- Written site supervision instructions to the Contractor, especially in relation to decision of final drilling depth, final size of the borehole and installation of casing and screen.
- A completed feed-back form comparing the drilling log with the geophysical survey.
- A completed performance evaluation form when the drilling work has been completed.
- Minutes of site meetings between Contractor, Consultant and Client staff.

- Certification of Contractors borehole record.
- Certification of Contractors submissions and verification of the contractors payment certificates.
- A completion report covering a number of boreholes for a particular contract schedule.
- A Certificate of Completion of Works.

4.3 DUTIES AND RESPONSIBILITIES OF THE SUPERVISOR

The duties and responsibilities of the Supervisor shall also include, but not be restricted to, the following: -

Pre-Mobilization Meeting: The aim of this meeting is to ensure that the Driller and Supervisor are fully aware of their exact roles and responsibilities and contract details.

Once the contract has been signed, and prior to mobilization, a meeting between the Client, Driller and Supervisor is essential. At the meeting, all three parties go over the design, materials and procedures for each step in the contract. Roles and responsibilities need to be clarified in detail. This provides an opportunity for any ambiguity to be resolved and the contract amended as necessary.

However, many Drillers do not read the contract, but simply add their prices into the *Bill of Quantities*. The pre-mobilization meeting ensures that everything set out in the contract is clarified verbally, thus preventing conflicts while on site. Without this, there is always a danger that the wrong equipment or inferior materials will be taken to site, and the Supervisor compromised due to time-pressure.

Programme of works: The Supervisor should discuss the *technical specifications* and drilling procedure with the Driller, and discuss and agree the target depths. Then the Supervisor should ask the Driller to submit a programme of works.

Sites identified for drilling are normally marked with painted wooden pegs or piles of stones and shown to the Community representatives. The sites are identified in each community and numbered in the order of priority.

Once the Supervisor is satisfied that the site (*accessible to the users and protected from pollution*) is the best selected during the surveys, he/she gives permission to start drilling.

Materials check: In some contracts, the suppliers, manufacturers, or sources of the material to be used, such as *drilling fluid, casing and screens*, are specified. The Driller should submit samples of the materials for the Supervisor's approval. The slot size and wall thickness should be checked, for example.



Figure 8: PVC screen slot sizes (left 0.75mm slot, right 1mm slot)

Data collection forms: The format of drilling data collection, that meets the contract requirements, should be agreed on. Templates as are provided in the contract must be agreed on. The final version for copying will be agreed on site between the Driller and Supervisor, and signed by both parties once all the stages of the contract are completed.

Responsibilities of the Supervisor

- Issuing necessary instructions using a triplicate book. Copies must be filled in triplicates so that the Consultant keeps a copy of all instructions given, and one copy can be filed in the project file and the third copy is kept by the site supervisor. **All instructions shall be clearly written, dated and signed.**
- Be responsible for the decision on final drilling depth and borehole construction details including, size of the materials installed, and the placement of the lining materials during borehole construction. The Supervisor needs to know the depth of the *drill bit* at all times to ensure

that proper data logging is being done, to know the depth at which to tell the Driller to stop and to compare the drilled depth with the depth recommended in the contract. An unscrupulous Driller can try to rip off the Client either by drilling excessively deep, or by pretending that the borehole has been drilled deeper than it actually has been. The drilling depth can be monitored by measuring the length of the drill pipe and multiplying the number of full pipes that have gone down into the hole

- Monitor and supervise all drilling operations, construction supervision (*whether temporary or permanent*), borehole development, test pumping, casting and installation. Ensure that all operations are performed in a professional manner and to the best standard of workmanship, in accordance with the relevant clauses in the Contractors contract (*Technical Specifications*). The supervisor should ensure a high-quality borehole is drilled in a way that is safe and well-documented.
- Drilling is a very hazardous activity. Safety of the workers on site is absolutely vital. Responsibilities for ensuring safety should be clearly set out in the contract. The Supervisor must be constantly vigilant to prevent accidents, and to minimize injuries should accidents occur.



Figure 9: Poor Safety – No Hard Hat – No Clearly Defined Barrier

The Supervisor should look after his or her own safety and be aware of risks to the Driller's crew and the public. A drilling operation is a novelty, and it quickly attracts a crowd, particularly children. The supervisor must ensure that spectators are kept behind a clearly defined barrier where they

cannot be struck by falling objects, such as a drill pipe, or a hose breaking loose from a *compressor* or mud pump - which could be fatal. A community representative can be asked to support the process of policing the barrier tape.

- The supervisor should always have a copy of the Contractor's Contract on the drilling site.
- Fill in all pertinent data sheets showing operations, instructions, events and measurements, number/size of installed casings/screens, observations on penetration rate and geological conditions, test pump data, casing and installation data for documentation. Present the data sheets to the Project Manager at the completion of work at each site.
- Prepare "Daily Log for Construction Supervision" for each borehole.
- If any incident takes place which influences the performance of work which is not in accordance with the specifications in the contract or the work plan, the Supervisor shall note this and ensure it is signed by himself and the Contractor. Subsequently, the Supervisor shall inform/consult the Project Manager of the incidence and any decisions made on site.
- Measure and inspect all borehole lining materials before installation to ensure that they meet the contract prescribed specifications, undamaged, with no deformations and are of correct dimensions. Inspect all filter pack before installation.
- Ensure sample collection. To collect the samples, the Driller stops drilling, flushes all cuttings in the hole to the surface, resumes drilling, and then collects the cuttings. In air drilling, the samples are caught in a bucket placed in the stream of air jetting from the borehole. In mud drilling the samples are collected by inserting a spade into a small collection pit as the cuttings flow to the main pit. It is the Driller's responsibility to ensure that the mud pump is of such rating and condition that it can lift the cuttings out of the hole. If the hole is not properly flushed, cuttings may become mixed up and not lifted out so that during lining, the casings do not get to the required depth. The supervisor should ensure that drill samples are collected.



Figure 10: Samples are laid out and logged for 1m depth intervals

The depth interval of collecting samples might have been stated in the *Technical Specification*, but drilling conditions may require that this is reviewed. It might have been specified that samples should be taken at every metre interval. However, in a deep borehole where the formation does not change rapidly, the interval could be increased to three metres. Equally, where there is rapid change in *lithology*, the Supervisor may change the interval to half a metre.

- Drill samples should be described and a strata / lithological log prepared by the Supervisor. The supervisor should have a full description of the samples, based on colour, texture, grain size and shape, material and rock type. For example; dark grey hard CLAY or grey brown coarse angular grained loose SAND. From the strata description, the Supervisor will prepare a graphic strata / lithological log which will form part of the final borehole report.
- At regular intervals and where possible inspect the Contractors base camp, the set up and all stored materials and satisfy himself that materials and storage conditions are appropriate and according to the contract. Upon abandonment of camp ensure that Contractors' clean-up of the site is satisfactory. A copy of the inspection log (completed in triplicate) should be given to the contract every time this activity is carried out
- Participate in scheduled meetings as required by the either the Consultants' or the Contractors' Contract, normally every month, and prepare minutes of these meeting.

- Approve the Driller's reports. Verify and approve the Contractor's payment certificates and statements for work done.
- Present a report on each group of boreholes drilled during a particular signed contract schedule.
- Complete the feed back form relating the information obtained from drilling to the information derived during the Hydrogeological and geophysical investigations.
- Prepare Certificate of Completion of Works.

4.4 SUPERVISORS RECORDS

A series of records have to be kept and maintained by the drilling supervisor for the entire project/contract time. These have been indicated above. However, as a guide these are categorised as either;

- Supervisor's daily records;
- Supervisor's borehole technical records;
- Supervisors site records.

4.4.1 Supervisors Daily Records.

The daily records should be recorded on standard forms (*see appendix*). A copy of the supervisors' daily records shall be made available to the client as and when requested and may include other data as may be requested from time to time.

The daily records must include the following;

- Site name;
- Site location (*Village, Parish, Sub county, County and District*);
- GPS coordinates of site (*preferably UTM zone, Easting and Northing*);
- Date of reporting;
- Name of supervisor's representative;
- Name of contractor;
- Details of contractor's plant and equipment on site;
- Details of work completed by the contractor, especially time-based activities;
- Gender representation on site (*number of women that visit the site*);
- Participation of the community, if any;

- A copy of the supervisor's instructions to the contractor;
- Problem encountered/resolved.

4.4.2 Supervisors Technical Records

The technical records should be recorded on standard forms that constitute the drillers log (see *appendix*). A copy of the supervisors' daily records shall be made available to the client as and when requested and may include other data as may be requested from time to time.

The daily records must include the following;

- Site name;
- Site location (*Village, Parish, Subcounty, County and District*);
- GPS coordinates of site (*preferably UTM zone, Easting and Northing*);
- Date of reporting;
- Name of supervisor's representative;
- Name of contractor;
- Depths/diameters (*drilling*);
- Materials installed such as casings, screens, gravel etc (*drilling*);
- Equipment installed such as pumps, rising mains etc;
- Lithology log (*drilling*);
- Penetration rate (*drilling*);
- Water strike/level/static water level/estimated yield (*drilling*);
- Discharge rate/drawdown (*testing*);
- Water quality (*conductivity/pH/colour/taste*);
- Problems encountered/resolved.

4.4.3 Supervisors Site Record

The technical records should be recorded on standard forms that constitute the drillers log (see *Appendix*). A copy of the supervisor's daily records shall be made available to the client as and when requested and may include other data as may be requested from time to time.

- Site name;
- Site location (*Village, Parish, Sub county, County and District*);
- GPS coordinates of site (*preferably UTM zone, Easting and Northing*);
- Village location map;
- Geophysical survey information and interpretations in an agreed format;

- Test pumping data in an agreed format;
- Water quality data in an agreed format;
- A water source location map (signed by the chairperson of the WUC or member of the WUC. The land owner of the area where the final site is located should also sign;
- A copy of the technical record for the site;
- A copy of the supervisors' daily record reports;
- Any other pertinent documentation relating to the site.

5.0 CONTRACT PRE-COMMENCEMENT CHECKS

5.1 ACCESSIBILITY

Before the drilling rig and equipment is taken to the selected drilling sites for the construction of boreholes, the following should be noted:

- The road tracks leading to the selected drilling sites should be repaired or cleared.
- Although trees and/or branches close to the roads should be cut so that there is no obstruction when transporting the equipment, the supervisor should ensure minimal damage to the environment.
- The Contractor and the Supervisor must inspect the roads and the selected sites to make sure that the drilling rig and all the equipment can reach safely.

5.2 SITE INSPECTION

Any site selected for drilling should always conform to the following:

- The ground around the site should be firm and solid for proper jacking up during rigging up.
- Sufficient space around the site should be cleared by the future water source users of any tree stumps and any other obstacles to the drilling rig and equipment.
- For safety precautions, the community around the drilling site should construct a perimeter fence with enough inside working space.
- The community near the drilling site should construct a temporary shelter. The shelter will act as a working place for the Supervisor and the Contractor and as a temporary store for the drill samples.
- Sanitation conveniences should be ensured near but not very close to the drilling site. These should be NOT less than 50m up-slope and 30m down-slope of the source under construction

- The Supervisor and the Contractor in consultation with the local authorities should select suitable areas for the Contractor's mobile camp, which should be inspected at intervals to ensure adherence to environmental guidelines.

5.3 EQUIPMENT AND MATERIALS INSPECTION

The Contractor should submit a complete list of machinery and equipment to be used during the drilling program.

All machinery and equipment provided by the Contractor must be inspected by the Supervisor and the Client's representative at the Contractor's yard at the start of the contract. The purpose of the inspection is to verify the specifications and state of repair of all major items of drilling plant. Particular emphasis should be placed on the following: diameters and state of drilling bits; number, diameter and length of drilling rods and temporary casings, and state of repair of service trucks.

5.3.1 Some of the major items to be inspected should include the following:

- i. Drilling rig (*top head drive, air rotary percussion*).
- ii. Compressor (*700 cfm or greater, truck or rig mounted*).
- iii. Support truck (*at least one per drilling team*).
- iv. Water tank (*truck or trailer mounted*).
- v. Light support vehicle (*preferably 4WD pickup*).
- vi. Tricone roller bits (*10 5/8"*).
- vii. Drag bits (*10 5/8", 8"*).
- viii. DTH button bits (*10 5/8", 8", 6", 4 1/2"*).
- ix. Temporary casings (*at least 8" internal diameter*).
- x. Drilling rods - total length about 150m with min. diameter 4 1/2".
- xi. Grouting pump and accessories, including tremmie pipes.
- xii. Hammers (*to accommodate 8", 6" and 4 1/2" bits*).
- xiii. Borehole caps (*wooden, plastic or metallic*).

5.4 STAFF INSPECTION AND FAMILIARISATION

The Contractor should always introduce the drilling crew to the Supervisor. The staff should include the Driller himself, technician, helpers and camp attendants.

The Supervisor should inform the drilling crew about the whole programme and how it will be accomplished.

According to the locations of the selected sites, a drilling programme should be established by the Contractor in co-operation with the Supervisor. This programme should be maintained for easy communication with the Client's head office. Any change in the programme should be communicated immediately to the Client's office via the Supervisor.

In the case of a Consultant supervised contract all formal communication from the Contractor to the Client (or the Employer) should be through the Consultant. Only the Client (or the Employer) is supposed to communicate with the public e.g. the press and Govt officials, about the whole exercise of drilling for that contract period.

All official communications across the parties should be in writing.

6.0 DRILLING SUPERVISION

Borehole construction can be divided into five main operations. These are:

- Drilling the hole,
- Installing plain and screen casings,
- Cement grouting,
- Installing filter pack,
- Installing a clay seal;
- Casting a sanitary seal;
- Developing the borehole to ensure sand and silt free water.
- Well capping and cleaning site.

Supervision requirements for each of these operations are noted below.

6.1 BORE HOLE DESIGNS

Conventional drilling in Uganda employs two basic design including;

- Design A
- Design B

6.1.1 Borehole Design – A

This includes boreholes that are drilled with a “telescopic design”. In this kind of design, the diameters of the well decrease with increase in depth. In most cases, these boreholes are completed in “open-rock” with the final completion diameters being 4½” for hand pumped boreholes and 6”/7”/8” for boreholes with high yields (*that are usually to be installed with motor driven pumps*).

6.1.2 Borehole Design – B

This includes boreholes that are drilled and cased to the bottom. In this kind of design, the well diameters may differ but the final well diameter must allow for installation of 5” for hand pumped boreholes and 6”/7”/8” for production boreholes (*large diameter, high yield boreholes*) up to the bottom of the well.

Because the borehole is cased to the bottom, this borehole design is most often referred to as “Shallow well design”.

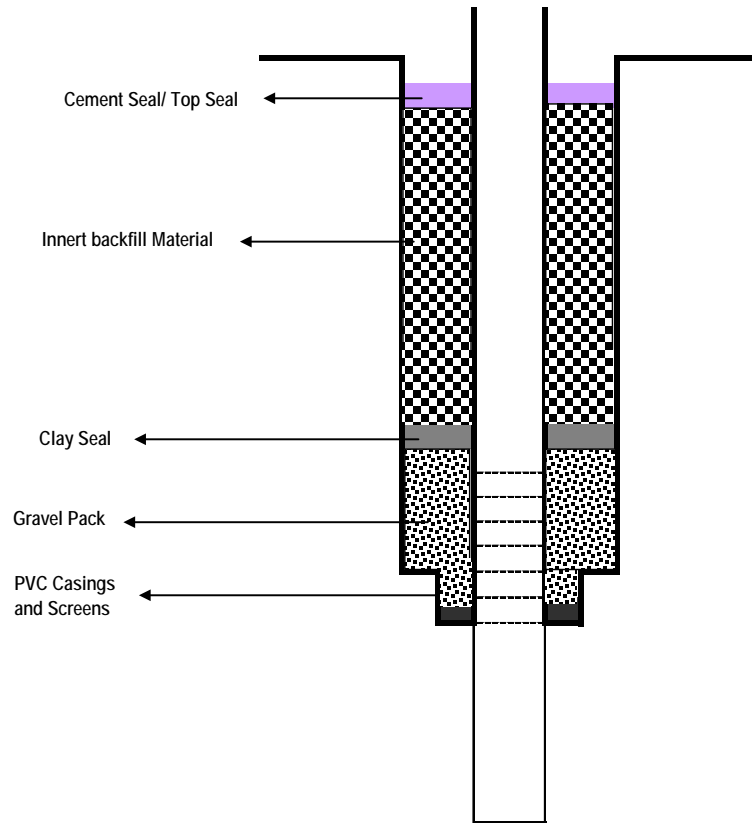


Figure 11: Schematised Borehole Design A

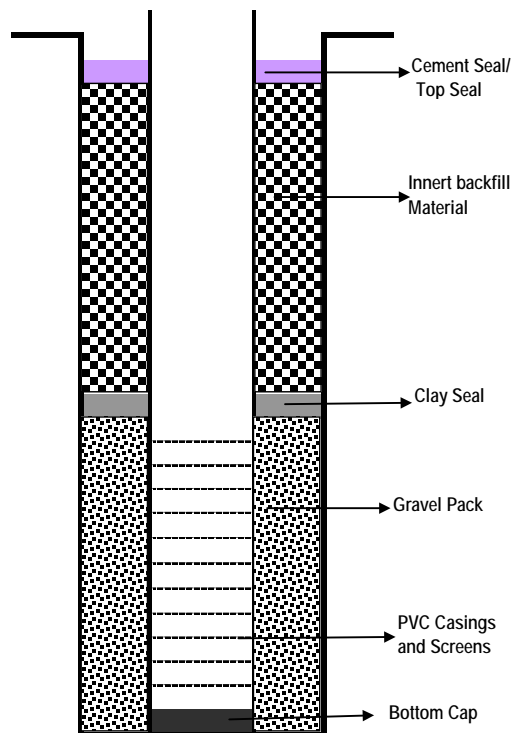


Figure 12: Schematised Borehole design B (Shallow well design)

6.2 INITIAL INSTRUCTIONS AT THE BEGINNING OF A HOLE

The Driller should be given instructions, which must be signed by both the Supervisor and the Driller, on the following:

- To drill the borehole at the exact locations where the peg was placed by the surveying Hydrogeologist.
- To align the machines properly during rigging up in order to drill a plumb borehole.
- To note date/day/time when drilling of the hole commences.
- To record all details on borehole location, and to enter all details of subsequent construction activities as they take place.

6.3 INSTRUCTIONS DURING DRILLING

- To drill through the overburden using either a drag bit or 10 5/8" or 12" DTH up to the hard weathered rock. If the formation is collapsing, to use foam (*biodegradable polymer*), or temporary casing, to stabilise the walls of the hole.
- When hard formation (*rock*) has been reached, to pull out the drill string and the 10 5/8" or 12" bit. To drill at least 3.0 m into the hard formation using a 6"/8" diameter DTH bit, and then pulls out the drill string and bit.
- To install the 8" internal diameter temporary casings to the bottom of the 8" hole. This temporary casing should remain in place and only be retrieved during gravel packing process.
- In case a substantial amount of water has been struck, to install PVC casings and screens as instructed by the supervisor. This instruction will lead to borehole design B.
- In case little or no water has been struck, to drill 4-6 m into the hard formation using 6" or 4 1/2" diameter DTH bit to prove that the formation is bedrock and not a hard band in the weathered zone.
- To continue drilling with the 6" or 4 1/2" diameter DTH bit to final depth. This instruction will lead to borehole design A
- To estimate the yield in m³/h during the drilling process every moment a noticeable increment in flow is observed/realised and during development.

The estimation should be done using a calibrated bucket or standard discharge measurement equipment.

- To monitor drilling penetration rates and record any sudden changes in penetration rate and blowout yield.
- To monitor daily drilling progresses and keep records. This should be done independently from the driller's log.
- To note daily drilled depth, first and main water struck depth at which diameters change, depth and length of screen etc.
- To note reasons for stopping drilling, reasons for shutting down of drilling rig should be adequately recorded with date and time. (e.g. *breakdown of equipment, weather conditions or ground conditions etc*).

As a guideline, the final depth of the borehole will depend on the following:

- If the Supervisor, based on observations during drilling and especially the airlift tests, feels convinced that the borehole will give a sustainable yield at 1000 l/hr. for a hand pump, then drilling may be stopped. In case of the production well, as high yield as possible.
- The drilling may be stopped if the Supervisor concludes that the probability of finding more water-bearing zones at greater depth is very low.
- The drilling should normally be stopped at the depth indicated in the borehole siting report, unless the yield is low and at this depth there is a clear indication that **more water bearing zones** may be found at greater depth.
- When deciding the final completion depth, the Supervisor should allow for 'sump' or silt trap of 3 metres at the bottom of the hole.

6.4 OPERATIONAL GUIDELINES DURING DRILLING

The Supervisor should take note of the following operational guidelines during drilling, and should issue appropriate written instructions to the Driller as necessary. All items noted below form part of the Contractors obligations under his contract.

6.4.1 Formation Sampling

- The Driller should collect representative lithological samples of the strata penetrated for each change of colour or texture, or 1m interval, and in a continuous order. The Driller should always take every precaution to guard against sample contamination or mixing during the sampling process.
- The representative samples should not be washed.
- The Supervisor should do the geological logging of the lithological samples.
- The Driller should ensure that samples are put into suitable bags or tubes labelled with the following:-
 - Location data.
 - Borehole identification number.
 - Depth intervals, and stored such that they will not be contaminated by site conditions or drilling operations.

Samples of each drill hole should be kept separately in sealed boxes and delivered by the Contractor to Geological Surveys and Mines.

6.4.2 PVC Plain Casings (5" Diameter or 6" or 8" Diameter for Production Wells)

After drilling through the overburden (collapsible formation), if no substantial amount of water is struck, PVC plain casings should be installed into the hard rock and grouting undertaken. Approximately 0.5 m of casing should be left above the ground surface.

6.4.3 PVC Screens (5" Diameter or 6" or 8" Diameter for Production Wells)

If enough water is struck in the overburden aquifers, PVC screens should be installed to tap this water. The casing string should have at least one plain casing at the bottom followed by the specified number of screens, with more plain casings placed at the top to prevent collapse of topsoil.

N.B. The Supervisor must always carefully record the number of PVC (*plain casings and screens*) used on each borehole.

6.4.4 Cement Grouting

With respect to this operation the following should be noted:

- Cement for mixing of slurry must be clean and free of lumps. If any small lumps are found in the dry cement, these must be sieved out.
- The cement slurry should be mixed in a clean and empty oil drum.
- The slurry should be prepared by mixing 24 litres of water per 50 kg of cement.
- Mixing should be done vigorously to obtain uniform slurry.
- The slurry (*grout*) should be injected into the annulus between the casing and the walls of the hole using a tremmie pipe or any other agreed method. It is not acceptable for the Driller to pour the grout down the hole, as it may clog the screens and will probably not reach the bottom of the casing string as intended.

NB. The Supervisor should carefully record the amount of cement used on each borehole (*in bags*).

6.4.5 Gravel Packing

Gravel should consist of well-rounded particles of uniform grading and dependent on the screen slot sizes specified in the contract. The size of the gravel should be of uniform grading between 2.5 and 4.0 mm and shall comprise 90% siliceous material and must contain no clay, shale, silt, fines and excessive amounts of calcareous material or crushed rock. The following point should be noted:

- After installation of casings and screens and after grouting has been completed, the annular space between the sides of the drilled hole and the screens should be filled with gravel pack.

- Sufficient gravel pack should be placed against the screens i.e. from below the lowermost screen to above the uppermost screen. The gravel pack should extend to approximately 2 - 3 m or more above the uppermost screen to allow for settling during well development.
- The gravel pack should be capped with a clay seal (*pure clay*) to prevent contamination via the annular space.

NB: Amount of gravel (*in 50kg bags*) used on each borehole should be carefully recorded by the Supervisor.

6.4.6 Back-filling the Borehole

The annular space above the clay seal should be back-filled with inert drill cuttings. The top 3m of annular space should be left for sealing the borehole with cement slurry.

6.4.7 Well Development

The main objective of well development is to remove finer materials like native silts, clays, sand, drilling fluid residues deposited on the borehole walls during the drilling process from the borehole and immediate surroundings (*gravel pack and the aquifer*). The pack and the aquifer are cleaned and opened up so that water can flow into the well more easily. The following points should be noted:

- The well should be developed before the borehole is back-filled up to ground level. The reason for this operation is that the gravel pack around the screens will settle and become compact during development, and therefore more gravel has to be added up to the design level, before any other back-fill is put into the borehole.
- Development can be done by either of the following methods:
 - Continuous airlift until water is free from sediment OR
 - Intermittent airlift development. The cycles to be determined depending on the rate at which water is clearing. Typical cycles are 10 minutes airlifting followed by 5 minutes' recovery. Intermittent airlifting should be carried out until water runs clear to the satisfaction of the Supervisor.

- The Supervisor should always accurately record date and duration in hours for well developing. After well development, the plant can be rigged down.

6.5 INSTRUCTIONS AT THE END OF DRILLING

6.5.1 Sealing the Borehole

The upper 3m of the borehole annulus should be grouted with cement slurry to provide an effective seal against entry of contaminants.

6.5.2 Capping the Borehole

The borehole should always be capped with a wooden cap after well development.

A borehole reference number should be marked on the borehole casing above the ground surface.

6.5.3 Clearing the Drilling Site

On completion of the construction of the borehole the site should be left clean and free from all debris, hydrocarbons and all sorts of waste. All dug pits should be filled with soil or murrum free of hydrocarbons. Only then can the drilling plant and equipment be transferred to the next drilling site on the programme. The shifting distance in kilometres between sites should be recorded.

6.5.4 Low Yielding and Dry Boreholes

Design-A boreholes (*figure 11*), with yields less than 300l/hr or which are completely dry should be back filled with native soil from the bottom to within 3 m from the ground. Two metres are then to be sealed by concrete, cement grout or neat cement, with upper 1 m of the borehole back filled with native soil.

Design-B boreholes (*figure 12*) are not to be back filled but should be capped whether they are low yielding or completely dry. These boreholes can be added to the national monitoring grid and can be used for monitoring.

7.0 TEST PUMPING SUPERVISION

For every successfully drilled borehole it is important to carry out test pumping. Test pumping is performed to determine the optimum yield (*quantity of water that can be drawn out of a borehole in a given time - Q*) of a borehole and the depth at which the pump needs to be installed (*PID*). An advice on the pump (*hand pump or a certain type of motorised pump*) to be installed can be given based on interpretation of the data, leading to an advised yield and an estimated dynamic water level (*DWL*). The test pumping procedures and details about test pumping are in guidelines for test pumping.

During test pumping a sample of water (*1–2 litres*) is collected and taken to the laboratory for analysis of physico–chemical properties in order to determine portability and acceptability. *It should be stressed that there are agreed water quality as well as quantity limits below which no installation of hand pumps is permitted.* The water quality guidelines are found in the technical specifications for borehole drilling.

7.1 INSTRUCTION AT THE BEGINNING OF TEST PUMPING

On the basis of information obtained from the drilling reports and in accordance with the relevant clauses in the Contractors contract, the Supervisor should issue written instructions to the Contractor on site before commencement of the test pumping. Such instructions may be subject to modification during the course of the test, but any modification made by the Contractor must be with the approval of the Supervisor. Key instructions to be issued by the Supervisor at the beginning of a test should include the following:

- On arrival at site, the location details of the site should be entered on an approved test pumping data sheet.
- After removing the borehole cap, the static water level should be measured and recorded.
- The entire riser pipe and pump assembly should be examined to ensure all are securely connected, and then installed to a depth specified by the Supervisor.

- Immediately after switching on the pump, the gate valve should be adjusted to the specified discharge rate in less than 3 minutes. The initial discharge rates must be confirmed using the calibrated container.
- The step test should last at least 60 minutes each step, while the constant rate test should last at least 3 hours or until the Supervisor feels the dynamic water level has attained equilibrium.

7.2 INSTRUCTIONS DURING TESTING OPERATIONS

Additional instructions to be given to the Contractor during the course of the testing operations may include the following:

- The discharged water should be disposed of beyond the radius of influence of the test on the aquifer. The distance should be at least 100m from the borehole, but may be reduced or increased where deemed necessary by the Supervisor.
- Readings of the dynamic water levels should be taken in accordance with the time intervals specified on the test pumping test sheet. Each step during a step test should be recorded on a separate sheet.
- Electrical Conductivity and pH measurements should be taken periodically and whenever required by the Supervisor.
- Water samples should be collected as specified in the Contractors contract, or as required by the Supervisor.
- The Contractor should note any changes in watercolour, discharge rates and technical failures during the entire operations.
- The final step of the step test should not lower the final dynamic water level to less than 3m above the level of the pump.
- The pump should be switched off at the end of the final step, and monitoring of aquifer recovery should commence immediately. If feasible within the time allowed (*i.e. 25% of the total testing time*) the water level should recover to 95 % of the draw down before recovery monitoring is terminated.

7.3 INSTRUCTIONS ON COMPLETION OF TESTING OPERATIONS

After completion of the testing schedule at any particular site, instructions from the Supervisor to the Contractor may include the following:

- After recovery monitoring, the equipment should be taken out of the borehole with care to avoid the pump or pipes falling back into the borehole.
- The borehole capping should then be replaced and protective branches put around the borehole.
- The site should be cleared of any foreign materials introduced during the testing.
- Any water samples collected by the Contractor should be passed on to the Supervisor before the Contractor leaves the site. The Supervisor should then ensure that samples are delivered to the laboratory within 7 days of being collected.

8.0 INSTRUCTION DURING PLATFORM CASTING AND BOREHOLE INSTALLATION

Successful borehole development is concluded with platform casting and hand pump installation. This usually includes the above the ground concrete work activities as detailed below.

8.1 INSTRUCTION BEFORE THE PLATFORM CASTING OPERATION

- While on site, determine the best direction with a slope to allow free-flow (*by gravity*) of the water off the concrete works.
- Clear the area surrounding the borehole casing pipe that stands above the ground
- Excavate around the borehole casing pipe a pit of dimensions 0.5 X 0.5 X 0.5 meters.
- Place and setup the casting mould around the borehole as indicated in the appendix drawings.

8.2 INSTRUCTIONS DURING PLATFORM CASTING OPERATIONS

- Cut/trim the casing pipe such that not more than 0.5m of the pipe is above the ground surface level.
- Place the pedestal in over the casing pipe in the excavated pit such that;
 - Parts of the pedestal including the three legs are in the excavated pit
 - The third leg of the pedestal is in line with the spout and are all facing the chosen spill way direction.
- Prepare a concrete mix with a ratio of 1:2:4 (*Cement: Sand: Aggregate*)
- Apply the concrete first to the pedestal stands/legs then later all over the area covered by the mould down to the spill way.
- Allow the concrete to set for at least 24 hours before removing the mould. Apply the fine cement slurry to give a final finish.
- Allow the concrete to cure for at least 5 days while keeping the concrete works wet all day.

NB: unless otherwise specified, no brickworks should be allowed/accepted during casting

8.3 INSTRUCTIONS ON COMPLETION OF PLATFORM CASTING AND HAND PUMP INSTALLATION

- Measure and record the SWL before Installation.
- Refer to the test-pumping data and determine the installation depth by using the relationship below;

$$\text{Installation Depth, ID (m)} = \text{DWL (m)} + 6$$

This relationship gives an ideal installation depth however; the actual installation depth should be in multiples of 6 because of the pipe lengths.

9.0 A PRACTICAL GUIDE TO CONTRACT MANAGEMENT

9.1 INTRODUCTION

In the context of overall contract management, the role of the site Supervisor is extremely important. As noted earlier, the Supervisor acts as the representative of the Client (*or Employer*) at the site of works, either directly on the Clients' behalf or on behalf of a Consultant who has been engaged to undertake work and act for the Client. In this role the Supervisor is required to make decisions on behalf of the Client. These decisions should be in the best interests of the Client, but must also consider the interests of the Contractor and ensure a smooth and efficient completion of the works for which the Contractor has been engaged. It is essential, therefore, that the Supervisor establishes a good professional working relationship with the Contractor. The Contractor's advise and technical experience (*which is often greater than that of the Supervisor*) should be considered in the decision making process, and both Supervisor and Contractor should apply their skills together in order to successfully complete the work.

The essence of good contract management is to ensure that the terms of the contract signed between the Contractor and the Client (*or Employer*) are followed by the Contractor as well as the Client (*or Employer*) in relation to all matters. The quantity and quality of works and services, time tables and payments are all important. If the Contractor does not follow the contract, certain 'remedies' are available in the contract document that can be used to rectify the situation, or eventually to terminate the contract if necessary. Similarly, the contract also includes clauses that protect the Contractor if the Client (*or Employer*) does not follow the terms of the contract; or if circumstances that could not reasonably have been foreseen make it impossible for the Contractor to adhere to the intentions of the contract.

Virtually all contracts include a standard set of General Conditions of Contract, along with certain special conditions that are related to a particular contract. The Supervisor should become as familiar as possible with these conditions, as well as the actual technical specifications that the Contractor is required to follow. In the following sections, some of the key points in relation to the most common contract documents are outlined.

However, it is important to note that these guidelines do **NOT** constitute a contract document, and that the actual contract should be well known to and used by both the Contractor and Supervisor alike.

9.2 THE ROLE OF CONTRACTOR, SUPERVISOR/CONSULTANT AND EMPLOYER OR CLIENT

The **Contractor's** role is relatively clear: he is responsible for and has to carry out the works that he has contracted to undertake (*siting, drilling, test pumping, installation etc.*). He shall follow the contract and instructions issued by the Supervisor on behalf of the Client or the Consultant. He must not take instructions from any others, including from any other Client staff. The Contractor shall also only accept instructions from the Consultant which result in additional work if such instructions have been approved by the Client.

The **Supervisor/Consultant** is employed by the Client to manage the Contractor's contract on behalf of the Client, whilst at the same time acting as much as possible as an impartial arbitrator to the Contract, between the Client (*or Employer*) and the Contractor. The Consultant is also expected to guide the implementation of the contract in relation to quality of work and financial issues in a professional manner, and to advise the Client when the need arises.

The Consultant normally delegates most of the daily supervision to a Supervisor. As previously discussed, the role of the Supervisor is to ensure that the Contractor follows the contract and to issue the necessary instructions and approvals to enable this to take place. If such instructions may result in expenses on the Contractor's side which the Contractor did not and had reason not to anticipate, then the Consultant shall get approval in advance from the Client (*or Employer*). The Consultant shall then certify and the Employer pays such reasonable expenses.

In consultation with the Client, the Consultant also has the power to suspend the Contractor's progress, but this is a serious issue and must be referred to the Client (*or Employer*) as in some cases the Employer may have to pay for the suspension.

The Consultant shall also verify the Contractor's progress reports and certify on behalf of the Client the payments to the Contractor.

The **Employer** or Client is the body that employs the Contractor to execute the required work under the terms and conditions of the contract. The person

signing the Contract with the Contractor represents the Employer, but this role is most often delegated to other persons or bodies.

9.3 COMMENTS ON IMPORTANT CONTRACT CLAUSES

❖ Approval in writing

“Approved” means approved in writing. It is therefore crucial that all approvals are given in writing - as well as instructions and other communication in general.

❖ Supervisor

The Supervisor shall generally check that the construction work is carried out in accordance with the contract, in particular the Technical Specifications. The Supervisor must therefore have a copy of the contract on site in connection with the supervision and be familiar with all details of the contract. The Contractor is obliged to follow instructions from the Supervisor. All instructions shall be given in writing.

❖ Use of Sub-Contractors

The Contractor needs a written approval from the Employer (*sought via the Consultant, if appropriate*) before he can assign a Sub-Contractor. If the Contractor has assigned a Sub-Contractor without obtaining such approval, he should be instructed in writing to stop the Sub-Contractors work until he has obtained such approval. Approval of sub-contractors should only be given if assignment of the Sub-Contractor is considered advantageous to the programme.

❖ Clause A: Contractor’s Superintendence and employees

The representative undertaking the Contractors superintendence must be identified. The Contractors superintendent must be capable of ensuring the necessary quality of the works as well as the necessary progress. Should this not be the case, the Supervisor should make a report to the Client, or the Consultant as the case may be, who may request that the employee be removed with reference to the relevant clauses in the contract.

❖ Clearance of Site on Completion

The Contractor has to leave the site clean when the works have been completed and shall be instructed to do so if cleaning has been unsatisfactory.

❖ **Clause B: Work Materials and Plant - Basis for Supervision**

This gives detailed specification of the basis for the supervision. Important details are:

- The work shall be in accordance with the contract and the Supervisors instructions.
- The Supervisor is allowed to perform tests on the works, and the Contractor shall assist and under certain conditions pay for tests to be performed.
- The Supervisor shall have access to all areas where work is performed, and can request that parts of the works are uncovered for inspection.
- The Supervisor can instruct the Contractor to remove and/or replace materials and/or personnel which are not in accordance with the contract, as well as to remove and re-execute work which “in respect of materials or workmanship is not in accordance with the contract”. If the Contractor fails to do so, then the Employer can employ and pay other persons to do this, and deduct the corresponding amount in the payment to the Contractor.
- The Supervisor may suspend all or parts of the works, but under certain conditions the Employer will have to pay the Contractor for the costs in connection with the suspension.

❖ **Clause C: No Night or Sunday Works**

The Contractor can only work at night or on Sundays/Sabbath days if the Supervisor who shall supervise the work has approved this.

❖ **Clause D: Plant and materials only to be used for the Works**

According to this clause, the Contractor is not allowed to use any type of equipment or materials used on the contract on other works unless the Client has approved this. For example, he may not drill a private borehole, even on a Sunday, with a drilling rig that is being used on the programme.

❖ **Clause E: Measurement and Payment**

The Supervisor should have carefully checked the quantity as well as the quality of the works in connection with his supervision, before payment is certified. Payment shall not be made for works not carried out, or work not made in accordance with the contract. Parts of the works, e.g. drilling boreholes, are generally required to be completed totally and satisfactory before they can be paid.

To take care of any unforeseen malfunctioning of the wells constructed, a percentage of the contractors' payment is withheld for a stated period. This percentage is referred to as Retention. Retention money shall be deducted from each certificate with the percentage indicated in the Form of Tender, until the Limit of Retention Money indicated in the Form of Tender has been reached.

This Retention money is finally paid to the contractor at the end of the defects liability period (*usually not less than 6 calendar months*) when the Period of Maintenance, including all repair works, has been completed and the Maintenance Certificate has been issued.

It is crucial that the Contractor is paid timely. The result of a late payment can be that the Contractor can claim interest, as indicated in clause It is advisable that the Client (*or Employer*) should therefore give timely payment a very high priority.

Attachments (Standard Data Sheets)

| |
|--|
| BOREHOLE Completed in triplicate (3) COMPLETION REPORT FORM C |
|--|

WATER POINT INFORMATION

1. IDENTIFICATION AND LOCATION DATA

| |
|--|
| Type of water point: <input checked="" type="checkbox"/> Borehole: <input type="checkbox"/> Dug well: <input type="checkbox"/> Augered shallow well: |
| Identification: DWD No: ----- Latitude; E: ----- N:----- Altitude (m):----- |
| Location: ----- |
| District: ----- County: -----Sub-county: ----- |
| Parish: ----- Village: -----Water point: ----- |
| Water point ownership: <input type="checkbox"/> Private: <input type="checkbox"/> Communal: <input type="checkbox"/> Institutional |
| Water point use: <input type="checkbox"/> Domestic <input type="checkbox"/> Irrigation: <input type="checkbox"/> Livestock: <input type="checkbox"/> Industrial: |
| Water point abandoned: <input type="checkbox"/> Low yield: <input type="checkbox"/> water quality: <input type="checkbox"/> Technical: |
| Date abandoned: ----- |

2. SITE SELECTION DATA

| |
|--|
| Site by: Organization: ----- Name of person: -----Title: ----- |
| ----- |
| Date site----- method of site selection: ----- |
| Electromagnetic: ----- |
| Seismic:_____Other, specify:_____ None:_____ |

Attach site selection results

3. CONSTRUCTION DATA

| |
|--|
| Contractor: ----- Drilled by: Name of person; ----- |
| ---- |
| Title: ----- |
| Method of construction: <input checked="" type="checkbox"/> Air rotary <input type="checkbox"/> Cable tool: <input type="checkbox"/> Mud rotary: |
| <input type="checkbox"/> Augered: <input type="checkbox"/> Dug: <input type="checkbox"/> other, specify: |

Date for completion of construction: -----

Total well depth at date of completion (m): -----

Water well diameter: mm ----- From; ----- to: -----
----- From: ----- to: -----

Permanent casing/well ring diameter: mm: _____

Permanent casing/well ring material: () PVC: () Mild steel:

() Concrete: () Bricks:
() Other: _____

Borehole sealing: () None: (✓) Cement: () Bentonite: ()
other,

Filter slot size & intervals: mm: ----- From: ----- to: -----

Borehole filters: () Gravel pack: (✓) Natural pack:

Well development: Duration (hrs): -----

Method of development: (✓) Air lift: () Bailed: () Compressed air:
() Other (specify): _____

4. INSTALLATION DATA

Type of pump: () Submersible pump: () Centrifugal pump: (✓) Hand pump: ()

Bucket:
() Other

Date of pump installation: day/month/year: _____

Name of pump: _____ Pump capacity: _____

Pump installation/intake depth: -----

Riser pipe material: () Galvanized iron: () Stainless steel: () PVC: () other

Riser pipe diameter: _____ mm

Pumping rod material: (✓) Galvanized iron: () Stainless steel: () Wire: () other

Pumping rod diameter: _____ mm

5. HYDROGEOLOGICAL DATA

Depth to bedrock: m b.g.l.: _____

Overall geological setting: _____

Lithology: (M b.g.l.) From: to:

From: to:

From: to:

From: to

From: to

Water strike, Aquifer and yield:

| Water strike (m.b.g.l) | Aquifer | Yield m ³ /h |
|------------------------|---------|-------------------------|
| | | |

6 YIELD TEST, FLOW AND WATER LEVEL DATA

Test carried out by: Organization: _____ Name: _____ Title: _____

Date of test: _____ Duration of test: _____

A. Step pumping test : () Yes / () No

| Step | Yield (m ³ /h) | Drawdown (m) | Spec. Capacity (m ³ /h/m) |
|------|---------------------------|--------------|--------------------------------------|
| 1 | _____ | _____ | _____ |

B. Constant discharge: () Yes / () No

Average discharge during test (m³/h) _____ Static Water Level, SWL (m.b.g.l) _____

Date measured _____

Pumping water level (m b.g.l) _____ Drawdown (m): _____

Transmissivity (m²/day) _____ Spec. Capacity (m³/h/m) _____

Hydro-fracturing: () Yes / () No. If yes day/month/year _____

C. Natural flow: () Yes () No

D. Air Lift test: () Yes () No

Attach pumping test results.

7 HYDROCHEMICAL DATA

Date of Sampling: _____

Method of sampling; pumping, () airlift, () bucket, () other (specify)-----

Sample preservation;

Analyzed by : Name.....
Organization:.....

Data sheets attached

8. OTHER INFORMATION (include information not catered for in the above sections)

| |
|--|
| |
|--|

9. DETAILS OF ORGANISATION SUBMITTING DATA

| |
|------------------------------|
| Name: _____ |
| Address:_____ |
| Telephone Number:_____. |
| E-mail: |
| Name of responsible officer: |
| Title:_____. |
| Signature:_____. |
| Date of data submission: |
| Stamp of organization |

| | | | | |
|---------------------|--|---------------------|--|-----------------------|
| | | | | |
| Project name | | Borehole No. | | Page of |

| | | | |
|------------------------|--|-------------------|---------------------------------------|
| Project No | | Location | Source Name |
| Grid E | | Parish | Driller yield m³/hr |
| Grid N | | Sub County | Village code |
| Altitude | | County | VES No |
| Geological Unit | | District | Map NO. |

| | | | | | | | | | | | |
|--------------|----------|-----------|-----|-------|------------------------------|--|--|---------|--------------|--|--|
| Date started | | | | | Length of drilling rods(m) | | | | Contractor | | |
| Date end | | | | | Table height (m) | | | | Driller/unit | | |
| Date/time | Drilling | | | Rate | Formation log and activities | | | Remarks | | | |
| | Pipe No | Depth (m) | Min | m/min | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |



DEEP WELL LOG



DEEP WELL LOG

| Project name | | | | Borehole No. | | | Page | of |
|--------------|--|--|--|--------------|--|--|------|----|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| Date/Time | Drilling | | | Rate M/Min | Formation log and activities (Lithology, fracturing, drilling method, bit, well development) | Remarks (collapsing, de water strike, yield, problems) |
|-----------|----------|-------|------|---------------|---|---|
| | Pipe no | Depth | Min. | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

| | | | | | | |
|--|--|--|--|--|--|--|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

DEEP WELL LOG

| | | | | |
|---------------------|--|---------------------|--|----------------|
| Project Name | | Borehole No: | | Page of |
|---------------------|--|---------------------|--|----------------|

| DRILLING SPECIFICATIONS | | | | | | | | | | |
|--------------------------------|----|---------------------|------------------------------|------|--------|------|-----------------|-----|------------|------|
| DEPTH (Mbg) | | Actual bit diameter | Bit type/ Nominal size in mm | | | | Drilling method | | | |
| From | To | (mm) | tricone roller | Drag | Button | Odex | Air | Mud | DTH-Hammer | Odex |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| LINNING INSTALLED | | | | | | |
|---------------------------------------|----|---------------|---------------|-----------|-----------|---------------------------|
| Length of casing above the ground (m) | | | | | | |
| Depth(Mbg) | | Diameter (mm) | casing/screen | material | slot size | Remarks. |
| From | To | inner/outer | C or S | PVC Steel | (mm) | Plain, Ribbed, Continuous |
| | | / | | | | |
| | | / | | | | |
| | | / | | | | |
| | | / | | | | |
| | | / | | | | |
| | | / | | | | |
| | | / | | | | |
| | | / | | | | |
| | | / | | | | |
| | | / | | | | |
| | | / | | | | |

| FILLING | | | | | | | |
|----------------|----|------------------|-------------------|--------------|-----------|--------|--------------|
| Depth (Mbg) | | Gravel pack size | Backfill Material | Type of Seal | | Packer | Bottom plug. |
| From | To | (mm) | | cement | bentonite | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Signature supervisor.....

1 Actual size, measure the actual size and record in mm

2 Nominal size, size of bit when new.

DEEP WELL LOG

| | | |
|--------------|---------|---------|
| Project Name | Well No | Page of |
|--------------|---------|---------|

**PENETRATION RATE
METER PER MINUTE**

LITHOLOGY

WELL DESIGN

Time (min)

Description/H₂O strikes

Diameter in

inches

5 10 15 30
6 4 4 6 8 10

10 8

